

The potential for urban and economic development partially depends on the availability of adequate supplies of surface water and ground water. Surface-water withdrawals are expected to remain high in the Fort Wayne area along the St. Joseph River. Ground-water withdrawals are expected to remain high in much of Allen and DeKalb Counties.

As water demands in the basin continue to grow, it will be necessary to develop additional surface-water and ground-water supplies, protect the quantity and quality of existing supplies, and increase efficiency of water use.

WATER USE AND PROJECTIONS

The total demand for water in the Maumee River basin is expected to increase in future decades, particularly in the Fort Wayne area, as the population and economy continue to grow. Annual water withdrawals for the major water-use categories were projected through 2000 and 2010 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 capability 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It should be emphasized that the term ‘water use’ in this report refers both to total amount of water withdrawn from available sources and to the intended purpose of the withdrawal.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 unavailable 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The portion of the withdrawn water that is consumed varies with the intended purpose of the withdrawal.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 Water withdrawn for purposes that have low consumption rates is returned to surface-water or ground-water systems within a short period of time, thus creating less potential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 1993, total combined withdrawals by the facilities in the basin were about 24 percent of the total withdrawal capability (figure 66).

Water is also withdrawn and used by non-registered facilities. Non-registered facilities include domestic wells, livestock operations, and other facilities capable of withdrawing less than 100,000 gallons of water per day.

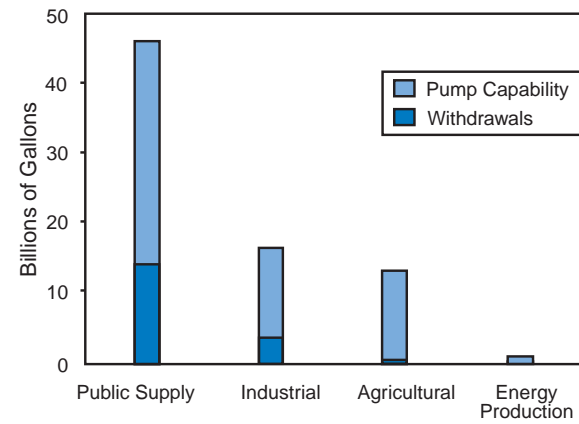
Basin overview

Total annual water withdrawal use in the Maumee River basin is estimated to be approximately 22.9 billion gallons (BG). Water used by registered facilities comprise approximately 18.7 BG or 82 percent of the total (table 25).

A total of 111 significant water-withdrawal facilities, representing 49 surface-water intakes and 190 wells, were registered in the Maumee River basin in 1993. Figure 67 displays the locations of the facilities; and table 25 summarizes the facilities by category, source, capability, and use. Registered water withdrawal facilities in the Maumee River basin had a combined surface- and ground-water withdrawal capability of about 77,479 million gallons (MG) for the year or 212 million gallons per day (MGD).

Although surface-water facilities represent only about one-fourth of the total number of registered

Figure 66. Registered withdrawal capability and reported water use (1993)



facilities in the basin, surface water accounts for approximately 79 percent of the water withdrawals.

Most of the water withdrawals in 1993 were for

public supply and industrial purposes, approximately 76 and 20 percent, respectively (figure 66). Water withdrawals for agriculture and energy comprised the remaining four percent. There were no registered facilities grouped under the rural or miscellaneous category.

The total water uses for any non-registered facility is fairly small, but the aggregate demand for domestic self-supply and livestock watering purposes is notable, nearly 4.2 BG or approximately 18 percent of the total water use in the basin. Ground water is the primary source of water for non-registered users.

Registered facilities

As figure 67 shows, most of the registered facilities in the basin, approximately 82 percent, are located in Allen County. The city of Fort Wayne alone has about 62 percent of the total water withdrawals in the basin. Appendix 17 summarizes water use in the basin by county.

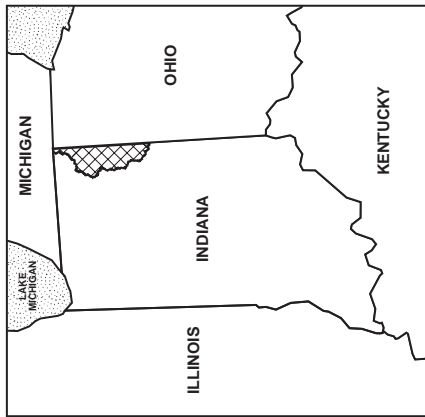
Table 25. Summary of registered water use during 1993

Registered Capability: Maximum pump capability of the registered facilities

Withdrawals: Water-use by registered facilities

Capability Development: Water-use as a percentage of the maximum pump capability of the registered facilities

Water Use Category	Registered Facilities (number)	Withdrawal Source	Withdrawal Points (number)	Registered Capacity (MG)	Withdrawals (MG)	Capability Development (%)
Public Supply	34	combined	92	46613.2	14306.1	30.7
		surface	2	30295.0	11667.5	38.5
		ground	90	16318.2	2638.6	16.2
Industrial	36	combined	72	16726.2	3658.6	21.9
		surface	16	9996.9	2902.6	29.0
		ground	56	6729.3	756.0	11.2
Agricultural	36	combined	67	13164.2	488.8	3.7
		surface	30	7905.0	126.1	1.6
		ground	37	5259.2	362.7	6.9
Energy Production	5	combined	8	975.0	254.3	26.1
		surface	1	170.8	117.6	68.9
		ground	7	804.2	136.7	17.0
TOTAL	111	combined	239	77478.6	18707.8	24.1
		surface	49	48367.7	14813.8	30.6
		ground	190	29110.9	3894.0	13.4



STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER
MAUMEE RIVER BASIN

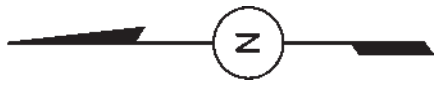
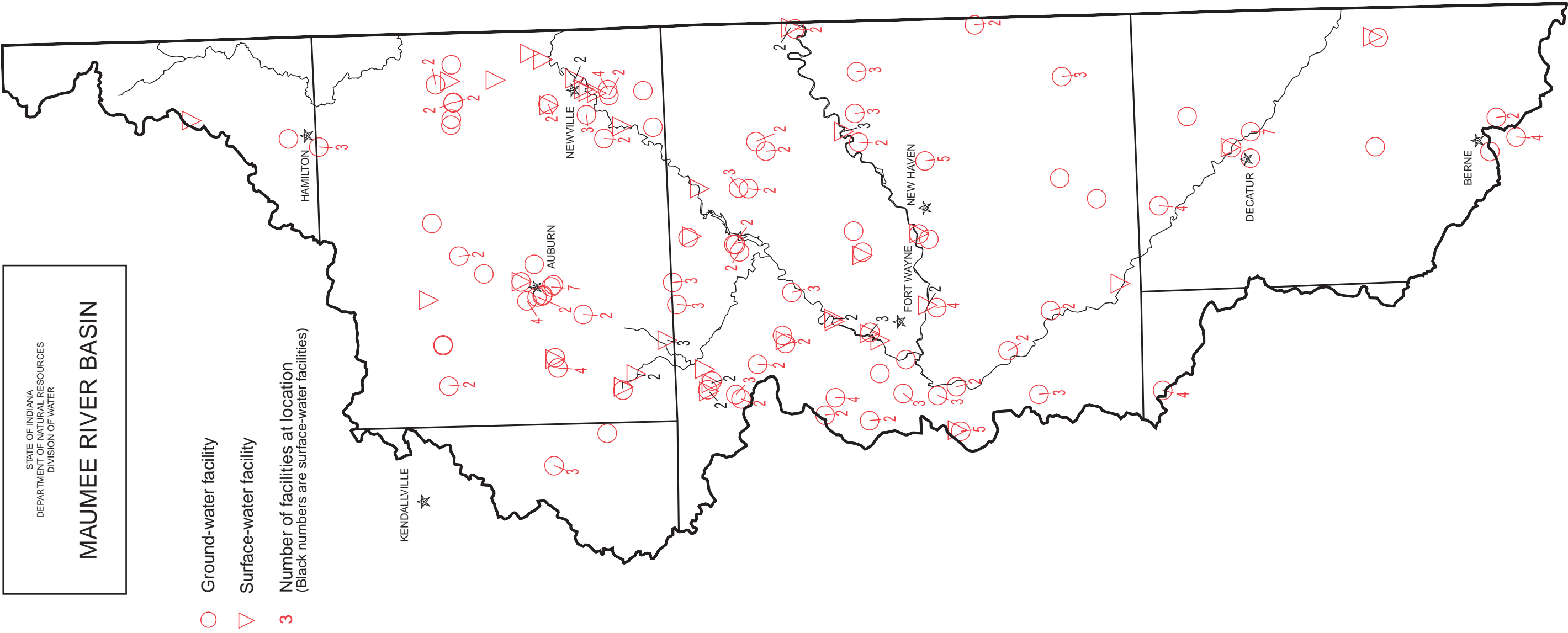


Figure 67. Location of registered water withdrawal facilities

Public supply

The public supply category includes the water that is withdrawn by public and private water suppliers and 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. This categorization system differs from systems used by some states and organizations, in which most of the latter water-use types generally are considered as either domestic self-supplied or commercial uses.

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 having many industries than for municipalities of comparable size having a small industrial base.

In 1993, registered public supply facilities withdrew a total of more than 14.3 BG (table 25) or about 76 percent of total water use in the basin. Peak water use for public supply facilities typically occurs in July and August (figure 68). The primary source of supply is surface water; however, smaller communities scat-

tered throughout the interior parts of the basin use ground water.

Of the 34 registered water withdrawal facilities classified under the Division of Water's public supply category (table 25), 20 are municipal utilities, eight are schools, four are subdivisions, and two are mobile home parks (table 26). Table 26 summarizes by county the 1993 withdrawal capability, population served, and reported use for each of these facilities.

The Fort Wayne Water Utility, having the highest water withdrawal in the basin, withdrew about 11,667 MG of water, or nearly 32 MGD, for public supply during 1993.

Fort Wayne and its water supply

The greater Fort Wayne area population is served primarily by two public water suppliers: Fort Wayne Water Utility which uses surface water and Utility Center, Inc. which uses ground water. Although greater Fort Wayne does not lie entirely within the Maumee River basin, water use for the area must be considered because it has potential for impact on the water resource of the basin.

The municipally-owned Fort Wayne Water Utility serves most of the population of the city of Fort Wayne using surface water from the St. Joseph River,

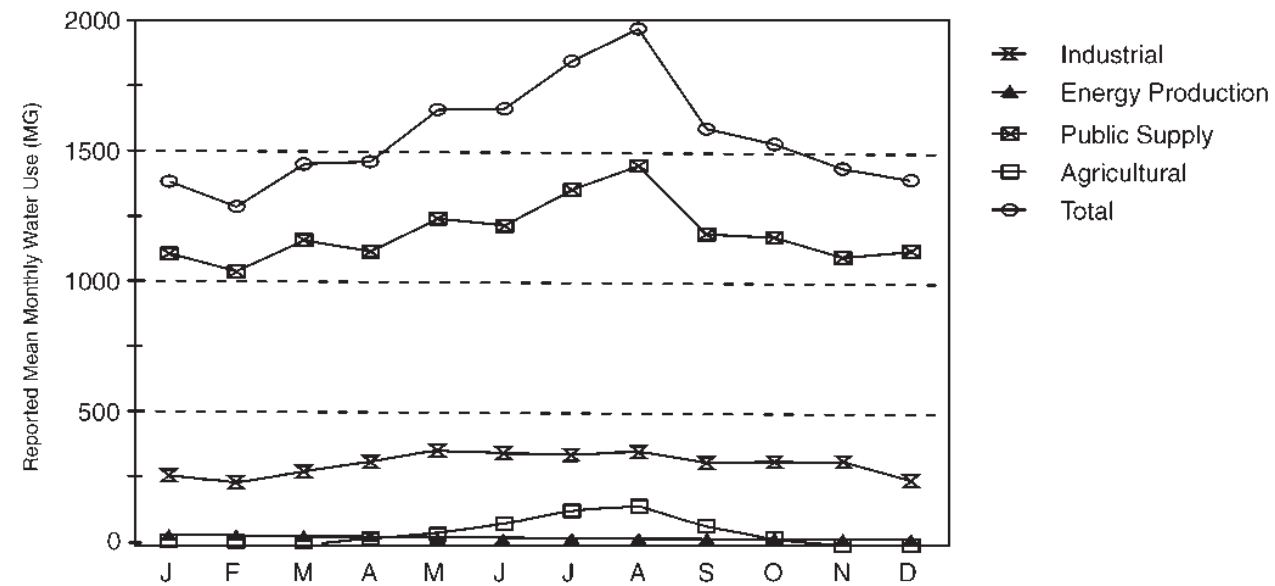


Figure 68. Variation of monthly water use (1993)

Table 26. Public water supply facilities and type of water use during 1993

County	Facility Name	Type	Pump Capability (MG)	Water use (MG)
ADAMS	Berne Water Department	Municipality	1072.2	198.4
	Decatur Water Department	Municipality	2522.9	634.6
	Oak Ridge Estates	Subdivision	131.4	5.2
	Town of Monroe	Municipality	52.6	0.9
ALLEN	City of Woodburn	Municipality	254.4	45.3
	Country Court Estates	Subdivision	131.4	9.0
	East Allen County Schools			
	- Harlan Elementary School	School	76.2	2.3
	- Heritage High School	School	42.0	3.4
	- Hoagland Elementary School	School	44.7	1.9
	- Leo Elementary School	School	44.7	3.2
	- Leo High School	School	107.7	3.7
	- Woodland High School	School	86.7	3.4
	Fort Wayne Water Utility			
	- St. Joe River Intake	Municipality	26280.0	11666.7
	- Hurshtown Reservoir	Municipality	4015.0	0.8
	Harlan Mobile Home Park	Mobilehome	52.6	3.3
	Huntertown Utilities	Municipality	325.9	63.2
	Perry Hill School	School	144.5	2.8
	Pioneer Village Water, Inc.	Subdivision	105.1	1.2
	Town of Grabill	Municipality	241.8	39.1
	Town of Monroeville	Municipality	315.4	31.1
	Utility Center, Inc.			
	- Lake River Water Plant	Municipality	788.4	147.3
- Washington Water Treatment Plant	Municipality	775.3	275.5	
DEKALB	City of Auburn			
	- North Street Treatment Plant	Municipality	1711.4	140.9
	- South Wayne Street Treatment Plant	Municipality	2986.5	521.4
	City of Butler	Municipality	919.8	113.4
	City of Garrett	Municipality	1261.4	185.6
	DeKalb County Central United School	School	13.1	0.02
	Hamilton Water Department	Municipality	341.6	62.5
	Kruse International	Subdivision	105.1	0.0042
	St. Joe Water Works	Municipality	162.9	18.6
	Town of Corunna	Municipality	210.2	0.9
	Town of Waterloo	Municipality	336.4	62.5
NOBLE	Town of Avilla	Municipality	882.9	53.1
WELLS	Kozy Kourt, Inc.	Mobilehome	71.0	4.9
	Total		46613.2	14306.1

Cedarville Reservoir, and Hurshtown off-channel reservoir (see **Surface-water hydrology** sidebar entitled, **Upland reservoirs/side channel reservoirs**). Although the St. Joseph River intake has the capability to withdraw approximately 72 MGD, the unregulated flow system does not always provide that quantity of water (see chapter on **Surface-water hydrology, supply potential of streams** section). During peak water-demand periods, water is released from the Cedarville Reservoir to augment streamflow at the Fort Wayne public water supply intake on the St. Joseph River. The original storage capacity of Cedarville Reservoir was 694 million gallons, but the reservoir is losing storage capacity at an average of 3.75 million gallons per year due to sedimentation. For drought years, the Hurshtown Reservoir provides a backup supply of 1.885 billion gallons of raw water and has a total pumping capacity of 11 MGD.

An analysis was made of the St. Joseph River/Cedarville Reservoir system to determine the dependable yield at the public supply intake on the St. Joseph River. Because the system serves as a public water supply, a dependability level of 98 percent was selected to model for a 50-year planning period (see detailed discussion **Surface-water hydrology, reservoirs**). A ‘critical yield’ draft of 34.6 MGD was modeled because that level of demand occurred during 1988, one of the driest years in recent times.

Because precipitation in the southern part of the basin was below normal in 1994 and 1995 (see figure 51), water use was 34.1 MGD and 33.7 MGD, respectively. Such demands are approaching the ‘critical yield’.

Of the three scenarios modeled for minimum flow requirements downstream of the public supply intake, we have chosen the “compromise yield” for purposes of this discussion. The “compromise yield” provides equal consideration for withdrawal and instream flow needs during times of water shortage. Assuming that the compromise instream flow values are adhered to, the dependable yield from the St. Joseph River/Cedarville Reservoir System is 21.8 MGD for the 50-year planning period. Combined with the yield from Hurshtown Reservoir (11.0 MGD), a dependable yield of 32.8 MGD may be attained. Such a yield would be barely enough to satisfy the critical demand of 34.6 MGD at the intake. However, it should be noted that the analyses may be somewhat conservative because the sediment pool (dead storage) of Cedarville Reservoir is assumed to be full when the

critical drought occurs. Whether the annual sedimentation rates increase or decrease depends on changes in land use and measures taken to minimize erosion in the watershed.

It is important to note that the critical yield modeled is based on demands of the existing population during dry periods and assumes no growth in demand related to population growth.

The Utility Center, Inc., a ground-water supply, serves customers on the outer fringes of Fort Wayne, especially to the west and northwest. The ground water used by this utility comes from the Silurian-Devonian Carbonate aquifer. It is difficult to predict the amount of dependable yield for the Silurian-Devonian Carbonate system because it is dependent on fractures and solution features (see **Ground-water hydrology** sidebar entitled **Ground-water flow and dissolution of carbonate rocks**). The area served by this public water supply facility is the most rapidly-growing sector of the greater Fort Wayne area. Additional discussion about this population growth, increasing water use, and pumping effects on the Silurian-Devonian Carbonate Aquifer appears in this chapter under the heading **Impacts of ground-water withdrawal**.

The population in the basin is growing, especially in the Fort Wayne area (see chapter entitled **Socioeconomic Setting, population** section). During the 2000s, water withdrawals by public supply facilities are expected to increase in the basin due to the anticipated population growth. Water use projections for public supply are presented in table 27. Another population trend which may also have potential impact on the water resource in the basin is the change in population density from many sectors of the city of Fort Wayne to its outer fringes, especially west and north. It is difficult at this point in time to predict how this shifting population will affect the resource balance in the area. In general, there is an increasing trend of dependence on ground water for public supply.

If current trends in population and economic growth continue, wise management of the area’s water resource might entail conjunctive use strategies, additional storage, and/or conservation techniques. Many modern utilities are examining the concept of conjunctive use of surface and ground water to enhance the overall capability of an area’s water resource. Additional storage capacity might be achieved by using large limestone quarries in the Fort Wayne area.

Table 27. Projected annual water use for public supply in basin

County	Population served 2000	Water use(MG) 2000	Population served 2010	Water use(MG) 2010
Adams	14,307	905.49	15,629	989.10
Allen	236,039	12,884.01	245,251	13,386.14
DeKalb	27,819	1,164.51	29,251	1,224.38
Noble	1,582	56.00	1,664	58.91
Wells	460	5.30	503	5.80
TOTAL	280,207	15,015.31	292,298	15,664.33

Not only would the quarries provide storage for surface water runoff, they would also provide ground water input.

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. Under the Division of Water’s categorization system, industrial water use includes only the withdrawals that a company develops for itself. If an industry also purchases water from a public supply utility, the amount of water purchased is included in the public supply category.

In 1993, industrial self-supplied water withdrawals totaled almost 3.7 billion gallons, or about 20 percent of the registered water withdrawals in the Maumee River basin (table 25). More than 70 percent of the total industrial water was withdrawn in Allen County. Withdrawals for industrial purposes remained fairly constant throughout the year (figure 68). Of the total amount of water withdrawn for industry, about 79 percent was derived from surface-water sources.

Most of the industrial water withdrawn, nearly 80 percent, was from stone quarries. One quarry alone withdrew more than 50 percent of the total industrial water withdrawals in the basin.

Future industrial water use was projected using two methodologies. For all SIC codes except SIC14 (mining and quarrying), water use was projected using a method described in a report by the Governor’s Water Resource Study Commission (Indiana Department of Natural Resources, Clark ed., 1980). Because the information used for projecting water use for SIC

code 14 is no longer published by the Bureau of Economic Affairs, water use projections for quarrying were made using a methodology described in the Kansas Water Office report (1987).

Future industrial water use in the Maumee River basin is expected to decline in the next 15 years (table 28) because, based on past performance, there will be an increase in water-use efficiency by industries.

Agricultural

Agricultural water use, formerly referred to as irrigation water use by the Division of Water, includes withdrawals for agricultural irrigation, golf course irrigation, field drainage and agricultural service purposes. Of the 36 registered facilities in the Maumee River basin grouped under the agriculture category, 23 are primarily used for golf irrigation, and 13 are mainly used for agricultural irrigation.

In 1993, agricultural water use was about 489 million gallons or less than 3 percent of the total water use in the basin. Approximately 78 percent of the withdrawals for agricultural purposes were used by golf courses, and the remaining 22 percent were used by farms for agricultural irrigation.

Irrigation is a seasonal water use that artificially replaces water in the root zone of doughty soils. Peak water withdrawals for such purposes typically occur during July and August (figure 68). Withdrawals from ground-water sources comprise about 74 percent of irrigation use in the Maumee River basin. Because irrigation water primarily is intended to replace water transpired by the irrigated crop, irrigation withdrawals are treated as a totally consumptive use.

Agricultural water use demand in the Maumee

River basin is not expected to increase significantly within the next decade.

Energy Production

Energy-production water use includes any self-supplied water withdrawals related to the energy production process, such as coal preparation, oil recovery, cooling water, mineral extraction, and power generation.

Energy production in the Maumee River basin comprised only about one percent of total withdrawals during 1993. The five facilities registered in this category withdrew almost 254 million gallons of water. The reported water use for energy production in 1993 was fairly evenly distributed between surface water and ground water (table 25).

Water withdrawals for energy production are expected to increase somewhat during the next decade as the population within the basin continues to grow.

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 132,700 residents or about 38 percent of the population of the Maumee River basin 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 (3.7 BG) constitute about 16 percent of total water use in the basin. The estimated values were obtained by multiplying the approximated self-supplied population within the basin portion of each county by an estimated per capita usage of 76.46 gallons per day (Indiana Department of Natural Resources, 1982a).

Domestic self-supplied water uses in the Maumee River basin for 2010 are expected to increase to approximately 4.1 BG, primarily because of projected increases in population.

Livestock

Livestock water use (table 29) was determined by multiplying the estimated population of a particular livestock category by an estimate of the amount of water consumed daily per animal (Indiana Department of Natural Resources, 1982a). According to these calculations, withdrawals for livestock watering purposes totaled approximately 1.25 MGD in 1992. About 88 percent of the water withdrawn was

Table 28. Major industrial water use (self-supplied) and projections

{All SIC category projections are based on Indiana Department of Natural Resources (Clark, ed., 1980); except SIC14 which is based on Kansas Water Office report, 1987}

SIC Category	Description	Water use in Million Gallons		
		1993	2000	2010
14	Mining & quarrying	2913.64	2855.66	2709.19
20	Food & kindred products	10.60	8.99	6.89
26	Paper & allied products	4.90	3.27	1.73
30	Rubber & misc. plastic products	444.29	406.04	326.02
32	Stone, clay, glass & concrete prdts.	0.07	0.06	0.05
33	Primary metal industries	174.16	176.59	177.66
34	Fabricated metal products	103.77	88.38	64.75
35	Machinery, except electrical	2.36	1.85	1.28
36	Electrical & electronic machinery	0.75	0.57	0.38
TOTAL *		3654.54	3541.41	3287.95

* excluding minor industrial water users

Table 29. Estimated annual water use for livestock category

{Average daily water use data is obtained from Indiana Department of Natural Resources, 1982a; estimated livestock number is derived from 1992 Census of Agriculture, 1994.}

Livestock class	Estimated number (1000 head)	Average daily water use (gal/head/day)	Average annual water use (MGD)
Beef cattle	2.20	11.5	0.03
Dairy cattle	13.10	22.5	0.29
Hogs	202.60	4.0	0.81
Chickens	1234.5*	0.1	0.12
Total			1.25

* Incomplete data

used for dairy cattle and hogs. In few cases, water withdrawals tabulated as livestock water use also may have been included in the agricultural category of the registered significant water withdrawal facilities.

Livestock water use is expected to increase only slightly during the next decade. Increases will depend largely on the farm economy and climatic factors.

Instream uses

Instream uses are defined as non-withdrawal uses taking place within a stream, lake or reservoir. Instream uses in the Maumee River basin primarily include recreation activities, fish and wildlife habitat, and waste assimilation.

The generation of **hydroelectric power** is another common instream use in some areas of Indiana. One hydroelectric power plant exists in the Maumee River basin, the Up-River Dam located on the St. Joseph River in Allen County. The plant, once capable of producing 175 kilowatts, is owned by the Fort Wayne Municipal Utility. The Utility used the power to operate pumps for movement of water to a filtration plant. At present, the plant is not operational and the Utility has no foreseeable plans for using the facility (personal communication, plant superintendent, September 1996). The potential for developing additional hydroelectric plants in the basin is minimal.

Water-related **recreation** needs in the next decade

will depend on user demand, the availability of facilities, and a variety of demographic and socioeconomic factors.

A statewide comprehensive five-year plan for outdoor recreation (SCORP) was developed in 1994 by the IDNR Division of Outdoor Recreation. The state was divided into 15 planning regions to assess outdoor recreation supply and demand. A recreation facilities inventory and a statewide outdoor recreation participation survey were conducted to assist in the assessment. The Maumee River basin is encompassed within planning regions 3A and 3B of the plan. Region 3A is a five-county region comprised of Huntington, LaGrange, Noble, Steuben, and Whitley Counties. Portions of Noble and Steuben are located within the Maumee River basin. Region 3B, a four-county region, is made up of Adams, Allen, DeKalb, and Wells Counties. Most of the Maumee River basin is encompassed within planning region 3B. For water-based recreation purposes, this report uses information developed in the 1994-1999 SCORP for counties lying partially within the Maumee basin. Gross comparisons are also made to the nine-county area that comprises planning regions 3A and 3B in the SCORP, because it seems likely that the proximity of facilities in all of the nine-county area are within a reasonable distance to be used by people living in the basin.

The most popular outdoor recreation activities identified in the basin are walking and picnicking. Popular water-based activities include: fishing in streams, lakes, and reservoirs; swimming and boating in lakes; swimming in pools; and commercial canoeing along portions of the St. Joseph River and Cedar Creek.

Values for lakes shown in table 30 are for entire counties and reflect potential supply, because all lakes do not provide public access. Lakes in Region 3B, which encompasses most of the Maumee River basin, are fewer and smaller than those in Region 3A.

Demand (table 30) is based on the assumption that residents of the nine-county area would participate in water-based recreation activities at the same rate as persons completing the survey. It does not imply that all participants use waters of the Maumee River basin exclusively as the location of their activity. Moreover, the values do not account for the number of visits from non-service area residents, nor the number of times persons from within the service area go outside the area for recreation.

Approximately seven percent of those surveyed in Region 3B expressed a desire to participate in boating

Table 30. Water-based recreation supply and demand

{Values are from the Statewide Comprehensive Outdoor Recreation Plan (1994-1999) (SCORP), Indiana Department of Natural Resources, 1994c, Division of Outdoor Recreation}

Supply			
County	Total number of lakes	Total acres	Lake acreage per person
Adams	1	24	0.001
Allen	14	839	0.003
DeKalb	7	240	0.007
Noble	73	4,189	0.073
Steuben	74	8,503	0.038
Wells	2	91	0.004
Total in-basin counties	171	13,886	0.030
Planning regions 3A and 3B (9-county region)	254	22,504	0.041
Demand			
Water-based activity	Region 3A (percent participation*)	Region 3B (percent participation*)	
Fishing			
boat	33	23	
bank	34	20	
Swimming			
lake	37	33	
pool	23	36	
Motorboating	30	NA	

* participated at least once within the last year of the survey

but were unable to do so, primarily due to expense. This is interpreted as a latent demand. Many boating and water-skiing enthusiasts in Region 3B look to water of Region 3A for recreational opportunities.

It should be recognized that future recreation needs may differ from present needs. The change in the age distribution of the basin's population will significantly affect the demand for recreation opportunities. Other concerns include: 1) the need for more water-based recreation facilities; 2) increasing need for access to the state's waters; 3) particularly high demand for greenways; and a significant need for more public land. These factors are discussed in more detail in a 5-year recreation plan (Indiana Department of Natural Resources, 1994c).

Summaries of basin **fisheries** and **wastewater** treatment were provided 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 pressure. Factors that will help maintain or improve surface-water quality in future years include control of nonpoint-source pollution, upgrading of wastewater-treatment facilities, improved treatment-plant operations, and improved compliance with discharge limits. Detailed information on wastewater-management plans is available from the Indiana Department of Environmental Management.

Wetlands are an excellent source of outdoor recreation opportunities, from fishing and hunting to canoeing and birdwatching. The conservation of wetlands 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 ensure the future conservation of wetland and riparian habitats.

SURFACE-WATER DEVELOPMENT

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

Wetlands

Although some withdrawals occur along wetlands in the basin, 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).

Lakes

Despite the large storage capacity of some public freshwater lakes in the Maumee River basin, few are used as water supply sources. Both direct and indirect pumping from natural lakes may have detrimental effects on local ecosystems, and may be cause for concern among local residents.

Existing state laws effectively preclude significant pumping from natural lakes. Most notably, I.C. 14-26-2 requires that lakes having a legally-established water level are to be maintained at that level. In accordance with this law, six of the eight natural lakes within the basin have established levels. Even temporary changes in lake levels from their designated elevation requires prior approval from a local circuit court and the Natural Resources Commission. Approval typically is granted only for shoreline improvements or lake restoration.

If the courts amend state laws to allow the lowering of lake levels for supply purposes, water treatment and

distribution costs limit the applications. Irrigation, livestock watering, and fire protection remain viable uses, while personal consumption does not. Lowering water levels can have harmful affects on water-quality, fisheries' habitat, and adjacent wetlands. Most lake-side property owners would object to even minor alteration of lake levels. Lowering lake levels could expose lake bottom sediments, and raising lake levels could eliminate valuable real estate.

Amending current laws to increase lake storage has drawbacks beyond the possible public nuisance. New control structures at potential sites might need to be constructed, and existing structures would need modification. Few lake-level control structures are designed to store water at elevations above the legal level. The actual cost of either option might exceed feasible benefits.

Streams

The largest water withdrawals from streams come from the St. Joseph River. The largest volumes of water withdrawn from streams in the Maumee River basin are used for public supply purposes.

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

individual 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. 14-29-1-8), 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 Maumee River basin, only the Maumee River from Hosey Dam, Fort Wayne, downstream to the Indiana/Ohio State Line is considered navigable in Indiana (27.05 river miles). The river is also navigable in Ohio, resulting in a total of 134.9 river miles which are classified as navigable.

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. 14-25-7.14). If established, the minimum stream-flow criteria may govern the amount of water withdrawn from streams in some areas.

In an 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 exam-

ined 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 Maumee River basin; namely, the Maumee River at New Haven and the St. Marys at Decatur. 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 Maumee River basin generally exceeds demand because streamflow in the St. Joseph River is augmented by storage from the two reservoirs. However, during periods of low stream flow, withdrawals from the St. Joseph River for public supply may produce instream use impacts on streamflow downstream of the public supply intake point.

GROUND-WATER DEVELOPMENT

Ground-water resource availability of the Maumee River is considered fair to good when compared to the rest of the state. Development of ground water in the basin is used primarily for public and domestic drinking water supplies.

Ground-water rights

Although the availability of ground water varies across the Maumee River basin, ground-water resources of the basin are generally considered adequate. Further ground-water development in and around the basin should be carefully planned to minimize conflicts among the many ground-water users of the region. Localized or short-term conflicts among ground-water users have occurred in the past and are expected to recur as ground-water demands continue to increase.

Provisions found in Indiana laws, particularly IC 14-25-4, will remain a key factor in developing and protecting ground-water resources in and around the Maumee River basin. Additional regulations, water conservation practices, and improved management

may be needed to protect ground water in localized areas.

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

In 1982 a new law (IC 14-25-4) 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 pumpage. 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 properly-constructed nearby small capacity wells if high-capacity pumpage has substantially lowered ground-water levels in the area, causing the wells to fail. The law (IC 14-25-4) was amended on September 1985 to provide protection for owners of small-capacity wells across Indiana. Water wells constructed in Indiana after January 1, 1986 must meet the standards established by 310 IAC 16.5 in order to be provided the protection afforded under IC 14-25-4.

Impacts of ground-water withdrawals

Dewatering operations at limestone quarries and ground-water withdrawals by public supply facilities are responsible for most of the documented water-supply conflicts in the Maumee River basin and vicinity. Impacts have occurred mostly in localized areas of the carbonate bedrock aquifer system in Allen County and the Teays Valley and Tributary Aquifer system in southern Adams County.

Explosive population growth in Aboite township of western Allen County during the previous decades (figure 69) led to the installation of public-supply water wells during the late 1980s. Operation of the high-capacity production wells that penetrated the Silurian and Devonian carbonate bedrock have had localized impacts on the potentiometric level of the aquifer. As of January 1, 1996 only one owner was believed to have been significantly impacted by the pumpage and was provided "timely and reasonable compensation" by the owners of the public water sup-

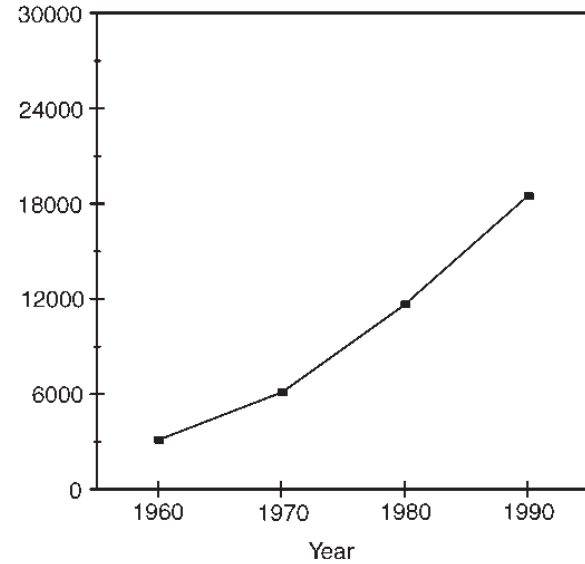


Figure 69. Population growth in Aboite township

ply facility in western Allen County. Although the area of concern lies just outside the Maumee River basin, the effects of increasing demands for ground water apply directly to the basin.

Figure 70 illustrates that the general decline of the potentiometric level of the carbonate bedrock aquifer at observation well Allen 8 in western Allen County is accompanied by increases in monthly high-capacity pumpage from nearby public water-supply wells. Although the carbonate bedrock aquifer appears capable of supporting current water withdrawals occurring in the area, continued increases in high-capacity pumpage for public supply should be carefully planned to minimize possible ground-water conflicts in the future, especially if population growth continues. Changes in ground-water levels in a carbonate bedrock aquifer cannot be modeled or predicted as accurately as changes in unconsolidated aquifers. Traditional ground-water flow equations can not fully account for flow occurring mainly through fractures, joints and solution openings (see sidebar titled **Ground-water flow and the dissolution of carbonate rocks**).

Dewatering operations associated with limestone quarries can cause a decline in the potentiometric level of the carbonate bedrock aquifer in the immediate vicinity. In west-central Allen County, there have been 20 domestic wells that were adversely affected

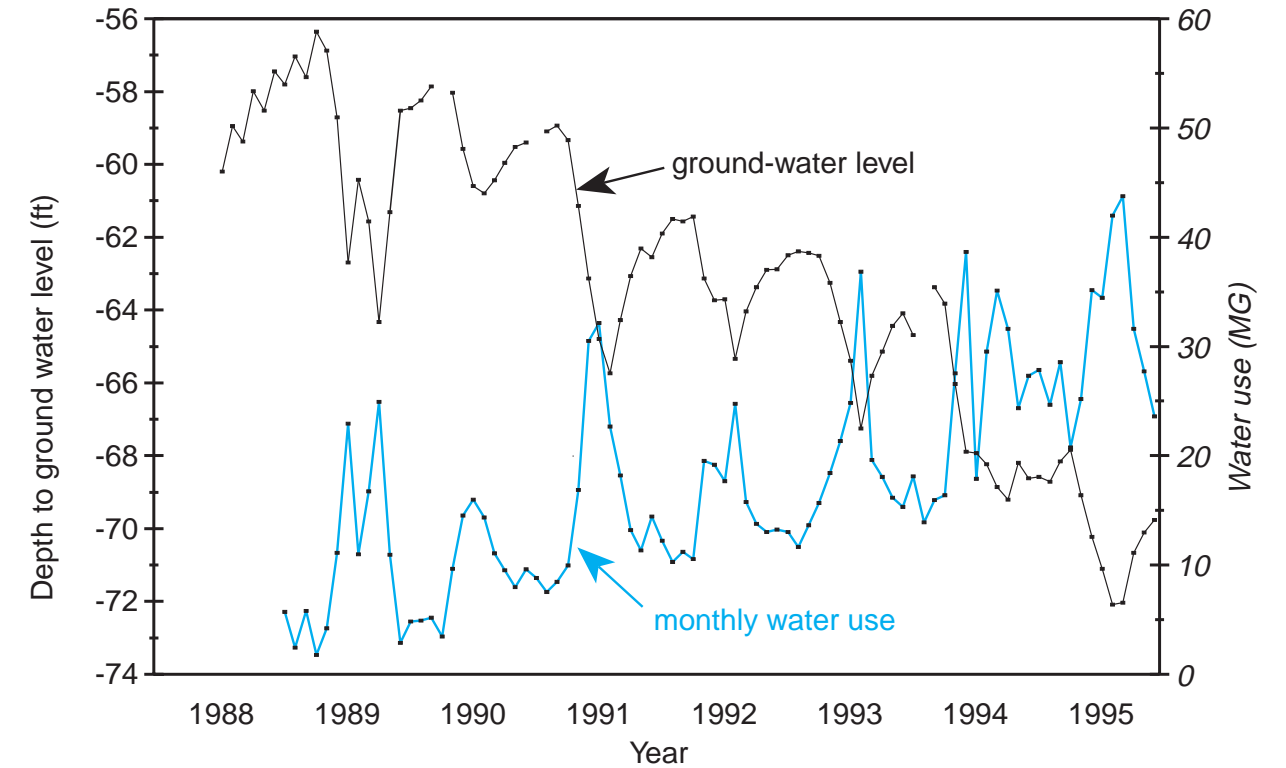


Figure 70. Mean monthly ground-water levels in Allen 8 and monthly pumpage from nearby public-supply wells

by dewatering operations of stone quarries over the last ten years. Ground-water rights investigations usually continue in areas of documented ground-water conflicts when the high-capacity ground-water facilities are in operation.

Past ground-water conflicts in the Maumee River basin occurred in southern Adams County where an increase in ground water development for public supplies began in 1988. The high-capacity public supply wells that tap the Teays Valley and Tributary Aquifer

system were believed to have impacted a few nearby domestic wells that also utilize the aquifer system. However, bedrock wells in the immediate vicinity of the public supply facilities were not impacted because the hydraulic connection between the outwash sediments of the bedrock valley and the carbonate bedrock is poor. Since 1988 there has not been any documentation of additional ground-water conflicts in southern Adams County that were caused by public water-supply wells.

SUMMARY

In response to legislative directives contained in the 1983 Water Resource Management Act, the Indiana Department of Natural Resources, Division of Water published a report describing the availability, distribution, quality and use of surface water and ground water in the Maumee River basin, Indiana. The fifth in a series of 12 regional watershed assessments, this report provides hydrologic data and related information for persons interested in the basin's water resource.

The Maumee River basin encompasses a total of 1283 square miles (sq.mi.) in northeast Indiana. Six Indiana counties lie partially within the Maumee River basin. The basin is dominated by its major population center, Fort Wayne. The location of Fort Wayne at the junction of three rivers has made it a focus of commerce and has also caused the city to experience major flooding.

Streams of the basin include the Maumee, St. Marys, and St. Joseph Rivers; Cedar Creek; and an extensive network of smaller tributary streams and ditches. Streamflow leaving the basin enters the state of Ohio and eventually reaches Lake Erie.

SOCIOECONOMIC SETTING

About 61 percent of the Maumee River basin's total population lives in urban areas. Nearly 80 percent live in Allen County. The total population in the basin is growing and is expected to continue to grow in the future.

Per capita income in the basin averages about 97 percent of that for Indiana. Recent unemployment trends are slightly higher than the state average, but lower than the national average. Employment and earnings by industry are largely based on manufacturing, the service industry, wholesale and retail trade, and government. These four economic sectors make up approximately 76 percent of the total employment earnings for the basin.

PHYSICAL ENVIRONMENT

The climate of the Maumee River basin is classified as temperate continental, which describes areas hav-

ing warm summers, cool winters, and the absence of a pronounced dry season. Precipitation and temperature throughout the basin vary considerably on a daily, seasonal and yearly basis.

Annual potential evapotranspiration in the Maumee River basin accounts for approximately 26.43 inches of the 34.5 inches of normal annual precipitation. The theoretical average annual water surplus of more than 8 inches is considered adequate for the basin as a whole; however, the variability of rainfall and its uneven geographic distribution can occasionally limit crops and water surplus.

The landscape of the Maumee River basin is primarily a product of latest Wisconsin glacial events of the Erie and Saginaw ice lobes. Major landscape elements include: 1) the Tipton Till Plain which is a vast region of very low relief and generally corresponds to the southern part of the basin; 2) the Maumee Lacustrine Plain, which is a flat, nearly featureless lake bottom that generally corresponds to the central core of the basin; and 3) the Steuben Morainal Lake Area which is characterized by low- to high-relief and generally corresponds to the northern part of the basin.

The land surface over the greater part of the Maumee River basin is underlain by glacial till or till-like sediments. Such sediments are fine- to medium-grained and poorly-sorted having minimal reworking by meltwater and mass movement. The surface till in most of the Maumee River basin is typically clay-rich, reflecting the abundance of both lake and shale bedrock in the source area of the Erie Lobe east of the basin. In contrast, tills of the Saginaw Lobe, which underlie Erie Lobe tills in many places in the northern part of the basin, are sandy due to the combination of coarse-grained bedrock and abundant outwash in the source area.

Deposits formed in glacial lakes are also widespread in the Maumee basin, especially in the east central part of the basin known as the Maumee Lacustrine Plain. Sediments range from silt and clay laid down in quiet water in the central portions of the lake, to coarse sand and gravel associated with high-energy shorelines.

Outwash sediments of sand and gravel also occur in the Maumee River basin in small valley trains along the St. Joseph River and Cedar Creek, and in broader

aprons and fans. Large buried outwash bodies also occur at many places in the basin.

The great variability in thickness of the unconsolidated deposits in the southern and northern parts of the basin, 50 to 100 feet and 150 to 400 feet, respectively, is an indication of the differences in glacial activity in the northern and southern parts of the basin.

Regional bedrock structure in the Maumee River basin is controlled by two principal features; the Cincinnati Arch in the south and the Michigan Basin in the north. Bedrock is not naturally exposed at the land surface; but rocks occurring at the bedrock surface range from Ordovician to Mississippian age.

Soil parent materials differ from south to north in the Maumee River basin. In the south, moderately fine textured soils are associated with Lagro glacial till. Very fine to fine textured soils predominate in the lacustrine plain of the east central portion of the basin. Loam and sandy loam soils are a product of the loamy Trafalger till in the northwest.

SURFACE-WATER HYDROLOGY

The surface-water resources of the Maumee River basin include the Maumee, St. Marys, and St. Joseph Rivers; Cedar, Little Cedar, Blue, Fish, and Spy Run Creeks; an extensive network of smaller tributary streams and ditches; two man-made reservoirs; natural lakes; ponds; and scattered remnants of marshes, swamps, and other wetlands.

The present surface-water hydrology of the Maumee River basin is different from the natural drainage conditions that existed prior to permanent settlement of the area. The most extensive changes are related to clearing of hardwood forests and ditching and tiling of former swamps.

Of the major streams in the Maumee River basin in Indiana, the St. Marys River has the least potential as a water-supply source. It has the lowest percentage (29 percent) of base flow and the steepest flow-duration curve. The steep flow-duration curve indicates high overland flow and low base flow. Daily flows on the St. Marys are highly variable, but annual flows are fairly consistent.

The Maumee River has the most uniform flow characteristics and the highest potential for future development of the streams in the basin. Base-flow on the Maumee during a normal year constitutes about 42 percent of the total runoff.

Of the basin's streams, the St. Joseph River supports the largest number and the highest volume of high-capacity withdrawals, primarily for public supply. The river's value as a water-supply source stems from its large drainage area, the presence of outwash deposits which sustain stream flow, and its water quality. High base flow, approximately 50 percent, on the St. Joseph River is related to the presence of permeable sandy soils and outwash sand and gravel deposits.

The St. Joseph River has two water-supply reservoirs, the Cedarville and Hurshtown, which store water to supplement Fort Wayne's public water supply.

Flooding in the Maumee River basin has caused damage and loss of property many times in the past. Rains and/or snowmelt occurring in winter or early spring are the major contributory causes for peak annual flooding along the major streams in the basin. Floods along the Maumee River are intensified when the St. Joseph and St. Marys Rivers reach peak flow at the same time. Of the counties in the basin, flooding has been most disastrous in Allen County because of urban development in Fort Wayne.

Flooding problems in the basin have been addressed by a number of planning and construction initiatives undertaken by local and governmental entities.

SURFACE-WATER QUALITY

The Indiana Department of Environmental Management (IDEM) recently assessed water quality of 764 miles of stream in the Maumee River basin for designated uses of aquatic life support and recreational use. For aquatic life support, 649 miles or 85 percent are supportive; 31 miles or 5 percent are supportive, but threatened; nine miles or 1 percent, are partially supportive; and 75 miles, or 9 percent are not considered supportive. For full-body contact recreational use, 110 miles or 14 percent are supportive; 86 percent are not supportive.

The majority of river reaches that do not support aquatic life are impaired by low levels of dissolved oxygen (DO) in the water column. Recreational use impairment is primarily related to high levels of coliform bacteria, specifically *E. coli*.

Data from the six active IDEM water-quality monitoring stations in the Maumee River basin are used in this study to analyze selected constituents of streams in the Maumee River basin. Results are compared to

state and federal water-quality standards.

Apparent seasonal trends are noted in median levels of dissolved oxygen within streams in the Maumee River basin. The variations in seasonal median DO levels may be inversely related to seasonal changes in water temperature. Seasonal variations in specific conductance may not be significant for most stations. There appear to be large seasonal and spacial variations in nitrate-nitrite levels in the rivers of the basin. The seasonal trend in nitrates generally mirrors the runoff from the land surface.

Variations in water quality are observed among samples from different streams and from different locations within the same stream. The highest median dissolved oxygen (DO) is observed in water samples from the St. Joseph River just north of Fort Wayne. In the St. Marys River, there is a trend of increasing median DO levels as the river flows from near the Ohio/Indiana border to the city of Fort Wayne.

Median hardness levels range from about 280 mg/L to 330 mg/L, therefore, the waters in the basin are classified as "very hard".

Water quality is generally good in the streams of the Maumee River basin, although iron and manganese concentrations commonly are high, and the rivers are frequently turbid. Of the three major rivers in the basin, the St. Joseph has the highest water quality; and the St. Marys suffers the most from water-quality degradation. The Maumee River reflects an 'average' water quality due to mixing of water from the St. Joseph and the St. Marys.

In addition to collecting water samples from the basin streams, the IDEM has also collected biological samples of macroinvertebrates and fish to assess the overall health of the aquatic ecosystem. An index of biotic integrity is developed based on the number and types of species collected.

The IDEM has completed the preliminary phase in a macroinvertebrate sampling program by sampling 26 sites in the basin's three major drainage systems and developing a provisional macroinvertebrate Index of Biotic Integrity (mIBI). Of the 26 sites evaluated in the Maumee River basin, only one is classified as non-impaired; 17 are slightly impaired; and eight are moderately impaired; none of the sites sampled are classified as severely impaired.

In 1991, the USEPA and IDEM sampled fish populations in the Maumee River basin in Indiana. A total of 77 sites were sampled to develop an Index of Biotic

Integrity (IBI) for the basin. The three major rivers in the basin were evaluated using the IBI. Overall trends are toward increasing biological integrity with increasing drainage area. In general, the St. Joseph River and its tributaries contain the most diverse fish community in the basin, and the St. Marys, the least.

GROUND-WATER HYDROLOGY

Ground-water availability in much of the Maumee River basin is considered fair to good. The most important aquifers in the northern part of the basin, which comprises about 60 percent of the total area, consist of unconsolidated deposits of sand and gravel. In most of the southern part of the basin, Silurian and Devonian carbonates form the principal aquifer, although sand and gravel deposits in and above buried bedrock valleys are important in southern Adams County.

Seven unconsolidated aquifer systems are defined according to hydrologic characteristics of the deposits and environments of deposition. Two bedrock aquifer systems are defined on the basis of hydrologic and lithologic characteristics.

Only two of the seven unconsolidated aquifer systems are laterally extensive in the Maumee River basin; the Kendallville Aquifer system and the Hessen Cassel Aquifer system.

The Kendallville Aquifer system, extending across much of the northern half of the basin, consists of sand and gravel lenses occurring at various depths within a till and mixed drift complex that contains appreciable fine-grained sediments. Thickness of individual sand and gravel units within the system commonly ranges from 5 to 30 feet. Expected high-capacity yields range from 70 to 1000 gpm; but yields up to 2250 are reported in some areas. Of the aquifer systems in the basin, the Kendallville has the highest potential for future ground-water development.

The Hessen Cassel Aquifer System consists of scattered lenses of glacial outwash occurring amidst thick sequences of tills and, along its northeastern extent, some fine-grained glaciolacustrine deposits. Although the aquifer system extends across most of the southern part of the basin, there is an overall scarcity of productive zones of sand and gravel within this system. The sand and gravel lenses are commonly 5 to 10 feet thick and are either confined within glacial till or are overlying bedrock. Locally-thick outwash deposits

may produce yields from 75 to 85 gpm for high-capacity wells.

Other less extensive but locally-important unconsolidated aquifer systems include: New Haven, Cedarville, Eel River-Cedar Creek, Aboite, and the Teays Valley and Tributary.

The New Haven Aquifer system is relatively contiguous across its extent in north-central Allen County. It consists of outwash plain sediments confined by varied sequences of till and glaciolacustrine deposits. The aquifer, which commonly ranges from 5 to 10 feet in thickness, directly overlies bedrock in some places. High-capacity wells that penetrate locally-thick outwash deposits commonly yield from 100 to 250 gpm.

The Cedarville and the Eel River-Cedar-Creek aquifer systems, both occurring beneath major river valleys, have small areal extent in the Maumee River basin. Each consists of surficial valley train sediments and deeper outwash sand and gravel deposits having potential for ground-water development. Little is known about high-capacity yield potential of the Cedarville Aquifer system; but anticipated yields for the Eel River-Cedar Creek Aquifer system range from 300 to 600 gpm.

The Aboite Aquifer system located in west-central Allen County, consists of sand and gravel deposits that occur at several horizons within thick, clayey till deposits. The system is comprised of two distinct parts which exhibit somewhat different geohydrologic characteristics.

Sand and gravel deposits are more sporadic and less numerous in the northern part of the Aboite aquifer system than in the south. In addition, the productive deposits in the north do not have good hydraulic connection with the carbonate bedrock aquifer beneath them; whereas in the south, many such deposits directly overlie the carbonate. Common thickness of the individual aquifers that comprise the Aboite Aquifer system ranges from about 5 feet to 20 feet. Expected high-capacity yields range from 200 to 600 gpm, but yields up to 1000 gpm are reported in some areas.

The Teays Valley and Tributary Aquifer system consists of unconsolidated deposits in a buried pre-glacial bedrock in southern Adams County. In places, tills and outwash sediments above the bedrock valley exceed 385 feet in thickness. Outwash deposits of sand and gravel range from 5 to 185 feet in thickness in the main valley; and high-capacity wells may yield as much as 2100 gpm.

The Silurian-Devonian Carbonate bedrock aquifer system is the most utilized aquifer system in the southern part of the Maumee River basin. However, water-yielding capabilities of the aquifer system are not uniform throughout its extent. It is comprised of limestone, dolomite, and dolomitic limestone and is the only bedrock aquifer in the basin capable of supporting high-capacity pumpage. Yields from high-capacity wells range from 100 to 500 gpm, but higher yields may occur in areas where several feet of sand and gravel are present just above the bedrock surface.

GROUND-WATER QUALITY

Ground water in the Maumee River basin is generally hard to very hard and neutral to slightly alkaline. Ground-water chemistry in the northern part of the basin is dominated by calcium, magnesium, and bicarbonate; whereas, it is dominated by calcium, magnesium, and sulfate in the south. In general, ground water in the north is less mineralized than in the south.

Ground water in most of the basin meets drinking-water standards, although iron commonly exceeds the Secondary Maximum Contaminant Level (SMCL). Other constituents that commonly exceed SMCLs include manganese and total dissolved solids (TDS). Fluoride also equals or exceeds the SMCL in four samples from the bedrock and one sample from the Hessen Cassel Aquifer system; however, no sample exceeds the Maximum Contaminant Level (MCL) for fluoride.

Nitrate concentrations in the basin are generally below 1 mg/L except for three wells in Allen County and one in Adams. One of the ground-water samples from Allen County exceeds the MCL for nitrate.

Median sulfate concentrations in ground water of the Maumee River basin exceed the SMCL for all aquifer systems analyzed except the Kendallville. The relative proportion of samples having concentrations of sulfate exceeding the SMCL varies considerably among aquifer systems. In general, ground-water in the southern part of the basin exceeds the SMCL for sulfate.

Relative to other regions of the country, ground water in the Maumee River basin has high concentrations of strontium. Concentrations of strontium in most ground water generally range between 0.01 and 1.0 mg/L. In the Maumee River basin, samples from the unconsolidated and bedrock aquifer systems have

median strontium concentrations of 4.4 mg/L and 9.7 mg/L, respectively. Strontium levels in the southern portion of the basin are approximately twice as high as those in the north. There is no SMCL or MCL established for strontium.

The Kendallville Aquifer system, occupying most of the northern half of the basin, is the least mineralized system analyzed; however, the median total dissolved solids (TDS) level for the system slightly exceeds the SMCL. This system has the lowest median hardness and the lowest median concentrations for sodium, chloride, sulfate, strontium, calcium, magnesium, potassium, and TDS of those analyzed in the basin. Alkalinity levels for this system are among the highest found in the basin.

The Teays Valley and Tributaries Aquifer system is the most highly-mineralized system analyzed; however, it should be noted that this system has a small sample set. The median TDS level for the samples in this system exceeds the SMCL by a factor of three; and sulfate concentrations exceed the SMCL for all samples. This aquifer system has the highest median hardness, the highest median concentrations for sodium, chloride, sulfate, fluoride, calcium, magnesium, potassium, and TDS of those analyzed.

The Silurian-Devonian Aquifer system, the primary ground-water source for most of the southern half of the basin, is the second most highly-mineralized system analyzed. Median total dissolved solids (TDS) levels exceed the SMCL for over 75 percent of the wells sampled. Sulfate concentrations are in excess of the SMCL for over 70 percent of the wells sampled, and hydrogen sulfide gas is often detected. Fluoride concentrations also equal or exceed the SMCL for some samples. Two of the unconsolidated aquifer systems, the Hessen Cassel and the New Haven Aquifer systems, have very similar ground-water chemistry to the underlying Silurian-Devonian Carbonate bedrock aquifer system. In general, the concentrations of individual constituents in the two unconsolidated aquifers are slightly lower than those in the bedrock aquifer system. However, the median concentrations of sulfate in the two systems are much lower, approximately 40 percent, than those in the underlying bedrock. In contrast to most other constituents, alkalinity values for both unconsolidated systems are higher than those in the Carbonate. The New Haven Aquifer system has the highest median alkalinity of the aquifer systems tested in the basin.

The highly complex relationships of the various

glacial deposits in the Maumee River basin preclude site-specific comments about susceptibility of the regional aquifer systems to contamination. However, a few gross generalizations can be made. In general, the basin aquifer systems are not highly susceptible to surface contamination. The surficial deposits covering the greater part of the Maumee River basin are comprised of glacial till or till-like sediments which are not highly permeable. Lacustrine sediments, which are also important surficial sediments in the basin, also have low permeability. Only the Cedarville and Eel River-Cedar Creek Aquifer systems, having unconfined sand and gravel surficial sediments, are considered to be highly susceptible to surface contamination.

Numerous ground-water protection initiatives have been undertaken in the state in recent years, including development of a Ground-Water Protection Strategy and Implementation Plan and a Wellhead Protection Plan.

WATER USE AND PROJECTIONS

The total demand for water in the Maumee River basin is expected to increase in future decades, particularly in the Fort Wayne area, as the population and economy continue to grow.

Water withdrawn by registered water withdrawal facilities in the Maumee River basin totals 18.7 billion gallons. Surface-water accounts for approximately 79 percent of the total water withdrawn. Most of the water is used for public supply and industrial purposes, approximately 76 and 20 percent, respectively. Water withdrawal for agriculture and energy comprise the remaining four percent. Most of the registered facilities, approximately 80 percent, are located in Allen County.

A general increasing trend in demand is projected for most water withdrawal and instream uses in the basin.

WATER RESOURCE DEVELOPMENT

Future water demands in the Maumee River basin are expected to remain high, especially public water supply for the large population.

Lakes and wetlands will continue to provide a wide range of recreational opportunities, fish and wildlife

habitat, various hydrologic benefits, and in a few cases, minor water supply sources. However, these systems are not considered as significant sources of supply because of their limited storage capacity, water-quality considerations, and regulatory, economic and environmental constraints.

The largest withdrawals from streams come from the St. Joseph and the Maumee Rivers. The largest volumes of water withdrawn are used for public supply and industrial purposes. Stream withdrawals are expected to remain high. Surface-water supply in the basin generally exceeds demand because streamflow in the St. Joseph River is augmented by storage from the two reservoirs. However, during periods of low stream flow, withdrawals from the St. Joseph River for public supply may produce instream use impacts on streamflow downstream of the public supply intake point.

Ground-water withdrawals in the Maumee River basin are used primarily for public and domestic water supply and dewatering for industrial purposes. Although ground-water supplies are generally adequate for current demand in much of the Maumee River basin, increasing demands may continue to create localized or short-term conflicts among ground-water users.

Ground-water use conflicts in the Maumee River basin and vicinity have occurred primarily as a result

of dewatering operations at limestone quarries and ground-water withdrawals by public supply facilities. Impacts have occurred mostly in localized areas of the carbonate bedrock aquifer system in Allen County and the Teays Valley and Tributary Aquifer system in southern Adams County.

Although the carbonate bedrock aquifer appears capable of supporting current water withdrawals in the area, continued increases in high-capacity pumpage for public supply should be carefully planned to minimize possible ground-water conflicts in the future. If the population continues to grow in the greater Fort Wayne area, and if the population density continues to shift from many sectors of the city of Fort Wayne to the west and northwest, there will be a shift from dependence on surface water as a primary supply source for public supply to greater dependence on ground water.

Further ground-water development in and around the basin should be carefully planned to minimize conflicts among the many ground-water users of the region.

Provisions in Indiana laws, particularly IC 14-25-4, will remain a key factor in developing and protecting ground-water resources in and around the Maumee River basin. Additional regulations, water conservation practices, and improved management may be needed to protect ground water in localized areas.