WATER RESOURCE DEVELOPMENT

The potential for urban and industrial development depends considerably on the availability of adequate surface-water or ground-water supplies. In northwestern Indiana, abundant fresh water from Lake Michigan has promoted the development of an extensive urban and industrial belt along the southern coast of the Lake. Water supplies in the interior of the Lake Michigan Region come mainly from unconsolidated aquifers, including *glaciofluvial* and *glaciolacustrine* sediments. Bedrock aquifers, however, also provide an important water supply source for the southwestern part of the Region.

Future water demands in the Lake Michigan Region are expected to remain high, especially for both the large population and the manufacturing-based industries in northern Lake and Porter Counties. Therefore, it becomes increasingly important to protect the quantity and quality of existing supplies, and increase the efficiency of water use. Although political and legal constraints limit diversion from Lake Michigan, water supplies in the Region should be adequate to support a variety of water demands in the near future.

WATER USE AND PROJECTIONS

The demand for water in the Lake Michigan Region is dependent on socioeconomic factors, population shifts within, into or out of the Region, and water-use efficiency. The status of the economy can affect water use in the Lake Michigan Region because most of the withdrawals are used for industrial and energy production purposes.

During an economic downturn, water use by manufacturing-based industries may decline because of layoffs, plant closings, and cutbacks in production. Demands for energy may also decline, thus resulting in declines in water use for energy production purposes. Economic growth, on the other hand, may spur an increase in water use for both industrial and energy production purposes.

Population shifts from urban to suburban areas within the Lake Michigan Region, as well as the continued decline in total population may affect water use in the Region. Annual water withdrawals for the major water-use categories were projected through the 1990s to help identify areas of potential conflict between supply and demand. Projections beyond the year 2010 were not included because of data limitations and the variability of socioeconomic factors.

Withdrawal uses

Withdrawal uses involve the physical removal of water from its surface-water or ground-water source. As discussed in the **Socioeconomic Setting** chapter of this report in the section entitled **Water-Use Overview**, the Division of Water maintains a registry of facilities capable of withdrawing at least 100,000 gallons per day of surface water, ground water, or surface water and ground water combined. The Division also maintains annual reports of water used by registered facilities. Reported water use is determined by metering devices, the multiplication of pump capacity and total time of pumpage, or other methods approved by the Division of Water.

It should be emphasized that the term "water use" in this report refers both to total amount of water withdrawn from available sources and to the intended purpose of the withdrawal. The term "use" does not refer to the amount of water which is consumed or made available for reuse within a short period of time.

The portion of the withdrawn water that is consumed varies with the intended purpose of the withdrawal. Water consumption rates for livestock watering and irrigation are highest, ranging from 80 to 100 percent. In contrast, withdrawals for industrial, energy production and public supply uses have much lower consumption rates which range from 3 to 25 percent. Water withdrawn for purposes that have low consumption rates is returned to surface-water or ground-water systems within a short time period, thus creating less potential for significant impacts on water availability.

It should also be noted that the term "withdrawal capability" represents the amount of water which theoretically could be withdrawn by registered facilities if all pumps were operating at their rated capability 24 hours a day. During 1990, total withdrawals by the facilities in the Lake Michigan Region were more than 50 percent of the total withdrawal capability (figure 67).

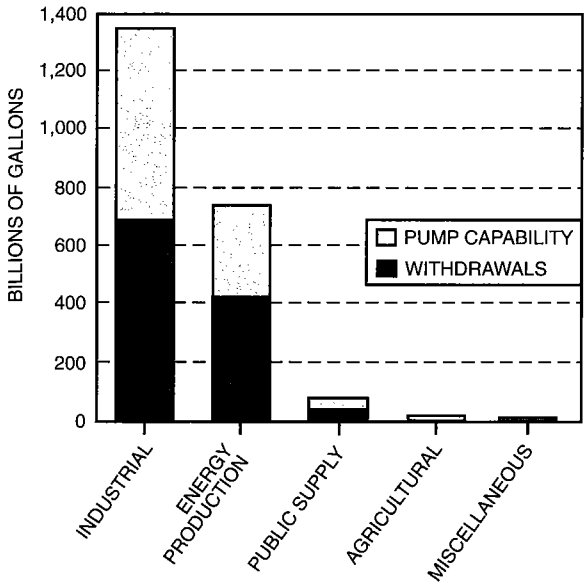


Figure 67. Registered withdrawal capability and reported water use (1990)

Region overview

A total of 80 significant water-withdrawal facilities representing 108 surface-water intakes and 112 wells in the Lake Michigan Region were registered in 1990 (table 23). These facilities had a combined surface-water and ground-water withdrawal capability of about 2185 billion gallons for the year or 5986 million gallons per day (mgd). Most of the registered facilities are located in the vicinity of the industrialized areas along the shores of Lake Michigan and the urban areas in the interior parts of the Region (figure 68). Consequently, these areas also have the highest registered water use in the Lake Michigan Region.

Non-registered facilities include domestic wells, livestock operations, and other facilities capable of withdrawing less than 100,000 gallons of water per day. The total water use for any non-registered facility is fairly low.

In the Lake Michigan Region, surface-water withdrawals accounted for approximately 99 percent of the registered withdrawals during 1990. Water withdrawn for energy production purposes came directly from Lake Michigan, but water withdrawn for industrial, public supply, agricultural and miscellaneous uses came from both surface-water and ground-water sources (table 23).

During 1990, most of the registered withdrawals in the Lake Michigan Region were used for industrial and energy production purposes (figure 67). Withdrawals for both water-use categories constituted about 97 percent of the registered withdrawals in the Region, while the remaining 3 percent of withdrawals were used for public supply, agricultural, and miscellaneous purposes. In 1990, there were no registered facilities grouped under the rural category in the Lake Michigan Region.

Registered facilities

The reported water use by category and county in 1990 is summarized in appendix 13. The number of facilities by category and the amount of water withdrawn, as well as the surface- and ground-water distribution are shown in table 23.

Industrial self-supplied

Industrial self-supplied water use refers to process water, waste assimilation, dewatering, sand and gravel operations, and some cooling and mineral extraction uses. Industrial water use is classified by the Division of Water as withdrawals that a company develops for itself. If an industry also purchases water from a public supply utility, the amount of water that is purchased is included in the public supply water use.

In 1990, industrial self-supplied water use was almost 682 billion gallons, or about 60 percent of the registered water withdrawals in the Lake Michigan Region. About 99.6 percent of the withdrawals for industrial purposes came from surface-water sources (table 23), with Lake Michigan being the primary source.

Many of the registered facilities grouped under the industrial self-supplied category are located in the highly industrialized and urbanized areas along the southwestern coast of Lake Michigan. Facilities are concentrated in northwestern Lake County and in the vicinity of Burns Harbor in Porter County (figure 68).

The various industries in northwestern Lake County accounted for more than 75 percent of the total industrial water use in the Lake Michigan Region. The high water use industries include steel manufacturing plants, oil companies, and both consumer product and building material manufacturers.

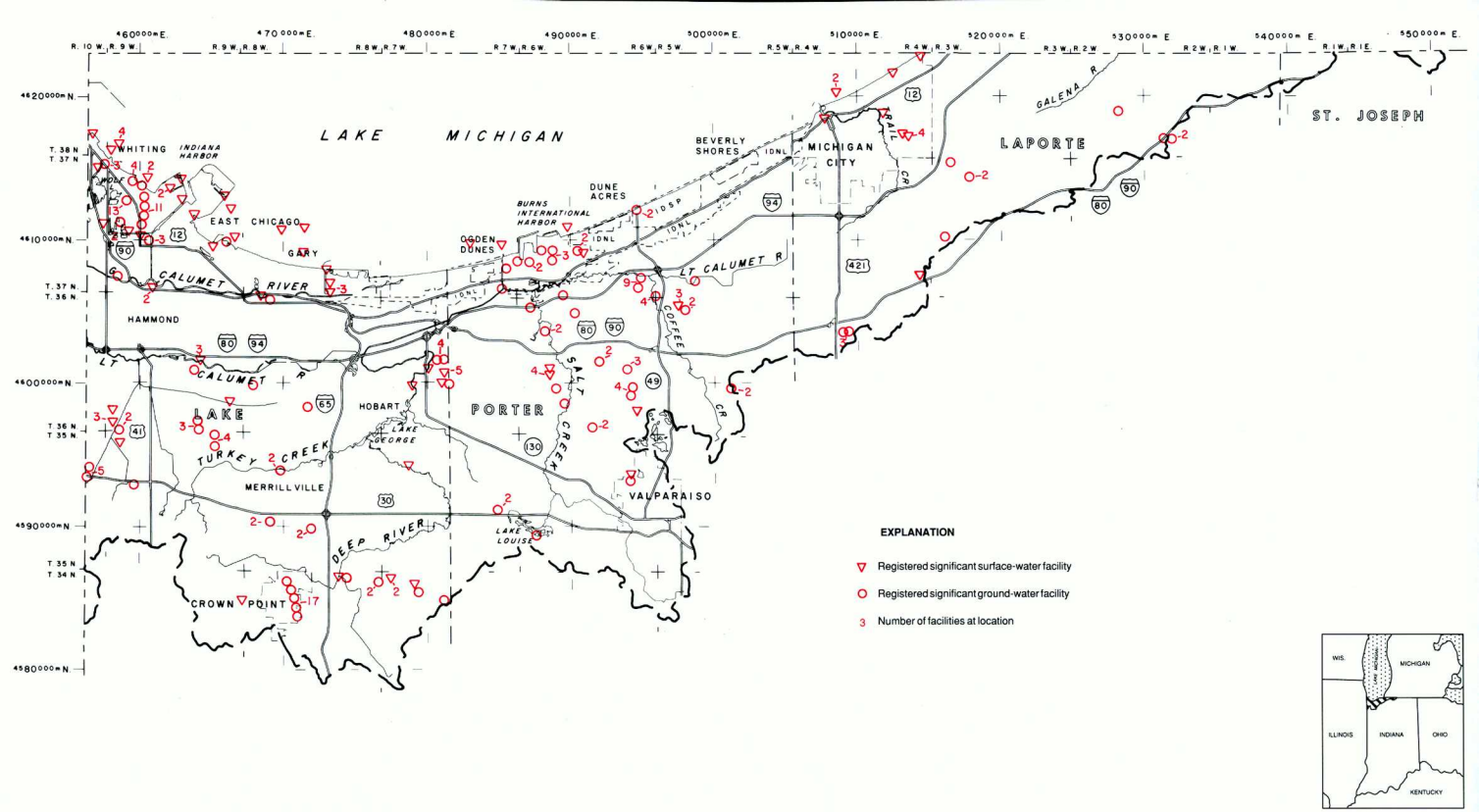


Figure 68. Location of registered water withdrawal facilities

Table 23. Summary of registered water-use during 1990.

Registered Capability (bg): Maximum pump capability of the registered facilities (in billions of gallons).
Withdrawals (bg): Water-use by registered facilities (in billions of gallons).
Capability Development (%): water-use as a percentage of the maximum pump capability of the registered facilities (expressed in percentages).

Water Use Category	Registered Facilities (number)	Withdrawal Source	Withdrawal Points (number)	Registered Capability (bg)	Withdrawals (bg)	Capability Development (%)
Industrial	19	combined	78	1352.3	681.5	50.4
		surface	54	1344.0	678.8	50.5
		ground	24	8.3	2.7	32.5
Energy Production	4	combined	4	731.4	412.0	56.3
		surface	4	731.4	412.0	56.3
		ground	0	0	0	-
Public Supply	25	combined	68	77.3	32.4	42.0
		surface	9	67.9	30.2	44.5
		ground	59	9.4	2.2	23.4
Agricultural	20	combined	53	16.7	0.4	2.4
		surface	36	15.1	0.3	2.0
		ground	17	1.6	0.1	6.3
Miscellaneous	12	combined	17	7.1	1.3	18.3
		surface	5	2.1	0.01	0.5
		ground	12	5.0	1.3	26
Rural	0		-	-	-	-
TOTAL	80	combined	220	2184.8	1127.6	51.6
		surface	108	2160.5	1121.3	51.9
		ground	112	24.3	6.3	25.9

Water use at the industrial complex near Burns Harbor in Porter County constituted about 24 percent of the total industrial water use in the Lake Michigan Region. The large steel manufacturing plants which dominate the complex are the only registered industrial water users in northern Porter County. Overall, the primary metal industry in Lake and Porter Counties accounted for more than 91 percent of the total industrial water use in the Lake Michigan Region.

Industrial water use in the Lake Michigan Region did not vary considerably during 1990 (figure 69). Monthly withdrawals typically ranged from about 50 to 60 billion gallons.

Future industrial water use in the Lake Michigan Region is expected to show a declining trend in the next twenty years (table 24). The projected decline in industrial water use can be attributed to an anticipated decrease in the population of the Region and an increase in water-use efficiency by industries. The methodology used for making the industrial water use projections is explained in a report by the Governor's Water Resource Study Commission (1980).

Energy Production

Energy-production water use includes any self supplied water withdrawals related to the energy produc-

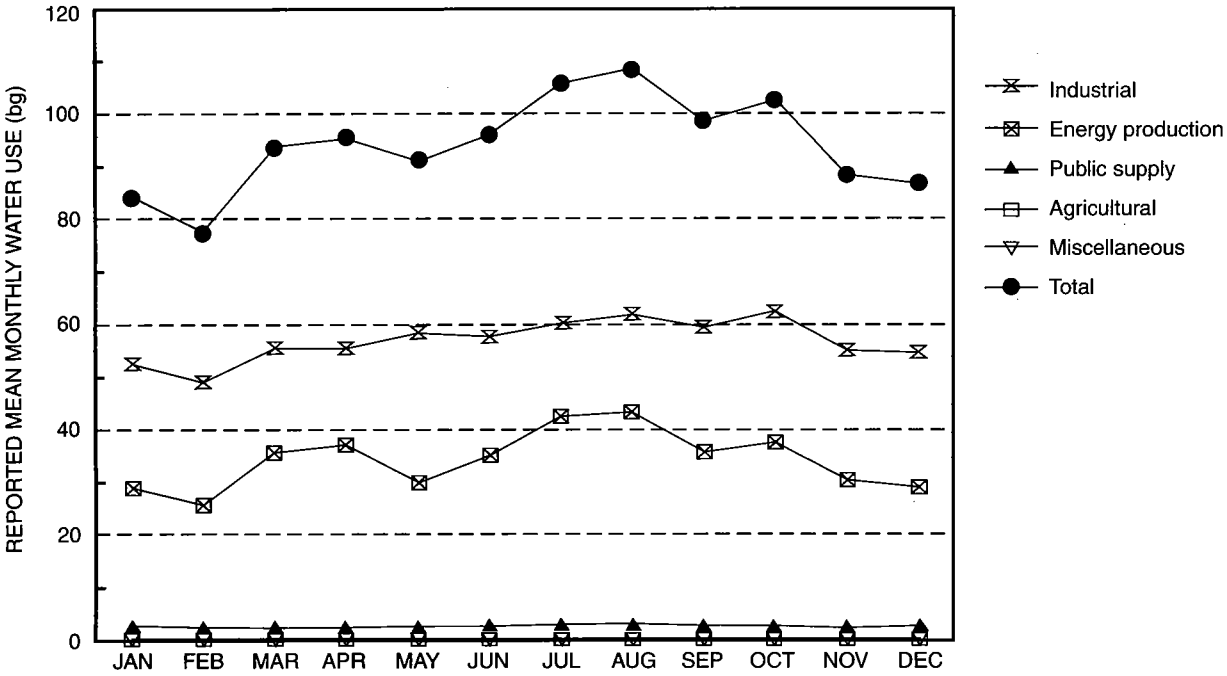


Figure 69. Variation of monthly water use (1990)

tion process. Included are withdrawals for coal preparation, oil recovery, cooling water, mineral extraction, and power generation.

Energy production was the second highest water use in the Lake Michigan Region during 1990 (figure 67). The four facilities registered under the Division of Water's energy production category withdrew almost 412 billion gallons of water from Lake Michigan or more than 36 percent of total withdrawals in the Region. There were no registered ground-water withdrawals in the Lake Michigan Region that were used for energy production purposes in 1990 (table 23).

Of the four facilities registered under the energy production category, three are operated by the Northern Indiana Public Service Company (NIPSCO). These include the D. H. Mitchell Generating Station in northern Lake County, the Bailly Generating Station in northern Porter County, and the Michigan City Plant in LaPorte County. The fourth facility is the Indiana State Line Generating Station in northwestern Lake County and is operated by Commonwealth Edison.

Energy-production water use in the Lake Michigan Region is highest during the summer months (figure 69). The peak energy demands that occur during the months of July and August are for air conditioning and other purposes.

Energy demands in the Lake Michigan Region are expected to decrease as the Region's population continues to decline. Consequently, water use for energy production purposes is also expected to decline barring abnormal conditions.

Public supply

Public supply water use includes withdrawals by both public and private water suppliers that are delivered to users who do not provide their own water. Water suppliers provide water for a variety of uses such as residential, commercial, and industrial use. As presently defined by the Division of Water, public supply also refers to subdivisions, mobile home parks, schools, healthcare facilities, hotels and motels, conservancy districts, and other facilities that have their own water supplies (usually wells) for drinking, washing, cooking and sanitary purposes. However, many of these water use types generally are considered as either domestic self-supplied or commercial uses by some states and organizations.

In 1990, 25 registered water withdrawal facilities in

the Lake Michigan Region were classified under the public supply category by the Divison of Water. Of the 25 facilities, thirteen are used by municipal utilities, six are used by schools, three are used by subdivisions, two are used by mobile home parks, and one is used by a state park (table 25).

Public supply water use in the Lake Michigan Region was more than 32 billion gallons or almost 3 percent of total withdrawals in the Region during 1990. The high withdrawal facilities are used primarily for municipal supplies (table 25).

The municipalities of St. John in Lake County and Valparaiso in Porter County are both located partly in the Lake Michigan Region. However, public water supplies for both municipalities are obtained from well fields that are located entirely in the Kankakee River Basin (Indiana Department of Natural Resources, 1990a).

Table 24. Projected annual water use for industry and public supply

Category	Water use (million gallons)	
	2000	2010
Industry	605,003	550,674
Public Supply	31,773	31,184

Most of the water withdrawn in the Lake Michigan Region for public supply purposes was derived from Lake Michigan. Many of the large communities in the northern and central parts of the Region are served by public-supply utilities that withdraw water from Lake

Table 25. Public water supply facilities and type of water use during 1990

County	Facility name	Type	Pump Capability (mg)	Water use (mg)
LAKE	Crown Point	Municipality	2922.3	747.0
	Dyer Water Dept.	Municipality	1232.5	360.0
	East Chicago Water Dept.	Municipality	10219.8	5112.3
	Gary Hobart Water Corp.	Municipality	18980.0	10206.9
	Hammond Water Works	Municipality	18249.9	11172.6
	Independence Hill Water Corp.	Municipality	37.3	11.2
	Lake Station	Municipality	578.2	311.0
	Schererville	Municipality	315.4	3.0
LAPORTE	J.B. Waterworks Inc.	Subdivision	88.3	12.5
	Long Beach Water Dept.	Municipality	657.0	73.3
	Michigan City Dept. Water Works	Municipality	11037.6	2661.9
	New Prairie School Corp.	School	42.0	1.1
	Jean Strachan	Subdivision	63.1	2.0
PORTER	Burns Harbor Estates	Subdivision	131.4	13.9
	Chesterton Utilities	Municipality	1314.0	380.7
	DNR-Dunes	Park	394.2	7.8
	Duneland School Corp.[4]	School	393.1	8.5
	Elmwood Mobile Home Park	Mobile home	72.0	18.4
	Evergreen Mobile Home Park	Mobile home	42.0	1.0
	Gary Hobart Water Corp.	Municipality	8760.2	999.9
	South Haven Water Works	Municipality	1674.0	368.7
	Union Township School Corp	School	126.1	0.4
IN-BASIN			77330.4	32474.1

[4] Four facilities

Michigan. However, the towns of Crown Point, Dyer, Lake Station and Schererville in Lake County and small communities scattered throughout the interior parts of the region use ground-water sources for public water supplies.

Water withdrawals for public supply in the Lake Michigan Region do not vary considerably during the year (figure 69). However, peak water use occurs during the summer months.

According to a Division of Water analysis, total and per capita water use increases with municipal population growth. Per capita use may be higher for municipalities with many industries than for municipalities of comparable size with a small industrial base.

During the 1990s, water withdrawals by public supply facilities are expected to decrease slightly in the Lake Michigan Region, roughly paralleling the anticipated decline in population (figure 5, appendix 1). Water use projections for public supply are presented in table 24.

Agricultural

Agricultural water use, formerly referred to as irrigation water use by the Divison of Water, include withdrawals for agricultural irrigation, golf course irrigation, field drainage and agricultural service purposes. Of the 20 registered facilities in the Lake Michigan Region grouped under the agriculture category, 12 are primarily used for golf irrigation, and eight are mainly used for agricultural irrigation.

In 1990, agricultural water use was about 368 million gallons or 0.03 percent of the total water use in the Region. About 94 percent of the withdrawals for agricultural purposes were used by golf courses, and the remaining 6 percent were used by farms for agricultural irrigation. Withdrawals by the Griffith Golf Center, which constituted about 58 percent of the agricultural water use in the Region, were not only used for golf course irrigation, but also for field drainage, and drinking and sanitary purposes.

Peak withdrawals for agricultural purposes usually occur during the irrigation season of late spring and summer. However, field drainage of severely flooded areas during November and December of 1990 greatly affected total agricultural water use in the Lake Michigan Region.

Withdrawals from surface water sources comprise about 85 percent of agricultural water use in the Lake Michigan Region. Of the twenty facilities that were registered in 1990, eight facilities withdrew surface water only, seven withdrew both surface water and ground water, and five withdrew ground water only.

Agricultural water use demand is not expected to increase significantly within the next decade.

Miscellaneous

Miscellaneous water use refers to withdrawals for fire protection, fish and wildlife areas, pollution abatement, amusement parks, hydrostatic testing, temporary construction dewatering, dust control and recreational field drainage. In 1990, twelve significant water withdrawal facilities in the Lake Michigan Region were grouped under the miscellaneous category.

Withdrawals for miscellaneous purposes constituted only 0.1 percent of total water use in the Region. More than 99 percent of the 1.26 billion gallons of water withdrawn for miscellaneous purposes was used for construction dewatering. There were minor withdrawals for snow making and recreational purposes in the Region. Miscellaneous water use did not vary considerably in the Lake Michigan Region during 1990 (figure 69).

Little or no increase in miscellaneous water use is expected within the next 10 years.

Non-registered use categories

Domestic self-supplied

Domestic self-supplied water use refers to residential water users who obtain water from private wells rather than from public supply systems. An estimated 85,810 residents or 14 percent of the population of the Lake Michigan Region have domestic wells. As stated previously, the Division of Water categorizes withdrawals by commercial or institutional organizations as public supply uses rather than as domestic self-supplied or commercial uses.

Estimated domestic withdrawals in 1990 (2.4 billion gallons) constituted about 0.2 percent of total water use in the Region. Estimates of withdrawals by county were obtained by multiplying the approximated self-supplied population within the portion of each county in the Region by an estimated per capita usage of 76.46 gallons per day (Indiana Department of Natural

Resources, 1982[a]).

Domestic self-supplied water uses for the next 10 years in the Lake Michigan Region are expected to decline, primarily because of projected decreases in population.

Instream uses

Instream uses are defined as non-withdrawal uses taking place within a stream, lake or reservoir. The primary instream uses in the Lake Michigan Region include commercial navigation, commercial fishing, recreation activities, fish and wildlife habitat, and waste assimilation.

Commercial navigation in the Lake Michigan Region plays an integral part in the regional and statewide economy. The harbors along the southern coast of Lake Michigan, which connect northwest Indiana to the St. Lawrence River waterway, are expected to continue handling both midwestern and global cargo.

Water-related recreation needs in the 1990s will depend on user demand, the availability of facilities, and a variety of demographic and socioeconomic factors. Estimates of recreational use demand were made for Lake, Porter, and LaPorte Counties (table 26) based on a survey sample of 278 residents.

The estimates are considered conservative since they were based on the number of respondents who participated in each activity at least once in the past 12 months. The estimates do not imply that all participants use waters in the Lake Michigan Region exclusively as the location of their activity. However, approximately 93 percent of the residents did participate in the activities within their region. In addition, the estimates do not account for visitors from outside the three-county area.

Future recreation needs in the Lake Michigan Region may differ from present needs, but predictions for water-based recreation demand are difficult to make. The change in the age distribution of the Region's population may affect the demand for recreational opportunities; however, although the general population is aging, the trend for older adults is to remain active rather than "slowing down" as was once the norm. In addition, little or no growth in the population is predicted for the Region in the near future. It is unclear how this trend will affect recreation demand.

A number of initiatives which have been taken to stimulate regional economic diversity may influence future water-based recreation demand. A shift toward a tourism and recreation-based economy is seen by locals as an answer to steel-industry downsizing in the Region. Marina development, river-boat gaming casinos, and greater public access could all represent a significant change in Lake Michigan shoreline use. Development of a Coastal Zone Management Program may also enhance recreational opportunities in the coastal zone. In addition, planned improvements to water quality in the lakes, rivers and streams of the Region could also have a positive affect on recreational demand.

Summaries of Region fisheries and wastewater treatment were presented in the **Surface-Water Hydrology** chapter of this report under the subheading **Surface-Water Quality**. The future quality of basin fisheries will depend largely on the water quality and presence of suitable habitat, the availability of sufficient stream flow, stocking activities by the IDNR, and fishing demand. Factors that will help maintain or improve surface-water quality in future years include control of nonpoint-source pollution, upgrading wastewater treatment facilities, improvement in both treatment-plant operations and compliance with discharge limits. Detailed information on wastewater-management plans is available from the Indiana Department of Environmental Management.

Table 26. Estimated recreation participation by local residents of the region

{Data from Indiana Department of Natural Resources}

Activity	Number of participants
Fishing	231,737
Swimming	282,027
Powerboating	78,571
Sailing	20,161
Waterskiing	46,314
Canoeing	26,209
Ice skating	24,193
Rowing	22,177
Jetskiing	20,161
Total	**751,550**
Other activities (enhanced by water)	971,021

The conservation of wetland wildlife habitat was discussed in the **Surface-Water Hydrology** chapter of this report under the subheading **Wetland Protection Programs**. Compliance with existing regulations, implementation of existing programs, and establishment of additional programs will help to ensure the future conservation of wetland and riparian habitats.

SURFACE-WATER DEVELOPMENT

Sources of surface water in the Lake Michigan Region include wetlands and lakes, Lake Michigan, and streams and ditches. Development of the potential sources of surface water depends not only upon the physical availability of water but also upon political and legal constraints.

Lake Michigan

Lake Michigan is by far the major source of surface-water withdrawal use in the Region, accounting for approximately 99 percent of total water withdrawals. In recent years there have been numerous suggestions for using water from Lake Michigan and other Great Lakes as a supply for other regions, especially portions of the western United States. For example, one plan proposed using water from Lake Michigan for the High Plains. Another proposal called for diverting water by pipeline from Lake Superior to the Missouri River, while yet another would have sent water to Wyoming for use in a coal slurry pipeline. Lake Ontario water was also to be diverted for New York City (Bixby, 1986).

Although Lake Michigan and the Great Lakes appear to be a limitless supply of water, the Lakes have a finite capacity. Under present climatic conditions, precipitation accounts for only 1.5 percent of the storage volume of the Great Lakes System (Bixby, 1986). The remaining volume of water accumulated in the past during wetter climatic conditions. Therefore, the long-term supply potential of the Great Lakes System is approximately 1.5 percent of the Great Lakes low-water datum volume, or approximately 90 trillion gallons.

Limitations on use

Various artificial changes such as diversions, consumptive uses, channel modifications, and construction of control structures to manage lake levels have the potential to affect Lake Michigan and the Great Lakes. Changes such as these have occurred in the last century and have become the subject of investigations by the International Joint Commission's (IJC) International Great Lakes Levels Board (1973 and 1993), and the Diversions and Consumptive Uses Study Board (1981).

Diversions

A diversion is a man-made transfer of water outside the basin or from one Great Lake to another. There are presently five major diversions of Great Lakes water. These diversions are regulated by control structures which change the natural water supply to the lakes or bypass a natural outlet. Two of the diversions raise water levels of the Great Lakes by minor amounts by diverting some of the tributary flow of the Hudson Bay southward into Lake Superior. Two interbasinal diversions have no overall effect on the Great Lakes-St. Lawrence River system, except to lower water levels of Lakes Erie and Michigan-Huron due to one of the diversions. The remaining diversion at Chicago, which diverts Great Lakes water through the Sanitary and Ship Canal to the Mississippi River, lowers water levels of the Great Lakes by minor amounts (See box on next page for additional details on the Chicago Diversion).

Both the diversion and control modifications affect the lake levels in terms of inches rather than feet and do not, therefore, constitute major factors in the natural system (International Joint Commission, 1989).

Consumptive use

Consumptive use is water that is withdrawn and not returned to the Great Lakes. It was estimated in the Great Lakes Basin Framework Study in 1975 that total consumptive use for the Great Lakes Basin was 4900 cfs (3.2 billion gpd) (Bixby, 1986). The estimate included water taken directly from the lakes and also from inland sources such as tributary streams and ground water. Approximately 71 percent of the consumptive use was a result of direct withdrawal from the lakes. The three largest consumptive uses in the Great Lakes Basin were manufacturing, municipal supply, and energy production at 50, 17, and 10 percent,

Lake Michigan Diversion at Chicago

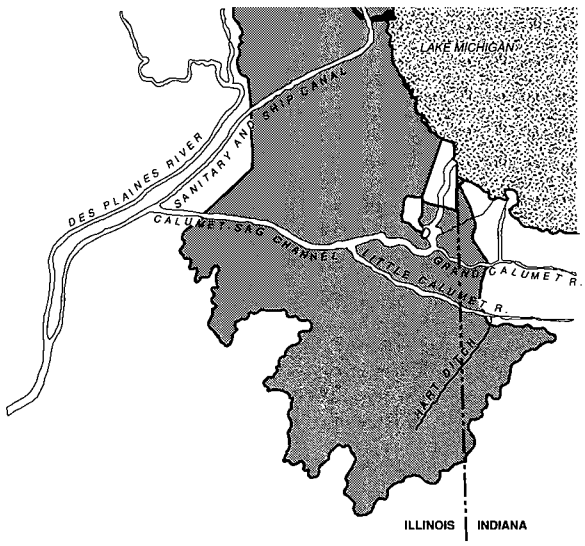
Water supplies for the City of Chicago and other communities in the Metropolitan Sanitary District of Greater Chicago come from Lake Michigan. After the water is used, however, the wastewater treatment plants divert the water to the Illinois River via the Chicago Sanitary and Ship Canal. This process which involves the diversion of water from the Lake Michigan Basin to the Mississippi River Basin is referred to as the Chicago Diversion.

The Chicago Diversion also includes water which is diverted directly into the Illinois waterway system to meet navigation and sanitary requirements and stormwater runoff from the Lake Michigan watershed that was formerly tributary to the Lake. In addition, Lake Michigan water that is used by a number of communities in Indiana is also diverted via wastewater treatment plants into the Little Calumet and Grand Calumet Rivers and eventually ends up in the Mississippi River Basin (see accompanying map).

In the late 1800s, an ambitious program was undertaken to reverse the flow of the Chicago and Calumet Rivers away from Lake Michigan, thus carrying the sewage from the City of Chicago away from its water-supply source. This monumental construction project was necessary to avoid epidemics of waterborne diseases like the outbreak of typhoid and cholera in 1885 which killed 90,000 people. In addition to the sanitary benefit, the project also created a navigation corridor between the Mississippi River system and the Great Lakes.

Water diversion from Lake Michigan into the Mississippi River Basin at Chicago initially began in 1848 upon completion of the Illinois and Michigan Canal. The current diversion by the State of Illinois began in 1900 with the completion of the Sanitary and Ship Canal by the Metropolitan Sanitary District of Greater Chicago.

The reversal of the Chicago River initially took place in 1900 under a permit obtained from the Secretary of War. Litigation resulted and has continued off and on since 1922. The Supreme Court issued decrees regarding the diversion in 1925, 1930, and in 1967.



Illinois presently operates under the 1967 Supreme Court decree which was amended in 1980. This decree allows Illinois to divert 3200 cfs on an annual basis averaged over a 40-year period. A 5-year accounting period can be allowed to compute this average, but the diversion may not exceed 110 percent of the authorized limit for any one-year period (Great Lakes Basin Commission, 1975c).

respectively (International Great Lakes Diversions and Consumptive Uses Study Board, 1981b).

In the same study, Lake Michigan consumptive use was estimated to be 1530 cfs (approximately 1 billion gpd) or nearly 31 percent of the total use in the Great Lakes Basin. Approximately 67 percent of Lake Michigan consumptive use was attributed to direct withdrawal from the lake. The three largest consumptive uses in the Lake Michigan Basin were also manufacturing, municipal supply, and power production at 51, 12, and 11 percent, respectively.

A more recent estimate of total consumptive use in the basin by Environment Canada (1993) of 4943 cfs shows little change from the 1975 estimate. Because there has been a decline in manufacturing use, percentages of total use by category have probably shifted.

The amount of consumptive use increases progressively through the Great Lakes System. Thus, the effect on water levels is least on Lake Superior, and greatest on Lake Ontario.

In 1985, the International Joint Commission (IJC) predicted that consumptive use by the Great Lakes states and provinces will increase to 8400 cfs by the year 2000. USGS estimates, however, produced a more conservative value of about twice the Chicago Diversion or 6400 cfs (Bixby, 1986).

Impact of diversions and consumptive use on the Great Lakes water

Consumptive use and diversions of water from the Great Lakes Basin have the potential to lower lake levels and produce undesirable effects. Lower lake levels reduce power-generating capacity of hydroelectric plants sited on the lakes; affect vegetation, wetlands, and fish and wildlife populations; and affect recreational boating facilities. Lower water levels of only a few inches can also reduce loading potential of cargo ships and necessitate costly dredging. Disposal of dredge spoil is another potential problem because contamination exists in some nearshore areas. In addi-

Destination of streamflow in the Region

The streams in the Lake Michigan Region may flow from Indiana into Lake Michigan or into the states of Michigan or Illinois. Of the 604 square miles of drainage area within the Region, 81 percent or 489 square miles drain directly into Lake Michigan, and 19 percent or 115 square miles drain into Illinois or Michigan. Most of the stream flow that enters the state of Michigan from the Region eventually flows into Lake Michigan. Little of the stream flow into Illinois, however, is returned to Lake Michigan, but is instead diverted to the Mississippi River. See box on Chicago Diversion for additional details.

Part of the Little Calumet River drains into Lake Michigan and part into Illinois. Stream-flow direction is influenced by a hydraulic divide between Hart Ditch and Deep River and flow conditions in the streams. West of the divide, Little Calumet water generally flows west into Illinois to the Illinois River and eventually to the Mississippi Basin. East of the divide, water in the river flows east into Lake Michigan via Burns Waterway in Porter County.

During flood flows, however, the flow in Hart Ditch and Deep River is split, part flowing east and part west (USACE, 1982). The westward overflow of Deep River floodwater is temporarily stored in a subbasin and returned eastward toward Lake Michigan when flood flows subside.

The Grand Calumet River system also has a hydraulic divide which is located near Columbia Avenue in Hammond. West of Columbia Avenue, the river flows to the west. East of Columbia Avenue, the river flows east or west depending on water level of Lake Michigan, effluent flow, and the influence of wind direction and velocity (Crawford and Wangsness, 1987).

Flow and discharge in the Grand Calumet River are difficult to determine and a regression equation has been developed to estimate flow entering Illinois from Indiana via the Grand Calumet River (Northeastern Illinois Planning Commission, 1985). The equation relates Grand Calumet flow entering Illinois from Indiana to water levels of Lake Michigan and flows from the Hart Ditch gaging station.

Numerous studies have been conducted to determine discharge and flow direction of the western portions of the Little Calumet and Grand Calumet Rivers. Recently, three stream gaging stations were installed by the USGS and IDEM to better define flow and discharge relationships of the Grand Calumet River and Lake Michigan. A description of the gaging stations may be found in the Chapter entitled **Surface-Water Hydrology**.

The contributing drainage area and ultimate destination of water from Wolf Lake are also difficult to determine. Flow direction of water from Wolf Lake is toward Illinois, but the flow direction of the Calumet River near the area of discharge for Wolf Lake appears to be toward the south. Hence, Wolf Lake water would drain to the Mississippi River drainage basin.

Additional details on various aspects of surface-water hydrology may be found by consulting numerous publications listed in the **Selected References** Section of this report.

Drainage destination	Drainage Area (sq mi)
Little Calumet River into Lake Michigan	331
Little Calumet River into state of Illinois[1]	56.6
Drainage into state of Michigan	56.6
Trail Creek and other streams directly into Lake Michigan	93.2
Grand Calumet River and adjoining drainage into Lake Michigan[2]	65
Thorn Creek into Illinois	1.9
Total	604

[1] Indiana portion only- Plum Creek, with a drainage area of 34.1 sq mi, drains from Illinois into Indiana near Dyer

[2] Includes drainage into Wolf Lake which flows to Illinois

tion, existing pollution problems in the lakes are increased by a reduction in dilution potential. However, there can be benefits from lower lake levels such as the reduction of erosion and flood damage.

Legal and political constraints

Present political and legal constraints limit diversion and consumptive use of water from the Great Lakes including Lake Michigan.

Concerns that diversion and consumptive use of Great Lakes water might cause adverse effects on the Great Lakes economy led to the development of a charter calling for management of the Great Lakes basin as one system. The Great Lakes Charter was signed by the governors and premiers of the Great Lakes states and Canadian provinces. It requires that any state or province that is considering approval of a new or increased diversion or consumptive use of Great Lakes water exceeding 5 million gallons per day in any 30-day period notify and consult with the governors and premiers of the other Great Lakes states and provinces.

In addition, a law was passed by the U.S. Congress in 1986. The law requires that any new or increased diversions of Great Lakes water be approved by all of the governors of the Great Lakes states.

Wetlands and lakes

Although some withdrawals occur along wetlands and lakes in the Region, these systems are not considered as probable major water-supply sources because of their limited storage capacity, water-quality considerations and regulatory, economic and environmental constraints (See discussion in **Surface-Water Hydrology, Surface-Water Development Potential** section).

Streams

The largest water withdrawals from streams come from the Grand Calumet and Little Calumet Rivers. Hart Ditch, Deep River and Trail Creek also have a few large-capacity withdrawal facilities. The largest volumes of water withdrawn from streams in the Lake Michigan Region are used for industrial processing and golf-course irrigation.

Stream rights

The impacts of withdrawal uses on stream flows must be considered to determine how the potential for water-use conflicts can be minimized, particularly during a drought. Historically, water users have developed the most readily available source of supply without consideration of the effects of such development on other uses, particularly instream uses. Constraints on water use in a particular location may result from its competing value for various instream and withdrawal uses.

Indiana has long recognized the "riparian rights doctrine". Riparian rights are based on ownership of land abutting a watercourse. Indiana has adopted a modified reasonable-use policy in which each riparian landowner's right to use water from the watercourse is limited to uses that are reasonable under the circumstances. The person who asserts the unreasonableness of the use has the burden of proof.

Withdrawal rights are considered as private rights arising out of land ownership. Instream-use rights, unlike withdrawal rights, may exist both for private individuals and public entities; however, public rights are not held to be paramount to every conflicting private riparian right or public activity. Resolution of conflicting interests as well as statutory expansion of public rights, are influenced by the state's economic interests.

Under Indiana law (I.C. 13-2-4-9), a permit is required for many facilities which withdraw water from a navigable waterway. The navigable river program is administered by the IDNR Division of Water. In the Lake Michigan Region, Lake Michigan and its extensions into Trail Creek (1 mi.), Burns Waterway Harbor (1.3 mi.), and Indiana Harbor have been designated as navigable. The Indiana Harbor Canal, including Calumet River Branch and George Lake Branch, are also considered navigable from the Indiana Harbor to the Grand Calumet River. In addition, the Grand Calumet River has been designated navigable from the Illinois State Line to Marquette Park. The Little Calumet River is also designated navigable from the Indiana-Illinois State Line to Burns Waterway Harbor and navigable for an additional 17.75 river miles to its junction at Kemper Ditch with Interstate 94.

Under the navigable rivers law, permit applications are evaluated for potential impacts on navigability, the environment, and safety of life and property at the withdrawal site. Although the permitting program is directly relevant to water-resource management, it has a number of shortcomings. First, the program is limited in scope because it applies only to navigable rivers and excludes public water-supply utilities. Second, the law is difficult to enforce because no administrative rules have been promulgated. Finally, the program's effectiveness is limited because no defined criteria exist for evaluating the effects of proposed withdrawals.

The existing Indiana stream program does not adequately provide certainty of rights to use, mitigation or resolution of conflicts over withdrawal and conveyance of water from its source, impacts of such withdrawals on other uses and interests, or over competing or conflicting uses. At present, there is no procedure, other than through the courts, by which questions of use may be resolved on a timely basis.

Because of such limitations in existing programs, additional steps may be needed to help protect streams in localized areas. The Natural Resources Commission may establish criteria for determination of minimum streamflow (I.C. 13-2-6.1). If established, the mini-

mum stream-flow criteria may govern the amount of water withdrawn from streams in some areas.

In an ongoing effort to establish a sound framework for administrative and statutory decisions, the Division of Water has contracted researchers to examine technical issues related to surface-water withdrawals. In one study (Delleur and others, 1988), investigators examined the ability of a variety of statistical models to reliably and accurately forecast low flows and assess the severity of a given low flow. The study further explored design flows for waste assimilation.

Another study (Delleur and others, 1990) expanded on the first study by evaluating how much stream flow should be protected from withdrawal in order to provide for instream needs such as fish habitat, waste assimilation, and recreation. This study examined 25 stream gage sites in Indiana, including two sites in the Lake Michigan Region; namely, Trail Creek at Michigan City and Little Calumet River at Porter. The study also suggested a general minimum flow criteria to be applied at a site when a detailed study is not warranted.

Surface-water supply in the Region generally exceeds demand. Although localized or short-term water-quantity conflicts may have occurred among water users, the greatest conflicts in the Lake Michigan Region have been related to water-quality issues. Refer to the chapter on **Surface-Water Hydrology, Supply potential of streams**, for discussion on specific streams.

GROUND-WATER DEVELOPMENT

Ground-water resource availability of the Lake Michigan Region is considered fair to moderate when compared with the rest of the state. Development of ground water in the coastal region has been somewhat limited, due primarily to the proximity of Lake Michigan's vast water resource. Ground-water withdrawals in the interior portion of the Region are used primarily for public and domestic drinking water supplies. Whereas, ground water withdrawals near the coast are used primarily for industrial purposes. The largest ground-water withdrawal in the Lake Michigan Region is used to recover petroleum product.

Ground-water rights

Historically, under Indiana's "common law" approach to water rights issues, a ground-water user was not held liable for damages to surrounding landowners if his use of ground water was reasonable and beneficial, and was not done maliciously or gratuitously. Conflicts involving ground-water supply and demand were handled on a case-by case basis, and often were resolved by court decisions.

In 1982, a new law (I.C. 13-2-2.5) was enacted to provide protection for individuals in Jasper and Newton Counties whose domestic or livestock wells were being adversely affected by declines in ground-water levels caused by nearby high-capacity withdrawals. Under the provisions of this law, the owner of a high-capacity ground-water withdrawal facility (capable of pumping at least 100,000 gallons per day) can be liable for impacts on adjacent domestic wells if high-capacity pumpage has substantially lowered ground-water levels in the area, subsequently causing the domestic wells to fail. In order to have protection under the statute, affected domestic or livestock wells had to meet minimum well-construction standards established by the IDNR. Because ground-water availability conflicts were occurring elsewhere in Indiana, the law was amended on September 1, 1985 to provide protection for small-capacity well owners throughout the state.

Ground-water quantity conflicts have not been a primary issue for the Lake Michigan Region. From September 1, 1985, when the Emergency Regulation statute became effective, to December, 1994, the Water Rights Section of the IDNR, Division of Water has conducted ten investigations in the Lake Michigan Region. Most investigations were made to collect "baseline" ground-water level data as a result of concerns expressed by domestic well owners about nearby high-capacity pumpage for agricultural irrigation, construction dewatering, municipalities, and industry. However, two of the ten investigations resulted in documentation that a dewatering operation for mineral extraction and another for construction purposes had impacted domestic wells, and "timely and reasonable compensation" was provided to the homeowners under the provisions of IC 13-2-2.5.