Illinois State Water Survey Division
SURFACE WATER SECTION

SWS Contract Report 477

ADEQUACY OF ILLINOIS SURFACE WATER SUPPLY SYSTEMS TO MEET FUTURE DEMANDS

by Sally M. Broeren and Krishan P. Singh

Prepared for the
Illinois Department of Energy and Natural Resources

Champaign, Illinois

December 1989

Illinois Department of Energy and Natural Resources

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Adequacy of Illinois surface water supply systems to meet future demands /

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1989
English Book [i], 54 p. : ill. ; 28 cm.
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Title:	**Adequacy of Illinois surface water supply systems to meet future demands /**
Author(s):	Singh, Krishan P.; Broeren. Sally M.
Corp Author(s):	Illinois State Water Survey Division.; Illinois. Dept. of Energy and Natural Resources.
Publication:	Champaign, IL: Illinois State Water Survey,
Year:	1989
Description:	[i], **54 p.: p.,** ill.;, **28** cm.
Language:	English
	SUBJECT(S)
Descriptor:	Water-supply — Illinois.
Note(s):	"December 1989."/ " SWS Contract Report 477." - Cover./ "Prepared for the Illinois Dept. of Energy and Natural Resources."
Responsibility:	by Sally M. Broeren and Krishanm P. Singh.
Document Type:	Book
Entry:	19900430

[redacted]

Update: 19950501

Accession No: OCLC: 21454913

Subjects Libraries ILL E-mail Print Export Help

WorldCat results for: **ti: adequacy and ti: illinois and ti: surface and ti: water and ti: supply and ti: systems and ti: meet and ti: future and ti: demands.** Record 1 of 1

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INTRODUCTION

The ability of surface water sources to meet the current and future demands of the public water supply systems they serve must be continually evaluated for water resource planning and management. Water demand changes over time, increasing with population growth and commercial and industrial development. Continuing sedimentation in surface water reservoirs reduces their capacities and reliable yields. Additional limitations are imposed on surface water supplies by emerging demands for recreation and mandatory low-flow releases from reservoirs to maintain streamwater quality, ecology, and aquatic habitats. These factors, singly or in combination, may lead to water shortages for some systems in the next 30 years.

Surface water sources, including Lake Michigan, large interstate rivers, and intrastate streams and rivers, supply more than 130 public water systems in Illinois. Ninety public surface water supply systems withdraw water directly from intrastate streams, rivers, and reservoirs. This report examines the adequacy of intrastate surface water sources to meet the future demands of the public systems they currently serve. The supply that can be provided by a given source during a design drought was determined and compared to demand projections for the next 30 years for each of the 90 public water supply systems. Systems that may face water shortages during a severe drought are identified. The analyses address two major factors affecting the current and future reliability of existing supply systems: projected demand levels and the reduction of reservoir yields as sedimentation reduces storage capacity.

Public surface water supply systems with reliable and consistent sources of supply, well in excess of demand, are not at risk and are not discussed in detail. Systems excluded from this study obtain their water from Lake Michigan, the Mississippi, the Ohio, the Wabash, the Illinois, and the Fox Rivers. Water diverted from Lake Michigan is managed to provide for many diverse needs: water supply, navigation, and water quality maintenance in the Chicago waterways. Interstate Rivers such as the Mississippi, the Ohio, and the Wabash have low flows far exceeding the demands of communities currently withdrawing water from them. Likewise, the Illinois and Fox Rivers, which are used by Peoria and Elgin, respectively, have relatively high, consistent flows. Both communities also have access to adequate ground-water sources to augment supply during low-flow periods.

This report is the third part of a study of public water supply systems in Illinois that rely on intrastate streams and rivers. The study was authorized and partially funded by the Division of Water Resources, Illinois Department of Transportation, as part of their ongoing efforts to manage and plan the best use of Illinois water resources.

Objectives and Scope

The objective of this study of the adequacy of public surface water supply systems is: 1) to identify systems that may become inadequate in the next 30 years on the basis of yields for 20- and 50-year design drought scenarios and future water demands and 2) to rank the systems with respect to the year when they become deficient. Lake Michigan and major rivers in Illinois are excellent sources of water. Therefore, this study focuses on systems that rely on intrastate rivers that are subject to extreme low-flow periods. These systems generally must accumulate adequate storage supplies during high-flow periods to maintain a consistent supply during drought episodes and dry periods.

The overall study is divided into four parts. The first part involved developing an inventory of the systems using intrastate rivers to identify water supply systems and their sources and water demand projections. The results of the investigation were reported by Singh et al. (1988a). A second report by Singh et al. (1988b) provided capacity projections for in-channel reservoirs that are subject to capacity loss due to sedimentation. A methodology was developed for detailed calculations of accumulated sediment volumes. The procedure was used to evaluate future storage capacities for in-channel public water supply reservoirs up to the year 2030. The third part of the study is reported here. It includes 1) a yield analysis of each public water supply source for design droughts having 20- and 50-year recurrence intervals; 2) a comparison of design drought yields with projected demands up to the year 2020; and 3) a ranking of systems that will become deficient in the next 30 years. The fourth part of the study addresses ameliorative measures in general and for specific systems in particular.

A water supply system consists of several major components: the source of supply, the pumping systems used to withdraw water from the source, storage facilities for raw water, the water treatment facility, and the distribution system. The adequacy of the raw water source(s) for each of the 90 systems was studied. Even if the source is adequate, water shortages can occur if any of the other components are inadequate. These "other" components are not examined in detail for each system. Problems reported on questionnaires completed by system operators are noted. Capacities of pumping systems used to fill side-channel reservoirs are discussed since the yield from the source is intrinsically linked to the water withdrawal system. Water quality is not examined in this report.

This report provides specific information for each of the 90 systems that rely on intrastate streams, rivers, and reservoirs, including: a table of yields from sources of supply, average and maximum demand projections, and a discussion of circumstances unique to each system. Care was taken to cross-reference identification numbers used in the previous two reports and keep names, identifiers, and terminology consistent. Each system that may become deficient in the next 30 years is described in detail.

Terminology

The following terms are defined in the interest of clarity and consistency:

Public water supply system denotes the supply sources and distribution networks that furnish water for drinking or general domestic use in incorporated or unincorporated communities in which 15 or more services or 25 or more people are served for at least 60 days per year. Public water supply systems serve domestic, commercial, and industrial users.

Source supply system is the operating unit that obtains raw water from a natural lake, from an artificial reservoir, or directly from a stream or river and distributes water to individual municipal and rural customers, other communities, and/or other water districts. Source supply systems may be publicly or privately owned.

Service area population refers to the total number of people who are supplied from a water source and receive their water through the public water distribution network. This includes persons served by communities or water districts that obtain their water through the source distribution system and own or operate their own individual metering and distribution system. It does not include customers who purchase bulk water at the treatment plant and haul the water to its final destination via ground transportation.

In-channel reservoir is an impoundment created by a structure built across a natural stream or river.

Side-channel reservoir is a unit located near the stream or river; water is pumped from an intake structure in the stream or river to the reservoir. Water may also be pumped from auxiliary or standby ground-water wells.

Direct withdrawal refers to a system in which water is withdrawn from a stream or river and conveyed directly to the treatment plant without significant storage. Although a low in-channel dam is often constructed immediately downstream of the intake structure to keep the intake immersed, it creates only a small amount of in-channel storage. The stored water may be sufficient to meet demand for a few days or weeks during very low flows.

Acknowledgments

This study was jointly supported by the Division of Water Resources, Illinois Department of Transportation, and the Illinois State Water Survey (ISWS). Gary R. Clark of the Division of Water Resources served in a liaison capacity during the course of this study. This report was prepared under the general direction of Richard G. Semonin (Chief) and Michael L. Terstriep (Head of the Surface Water Section), Illinois State Water Survey. Elizabeth Esseks performed calculations and data entry. Becky Howard typed and formatted the final report and Laurie McCarthy edited and produced the report.

BACKGROUND INFORMATION

River flows vary seasonally. High flows typically occur in the spring, and low flows typically occur in the late summer and fall. Daily flows fluctuate considerably within a season. Over the course of a year, public demand does not vary considerably, but historical data show that water use increases during hot dry weather when flows are typically lowest. With the exception of the Rock, Illinois, Kankakee, and Fox Rivers in northern and northeastern Illinois, intrastate rivers used for public water supply have very low flows during dry years. In order to provide a consistent and reliable supply, water is stored during high- and medium-flow periods for use during low-flow periods. In-channel or side-channel reservoirs are used, whose designs provide enough storage to weather periods of low river flows. Low in-channel dams located on rivers with relatively sustained and significant flows supply water during low-flow periods. These may create enough storage to meet a few days' or weeks' demand. Most of the 90 systems examined in this report (table 1) He in central and southern Illinois. This area has generally limited ground-water resources, and reliable water supplies from surface water systems are highly dependent on adequate water storage.

Of the 90 systems studied, 39 rely on a single in-channel reservoir for water storage; 18 systems use two or more in-channel reservoirs; 7 systems use a single side-channel reservoir; 2 systems use two or more side-channel reservoirs; 7 systems have both in-channel and side-channel reservoirs; 5 systems have low in-channel dams with some in-channel storage: and 7 systems use direct withdrawals from low in-channel dams with virtually no storage. Ground water provides a significant portion of the water supply for four systems that also use in-channel reservoirs and for one system with a side-channel reservoir. Many systems have multiple water supply sources. This situation occurs as additional sources are developed to meet significant increases in demand after the original reservoir was constructed; or more often, because the storage capacity of the original reservoir has significantly declined due to accumulation of sediment.

Naturally flowing streams and rivers carry suspended particles of sediment. Deposition of sediments in the quiescent waters stored behind in-channel impoundments reduces the water storage capacity of reservoirs. If the sediment is not flushed out or mechanically removed by dredging, the storage capacity in the reservoir, as well as its yield, can eventually become inadequate to meet demands. Reservoir sedimentation is a significant problem in Illinois. In many water supply reservoirs, 50 percent or more of the original storage capacity is occupied by sediments. Projections for water supply reservoir capacity from 1990 to 2030 (Singh et al., 1988b) demonstrate the statewide extent of this problem for in-channel reservoirs. Because the capacity of many water supply reservoirs has decreased considerably, evaluation of the yield based on the reduced capacity provides essential information for evaluating the future reliability of these systems.

More than two-thirds of the 90 supply systems studied depend on in-channel reservoir storage. Continuing sedimentation in these reservoirs will result in decreasing yields over time. Net yields of these reservoirs were computed using the projected capacities for the years 1990, 2000, 2010, and 2020 (Singh et al., 1988b). The results of the evaluation presented in this report demonstrate the significance of the impact of sediment accumulation on yields and subsequently on the future reliability and adequacy of the water supply systems.

Side-channel reservoirs are typically filled by pumping water from a stream or river, and in some cases this is augmented by ground water. Side-channel reservoirs do not have inflowing streams, and natural drainage is typically limited to minor, local, surface runoff. This may cause minor sedimentation problems. Because suspended materials in water can damage pumping systems, suspended matter in water pumped to side-channel reservoirs is minimized, and sedimentation in side-channel reservoirs is usually assumed to be insignificant. Side-channel reservoirs are typically much smaller than in-channel reservoirs. Their yield is intrinsically linked to the pumping system that withdraws the water. The reliable yield from a side-channel reservoir during a drought is as much a function of the relationship between the demand rate and the pumping capacity as the available streamflow.

Reservoir storage should be adequate to maintain an uninterrupted supply of water sufficient to meet demand through extended low-flow or drought periods. Droughts are defined in terms of a designated length of time (drought duration); the average flow for the period; and the frequency at which these conditions are expected to occur. Design droughts with 20-year and 50-year recurrence intervals were considered in this study. A drought with a 20-year recurrence interval has a 1-in-20 chance of occurring in any given year. Similarly a drought with a 50-year recurrence interval has a 1-in-50 chance of occurring in any given year. The design recurrence interval reflects the level of risk involved in a water supply being inadequate to meet demand.

Net yield from a reservoir during a 20-year or a 50-year design drought is a function of reservoir storage capacity, surface area, and hydrologic factors. The net yield is the draft rate (demand) that can be maintained during the most severe low-flow period (having a l-in-20 or a l-in-50 chance of occurring) given the reservoir capacity. The net yields determined for each reservoir system for the years 1990, 2000, 2010, and 2020 were compared to corresponding demand projections to assess the future adequacy of the system. For the systems having essentially direct withdrawals, streamflows corresponding to 20- and 50-year recurrence intervals and various durations were determined and compared to demand projections.

SOURCES **OF DATA**

Demand projections in millions of gallons per day (mgd) for each of the 90 systems evaluated in this report were derived in the first phase of this project. System demand projections for 1990, 2000, 2010, and 2020 are presented in Water Survey Contract Report (CR) 442 *Future Demands of Public Surface Water Supply Systems in Illinois* (Singh et al., 1988a). Future demands were estimated on the basis of population projections and historical trends in water usage. Characteristics unique to each system were considered, and details of procedures and original data sources were described. The inventory of all Illinois public surface water systems using intrastate rivers that was developed in the first part of the project included a questionnaire and follow-up phone inquiries to owners or managers of each system. Contract Report 442 also presents detailed information on the communities served by each system and the total service population as of 1986 (the year of data collection). Sources of supply are documented, including reservoir names and names of inflowing streams. The system identification numbers adopted in the first report are also used in this report.

In-channel reservoir capacity projections were made following the methodology described in Water Survey Contract Report 446 *An Improved Methodology for Estimating Future Reservoir Storage Capacities: Application to Surface Water Supply Reservoirs in Illinois* (Singh et al., 1988b). Nearly all of the water supply reservoirs used in the present evaluation were considered in the previous reports. Some reservoir capacities were recalculated when information regarding recent dredging activities or the raising of dams became known. Differences between the reports are noted in the tables presented in this report. Capacities given in this report supersede previous values. Reservoirs are identified with the county in which the dam is located. The reservoir county association may differ from the county with which the system is identified.

Physical data on reservoirs used in all phases of this project, such as capacity, surface area, and drainage area, were obtained from a variety of sources. The primary sources of data are Water Survey files, contract reports, and published and unpublished reports of sediment surveys conducted or collected by ISWS staff members over the years. Water Survey professionals who have been principal contributors to this data collection effort are noted in the previous reports (Singh et al., 1988a and b). National Dam Safety Program Inspection Reports published by the Chicago District of the U.S. Army Corps of Engineers are available for many of the reservoirs. The Illinois Environmental Protection Agency (IEPA) report *Assessment and Classification of Illinois Lakes* (IEPA, 1978) was reviewed for data not found in the above noted literature. Additional information was obtained through phone interviews of system owners or operators. Finally, some surface areas and drainage areas were determined from U.S. Geological Survey (USGS) topographic quadrangles by planimetering. When several data sources contained information on the same reservoir, capacity and surface area values typically differed. The quality of the data used to make the estimate, the method of estimating, and the age of the reservoir when the data was collected all contribute to inconsistencies. Actual reservoir surveys are the most reliable sources, and this data was used when available. Every effort was made to resolve conflicting information. The data collection effort was extensive, and the physical data used represent the best information available for each reservoir.

ANALYSIS METHODS FOR DESIGN DROUGHT YIELDS

The yield was determined for each surface water supply source that is used on a regular basis by a system. When a system regularly uses more than one source, the cumulative yield of all sources was estimated. The following sections describe the methods used to compute the design drought yields of the various system sources. Some in-channel reservoirs and side-channel reservoirs that operate independently were evaluated using conventional methods. In some cases multiple sources are not operated independently, and these special cases are described individually. The implicit assumption in the reservoir yield analysis is that the reservoir is full at the beginning of the design drought.

In-channel Reservoirs

The in-channel reservoir yield analysis was performed following the methodology and using the data presented in Water Survey Bulletin 67 (Terstriep et al.,1982). Bulletin 67 presents the results of a nonsequential mass analysis of a low-flow series developed from daily streamflow data at gaging stations. The analysis provides a relationship between gross yield (or draft rate) in terms of the percentage of mean streamflow, reservoir capacity, drought duration, and drought recurrence interval in years. This multivariate relationship was determined for 160 gaging stations in Illinois. The information was regionalized and presented in a nondimensional format for extrapolation to ungaged streams within the same hydrologic region. Draft-storage-recurrence relations are given in graphic and tabular formats, in which draft is the quantity of water withdrawn; it is expressed as a percentage of mean annual streamflow. Storage (reservoir capacity) is the quantity of water that must be stored to maintain a given draft rate; it is expressed in units of inches on drainage area. Drought recurrence interval is expressed in years. A complete description of the analytical methods employed and the data used are provided in Bulletin 67. Application of the method and needed assumptions are discussed in this report The terms "capacity" and "storage" are used interchangeably in this report.

The geographic location; the drainage area of the inflowing stream; the mean annual inflow (i.e., runoff from the watershed); the capacity of the reservoir; and its surface area are required to perform yield calculations using the procedure outlined in Bulletin 67. On the basis of geographic location and drainage area, a streamgage station is selected with a draft-storage-recurrence relation similar to that for the stream under consideration. An evaporation data collection station is also selected that best represents local or regional conditions. The useful storage of the reservoir is converted to inches of runoff from the drainage area. The percentages of mean streamflow (from the drainage area above the dam creating the reservoir) that could be supplied reliably during a 20-year and a 50-year drought are determined from the station relationships given in Bulletin 67. Gross draft rate is calculated as the product of percent mean streamflow and the mean annual inflow into the reservoir. Losses due to evaporation are subtracted from the gross yield to determine the net yield from the reservoir. The net yield is expressed in units of millions of gallons per day.

The entire volume of water stored in a reservoir may not be usable; inaccessibility and the poor quality of bottom waters both can restrict the full use of gross storage. The volume of nonusable storage will vary from reservoir to reservoir. Useful reservoir storage was estimated as 90 percent of the gross reservoir storage for the purpose of performing the yield calculations.

Since most of the water supply reservoirs are on ungaged streams, it was necessary to use the draft-storage-recurrence relations from a gage on a different stream. The general procedure described in Bulletin 67 is to select a gage with a drainage area close to the drainage area above the site being considered and within the same hydrologic region as defined in the bulletin. Eleven regions are delineated in Bulletin 67. The regional boundaries represent gradual transitions rather than absolute delineations.

The sensitivity of results to gaging station selection was also investigated. The geographical variation of storage requirements (expressed as water depth in inches on drainage area) was inspected for selected draft rates (expressed as a percentage of mean annual streamflow) and drought recurrence intervals. The variation of storage requirement with drainage area was also explored. Storage values were taken from the derived relations at the gage sites, and comparisons were made for draft rates ranging from 2 to 20 percent of the mean streamflow and for 20- and 50-year drought recurrence intervals. Inspection of the variation of storage requirements at gaged sites within each of the 11 regions and composites of adjacent regions showed that storage requirements usually decrease with increasing drainage area. This observation also applies to the variation of storage requirements with drainage area in individual basins. Thus, to sustain a draft rate equal to a given percentage of mean streamflow, more storage is needed at streams with smaller drainage areas than at streams with larger drainage areas. This is consistent with the observation that the larger the drainage area of the stream, the less flow values will vary relatively about the mean flow. Storage requirements vary regionally as indicated by the delineation of the various regions in Bulletin 67. Within the same region, drainage area appears to be a dominant factor influencing the amount of reservoir storage required to supply a consistent designated percentage of the mean streamflow. In comparing the storage values for the various gaging stations, some sites were found to exhibit atypical relations.

Considering the observed trends in storage requirements, gages within the same basin were selected if the drainage areas were more or less similar. If no gages were located in the reservoir basin with drainage areas similar to the reservoir under consideration, a gage from a nearby basin was selected. Storage values for gages within the reservoir basin were compared to gages in nearby basins with similar drainage areas. A gage for a drainage area similar to that for the reservoir was selected from a nearby basin when consistently similar storage values were noted at comparable gages in the two basins. Other factors considered in selecting the gage relationships to use for a particular reservoir were the length of record at the gage, the consistency of the gage relationship with nearby gages, and similarity between the gage and the reservoir outlet locations relative to the stream network of their respective basins.

Mean Annual Inflow. Mean annual inflow to a reservoir can be expressed in terms of depth of water (in inches) over the entire watershed during a year. Conversely, the quantity of runoff at a particular location can be calculated in cubic feet per second (cfs) by multiplying the mean annual inflow (in inches) by the drainage area of the watershed (in square miles) and dividing by 13.58. Runoff represents the flow collected from a drainage basin (or watershed) that appears at the outlet of the basin or at another specific location along the stream (Chow, 1964). Daily flow data at a gaging station are used to compute watershed runoff at specific locations. The inflow to a reservoir from an ungaged stream must be estimated by interpolating data from gaged sites.

In Illinois, runoff tends to increase from north to south, as does precipitation. The statewide runoff variations may be depicted by contour plots of equal runoff values. Runoff contours were developed for southern Illinois north of the Shawnee Hill area by Knapp et al. (1989) and were compared to the annual runoff values calculated for the gages in Bulletin 67 and to runoff values for those streamgage stations that were active in 1987 and that had records of 25 or more years (USGS, 1987). On the basis of these sources of information, inflow values were determined for each reservoir.

Evaporation. Maximum net evaporation series for six stations in Illinois were developed by Terstriep et al. (1982). Net lake evaporation is defined as the total gross lake evaporation over a specified duration, minus the total concurrent precipitation for that duration. The six long-term evaporation stations in or near Illinois are located at Rockford, Moline, Peoria, Springfield, St. Louis, and Carbondale. The evaporation station nearest to the reservoir was used with some consideration of rainfall patterns as recommended in Bulletin 67. Evaporation from a particular reservoir was calculated as a function of its surface area. The net evaporation series incorporates precipitation that falls directly on the water surface of the reservoir. Therefore, the water surface area of the reservoir was subtracted from the watershed area for inflow calculations.

Reservoir Surface Area. The surface area of in-channel reservoirs decreases over time as part of the sedimentation process. Coarser sediments delivered to the reservoir are usually deposited near the stream-reservoir interface. Typically sedimentation forms a delta at the inflow location. Evaporation losses are directly proportional to water surface area. The reductions in surface areas observed in surveyed reservoirs were found to affect calculated evaporation losses significantly, and thus net yield results were also affected. A method was developed for estimating surface areas to correspond to reservoir capacity projections.

Reservoir surface area varies with capacity. For design purposes, surface area is often estimated from desired capacity. A typical functional relationship between surface area (SA) and capacity (CAP) as given by Dawes and Wathne (1968) is:

$$SA = 0.23(CAP)^{0.87} \tag{1}$$

Water Survey files contain surface area and capacity data from surveys of more than 11 different reservoirs in Illinois. As noted earlier, this database is the product of numerou sediment surveys conducted during the past 50 years. Based on this data the best-fit regression model for surface area as a function of capacity is:

$$SA = 0.4041(CAP)^{0.8336} \tag{2}$$

This is a general relation derived from data of single surveys of more than 100 reservoirs with drainage areas ranging from 0.8 to 925 square miles.

Capacity and surface area data from two or more surveys of the same reservoir are available for only seven reservoirs. Also available are the original surface area and capacity reported for these reservoirs. Surface area and capacity data are also available from the reported original construction and from a later survey for four other reservoirs. These data show that the rate of change of surface area with change in capacity due to sedimentation does not follow the trend indicated by the expression determined using data from several different reservoirs

A simple linear regression was used to establish individual relationships between the logarithms of surface area and capacity for each of the 11 reservoirs. The coefficients for the best-fit line are shown in table 2. The simple correlation coefficient and standard error are shown for those reservoirs with three or more data points. Information on original surface area and capacity were included in the regression analysis when available. The rate of change of surface area with capacity is indicated by the b coefficient, the slope of the regression line. The b coefficient is analogous to the power superscript of 0.8336 found in the general relation (equation 2). The b coefficient determined from the reservoir data ranges from 0.2412 to 0.4645 (dropping the outlier value of 0.5638 with low correlation coefficient). The average of the ten b coefficients is 0.33. The intercept, a coefficient, varies considerably from reservoir to reservoir. Reservoirs with larger drainage areas tend to have greater a coefficients. The ten reservoirs represent different counties and have drainage areas ranging from 1.41 to 925 square miles.

The expression derived from the combined data shows that in general the larger the capacity of the reservoir constructed, the larger the surface area. However, the gradual loss of surface area due to sediment accumulation is best shown by considering individual cases. As noted earlier, most of the water supply reservoirs have either been surveyed only once or not at all. Thus, data are not available to determine an independent best-fit model for calculating surface area as a function of capacity for each reservoir. In many cases no information is readily available on surface area at all.

A method of estimating reservoir surface areas was developed to correspond to the projected reservoir capacities. The b coefficient determined for the ten reservoirs has a fairly narrow range of values, with a standard error of 0.08 about the mean of 0.33. A linear model with a slope value of 0.33 was used to represent the rate of surface area loss with decrease in capacity due to sedimentation. A pair of values for surface area and capacity was obtained for each reservoir. In some cases it was necessary to obtain surface areas by planimetering the surface shown on topographic maps. The surface area value was determined at the same point in time as the capacity value to ensure that they corresponded. Using these values the a coefficient was calculated for each reservoir. The expression

$$\log SA = a + 0.33 (\log CAP) \tag{3}$$

was used to calculate the surface areas needed to determine evaporation losses in future years. The value of a can be obtained from known values of SA and CAP from the original design or from a sediment survey.

Side-Channel Reservoirs

Water is delivered to the side-channel reservoir from the source stream or river via a pumping system. The relationship between the pumping system capacity, the demand draft rate, and the streamflow variability governs the quantity of water that may be obtained from the stream. For the simplified case where the total runoff is adequate and the pumping system can withdraw available water from a range of streamflows, the side-channel capacity can just augment water withdrawals from the stream when they are less than the demand draft rate. The required storage would be equal to the accumulated streamflow deficit (flows less than demand) occurring over the duration of the design drought, including evaporation and other losses. However, most systems cannot accommodate enough variable-speed pumps to achieve continuous pumping over a range of streamflows. Most of the water supply systems have one or two single-speed pumps that limit both the quantity of water that can be pumped at any given time and the range of flows during which pumping can continue. Flows must be greater than the pumping capacity to operate the pump, and flows in excess of the pumping capacity cannot be captured.

The side-channel systems were evaluated using data and relationships presented in Water Survey Bulletin 66 *Hydrologic Design of Side-Channel Reservoirs in Illinois* (Knapp, 1982). It presents a relationship between draft rate (expressed as a percentage of mean annual flow), recurrence interval (in years), and storage (in terms of days of supply) for side-channel reservoirs. The data were determined on the basis of daily flow data at 87 streamgage stations. The dependence of the streamflow-storage relationship on demand is incorporated by expressing storage in units of days of demand. The graphically depicted relationships were derived on the basis of a pumping system using two variable-speed pumps that can operate during flows from 0.25 to 8 times the gross water supply demand or higher. This primary relationship is a reasonable approximation of the optimal pumping system. It indicates minimum storage requirements, or conversely, maximum sustained yield for a given storage capacity. A pumping system adjustment ratio may be determined for the existing pumping capacities available at a particular installation. In this case, the reliable yield is reduced in proportion to the adjustment ratio. The impacts of alternative minimum instream flow requirements are discussed in the report. Illinois currently does not have a set policy defining protected minimum flows, so calculations reflect no minimum flow requirements. Protected streamflow levels may be mandated in the future for the sake of instream flow needs such as streamwater quality, ecology, and aquatic habitats. Then the withdrawals will be limited to the flows exceeding the protected flow. Evaporation losses are incorporated in the relations presented in the report

Storage adequacy for each side-channel reservoir was evaluated for two pumping system scenarios. First, an optimal pumping arrangement is assumed using the unadjusted results from primary relationships presented in Bulletin 66 (i.e. two variable-speed pumps operating over a range of flows from 0.25 to 8 times the draft rate). Then the calculations were adjusted using the pumping system adjustment ratio determined for the existing installation. In order to develop information comparable to the 20- and 50-year recurrence interval yields of in-channel reservoirs, an iterative calculation was performed to assess the reliable yield corresponding to those recurrence intervals. It is assumed that storage does not significantly change over time, so a single maximum yield (optimal pumping system) and an adjusted yield (current pumping system) were calculated for each drought recurrence interval.

Low Channel Dams and Direct Withdrawals

Some systems rely on little or no storage of streamwater. Low in-channel dams are often constructed to ensure that the pump intakes are immersed during low-flow periods, which typically last only a few days or weeks. In most cases low in-channel dams create little storage compared to the drainage area of the river. Yield calculations using the method for in-channel impoundments typically indicate reliable draft rates that are less than 2 percent of the mean annual inflow, but these rates are outside of the calculation range using the method of Bulletin 67. However, because the river drainage area in the vicinity of the impoundment is typically large, 2 percent or less of the mean annual inflow may be adequate to meet demand. Storage for a few days or weeks afforded by the low channel dam is sufficient to supplement low flows. Low-flow and drought-flow statistics for the source stream or river are provided for those systems that essentially rely on direct withdrawals from a stream or river. Low-flow statistics were determined on the basis of data from a nearby gaging station (adjusted for differences in drainage area). The drainage area of a stream at the intake location was estimated from either the drainage area of a nearby gage or by planimetering the drainage area using USGS topographic quadrangles. In some cases the location of the intakes is shown on USGS quadrangle maps, or it was described by the water treatment plant operator. If no information was available, the intakes were assumed to be upstream of the town or near a likely transmission line path from the river to the town. The 7-, 15-, 31-, and 61-day low flows and 3-, 5-, and 7-month low flows for 20- and 50-year recurrence intervals were calculated using daily flow data. These values were compared to the projected demands for the systems. Low-flow values range from less than demand to more than demand. The gage name, drainage area, and period of record are also given.

Typically, no firm information exists regarding the storage provided by low in-channel dams. Water supply system owners or operators were contacted to obtain information on the height and width of dams or estimates of days of storage based on their observations. This information is noted in the evaluation of the systems.

Multiple-Source Systems

Approximately one-third of the systems use some combination of sources to meet demand. Examples of multiple sources include two in-channel reservoirs; two side-channel reservoirs that receive water from the same stream; two side-channel reservoirs that obtain water from different streams; a side-channel reservoir that is filled with water pumped from an in-channel reservoir; and an in-channel reservoir that is augmented by water pumped from another stream, supplemental pumping of ground water to reservoirs, and system cross-connections. Procedures were developed to evaluate some of these system arrangements in a standard manner. Evaluations of systems with particularly unusual arrangements are discussed on a case-by-case basis in the section on results.

In cases where the two sources are operated independently, such as the two in-channel reservoirs or the two side-channel reservoirs that pump from different streams, each system was analyzed independently and the yields were added. When the durations of the low-flow periods for the in-channel reservoirs differed, they are listed separately. Given the proximity of the supply reservoirs, it is likely that low flows comparable to the statistical 20- and 50-year events would occur concurrently for each stream involved. The calculated yields represent the worst case for each source.

Some systems pump water from an in-channel reservoir to a side-channel reservoir. Both the in-channel and side-channel reservoirs were assumed to be full at the beginning of the drought period. It was also assumed that pumping would keep the side-channel reservoir as full as possible, thus allowing the in-channel impoundment to retain the inflow. On the basis of these assumptions, yields were calculated according to the method of Bulletin 67, using the summed capacities and surface areas of both impoundments. The yields thus calculated may sometimes be overestimated if the pumping system is not adequate to keep the side-channel full when overflow occurs at the in-channel dam.

When two or more side-channel reservoirs are used to store water from the same source stream, they were assumed to function as a single side-channel reservoir. Yield calculations were made on the basis of the sum of the capacities of the side-channel reservoirs. This arrangement is limited by the particular pumping and transmission line arrangement. Because this study was intended to examine the yield from the source, limitations imposed by facility arrangements were not investigated.

Ground water is sometimes discharged to an in-channel or side-channel reservoir. In such cases, the in-channel or side-channel yield analysis was performed as if no ground water were available. The well pump capacities are reported, but losses due to ground-water evaporation from the storage facility were not estimated. In all cases where ground water is used, the pump capacities are given if the information was available. Information on the long-term reliable well yields is given if it was available from Water Survey files. An in-depth investigation of ground-water sources was not made.

In a few cases, water was pumped from one stream to an in-channel impoundment on another stream. A relatively large in-channel impoundment may thus be constructed on a small tributary stream to take advantage of a natural topography, and water may be pumped to it regularly from a larger stream or river. When natural drainage to the reservoir is small compared to the water pumped from the supplementary surface water source, the reservoir essentially acts as a side-channel impoundment. However, the capacity may be somewhat reduced due to sedimentation. Assuming that the reservoir functions only as a side-channel storage facility, yield was also determined for each projected capacity. The reservoir yield was then calculated to account only for natural drainage to the impoundment, and this yield was compared to the side-channel yield value. The larger of the two values is reported. When the natural runoff is large compared to the water pumped from the auxiliary stream, the yield of the reservoir from natural runoff is given, and the pumping capacity from the other source is reported.

Drought Demand

Water use is usually higher during the summer and fall than in the winter and spring. Demands given in this report are the annual average daily water use, Q_d. In terms of the annual average, a typical distribution of water use during a year may be: spring Q_d, summer $I.2Q_d$, autumn Q_d, and winter $0.8Q_d$. Depending on the timing and duration of a drought, water use can be higher than the annual average water demand. This is particularly true if high temperatures accompany periods of low rainfall. High temperatures can lead to greater water use for cooling and high soil-moisture evaporation, which may result in large water consumption for lawn, landscape, and garden maintenance. In some rural communities ponds and streams may go dry, making it necessary to purchase water for livestock. Public water supply systems typically do not provide water for agricultural irrigation.

The extreme drought of 1988 affected most of the state and provided an opportunity to investigate water use during a drought period. Water use for June, July, and August of 1988 and the role of water use restrictions were studied for 28 of the water supply systems in this study. The average daily water use for the three-month period was compared to the reported average annual water use for 1986. Some communities observed voluntary water use restrictions, such as limited lawn watering and car washing. Other communities, such as Decatur, Springfield, Bloomington, and Pontiac, imposed mandatory limits on water use. Increases in water use during a drought were estimated on the basis of reported water use and in light of water use restrictions. If water use is unlimited, the average annual demand may rise to about 1.2 times the projected demand if the drought lasts longer than a year. Water demand during droughts that last less than a year may be 1.3 times the projected annual average if the drought occurs during the summer months when water use is high. These multipliers were used to estimate maximum demands for the years 1990, 2000, 2010, and 2020. The estimated maximum demands are given along with the projected average annual demands for each system.

The estimated maximum demands reflect unlimited water use during drought conditions. Much of the additional water use could be minimized through the enactment of voluntary or mandatory water use restrictions for nonessential applications. The information collected through our phone survey suggests that the imposition of water use restrictions was effective, particularly when the public was aware of the water supply

situation. A key factor in avoiding water shortages due to excessive water use during a drought is early recognition of the impending drought and reduction in water use during potential drought conditions. Those systems unable to support unlimited water use during droughts are identified in table 5 of this report. The table can be considered a guide to those systems that could become inadequate unless limitations are imposed on water use.

RESULTS

Each system evaluated in this study is listed alphabetically in table 1 and cross-referenced by system number. The system numbers are the same ones used in the previous report *Future Water Demand of Public Surface Water Supply Systems in Illinois* (Singh et al., 1988). Average annual water demands and estimated design drought yields Y (Y_{20} for a 20-year and Y_{50} for a 50-year drought) in millions of gallons per day (mgd) for 1990, 2000, 2010, and 2020 are listed in table 3 for each system. The systems are grouped according to the county in which the system owner or operator is located. The reservoirs are typically associated with the county where the dam is located, but this may differ from the system county. The counties are arranged alphabetically, and the systems within the county are also listed alphabetically. An explanation of symbols used in table 3 follows the table. Explanatory notes are provided for most of the systems, and these also follow table 3. An asterisk appears by the system name to indicate a note; notes are not numbered consecutively but referenced by the system number. Systems with yields less than the projected average annual demand Q_d and having no adequate auxiliary water source are identified with a double asterisk by the system name. In some cases it was not appropriate to include the yield from an auxiliary source in the yield values shown in table 3. A superscript appears next to those systems with auxiliary sources available that are adequate to meet demands. These systems are not listed as potentially inadequate, even though some tabulated yield values are less than demand.

Systems that may not have a water supply adequate to meet the annual average daily demand, Q_d, during the next 30 years were ranked according to the year and the drought recurrence interval when yields may be less than demand, Q_d. Twenty-four systems show either a 20- or 50-year drought yield less than Q_d. These systems are listed in table 4, along with the critical drought recurrence interval and the year (1990, 2000, 2010, or 2020) the system will become deficient. Deficient systems with yields less than the maximum projected demand (1.2 or 1.3 times Q_d) were ranked with respect to year and drought recurrence interval. These systems are listed in table 5. Systems that may experience water shortages during a drought comparable to the 20-year design drought are ranked higher (i.e.,

more critical) than a system that would encounter problems in the same year but for drought conditions similar to a 50-year event. Systems with standby water sources that are adequate to meet water demands were not considered in the ranking, even though tabulated yield values are less than the demands. All of the systems listed in table 4 are also listed in table 5, but the relative rankings may differ between the two tables.

The yield values provided in table 3 are the best estimates possible on the basis of available data. Assumptions are involved in each yield calculation. Assumptions related to the yield analysis applied are described in the methodology section of this report. Other sources of uncertainty may influence results measurably. Without benefit of an actual survey, the reservoir capacities used may be significant sources of uncertainly. Evaporation series used in the analyses reflect long-term averages. As illustrated by the events of 1988, higher than average temperatures (averaging 3 to 5 degrees above normal) were the driving force behind evaporation rates that were as much as 50 percent higher than the long-term averages. Calculations performed for this study show that water loss due to evaporation from the reservoir surface is significant. A 50 percent increase in evaporation rates would result in measurable yield reductions. Seepage losses were not directly addressed in the calculations. Table 4 includes those systems most at risk for meeting Q_d, and table 5 includes those capable of meeting 1.2 to 1.3 times Q_d. For evaluations of individual systems, some factor of safety should be applied to the yield values.

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Table 1. Alphabetic List of Public Water Supply Systems

System number	*System name*	*County*
046	ADGPTV Water Comm.	Macoupin
021	Altamont	Effingham
079	Alto Pass	Union
003	Ashland	Cass
084	Ashley	Washington
042	Blandinsville	McDonough
044	Bloomington	McLean
011	Breese	Clinton
065	Camelot Water Company	Peoria
028	Canton	Fulton
035	Carbondale	Jackson
047	Carlinville	Macoupin
012	Carlyle	Clinton
074	Carrier Mills	Saline
033	Carthage	Hancock
056	Centralia	Marion
014	Charleston	Coles
008	Clay City	Clay
068	Coulterville	Randolph
045	Decatur	Macon
080	Dongola	Union
018	Douglas Water Co. (Quantum Chemical Corp.)	Douglas
022	Effingham	Effingham
075	Eldorado Water Co.	Saline
090	Eureka	Woodford
069	Evansville	Randolph
086	Fairfield	Wayne
023	Farina	Fayette
009	Flora	Clay
081	Georgetown	Vermilion
048	Gillespie	Macoupin
031	Greenfield	Greene
001	Greenville	Bond
049	Hettick	Macoupin
054	Highland	Madison
061	Hillsboro	Montgomery
055	Holiday Shores Subd.	Madison
082	Inter-State Water Company (Danville)	Vermilion
063	Jacksonville	Morgan
039	Kankakee Water Co. (Kankakee)	Kankakee
072	Kaskaskia Water District	St Clair
013	Keyesport	Clinton
005	Kincaid	Christian
036	Kinkaid Reeds Creek Intercity Water System	Jackson
057	Kinmundy	Marion
034	La Harpe	Hancock

Table 1. (concluded)

System number	*System name*	*County*
062	Litchfield	Montgomery
076	Loami	Sangamon
010	Louisville	Clay
043	Macomb	McDonough
088	Marion	Williamson
015	Mattoon	Coles
050	Mount Olive	Macoupin
037	Mount Vernon	Jefferson
085	Nashville	Washington
017	Neoga	Cumberland
077	New Berlin	Sangamon
041	Northern Ill. Water Corp (Pontiac)	Livingston
040	Northern Ill. Water Corp (Streator)	La Salle
016	Oakland	Coles
083	Oakwood	Vermilion
071	Olney	Richland
030	Omaha	Gallatin
051	Palmyra-Modesto Water Commission	Macoupin
006	Pana	Christian
019	Paris	Edgar
058	Patoka	Marion
066	Pinckneyville	Perry
067	Pittsfield	Pike
026	Rend Lake Intensities Water System	Franklin
027	Royalton	Franklin
024	St Elmo	Fayette
059	Salem	Marion
052	Shipman	Macoupin
002	Sorento	Bond
089	Southern Illinois Electric Co-op	Williamson
070	Sparta	Randolph
078	Springfield	Sangamon
053	Staunton	Macoupin
073	Summerfield, Lebanon, Mascoutah Water Commission	St. Clair
007	Taylorville	Christian
025	Vandalia	Fayette
029	Vermont	Fulton
038	Vienna	Johnson
004	Virginia	Cass
060	Waterloo	Monroe
064	Waverly	Morgan
087	Wayne City	Wayne
020	West Salem	Edwards
032	White Hall	Greene

Table 2. Linear Regression Coefficients for Estimating Surface Area

Drainage area (sq mi)	*Reservoir name*	*County*	*a*	*b*	*r*	*n*	*SE*	*for b = 0.33*	
								a	*SE*
1.41	Ridge Lake	Coles	0.6694	0.2589	--	2		0.5083	0.0013
2.07	Mt. Sterling	Brown	0.7440	0.3097	0.9947	3	0.0027	0.6389	0.0026
2.23	Eldorado	Saline	1.0528	0.3199	-	2		1.0235	0.0003
11.10	Lake Pittsfield	Pike	0.8157	0.4509	-	2	0.0054	1.2379	0.0069
18.10	Lake Paradise	Coles	0.8159	0.4460	-	2		1.1895	0.0034
20.20	Spring Lake	McDonough	0.3574	0.5638	0.8130	4		Dropped	
32.60	Lake Mauvaisse Terre	Morgan	1.4887	0.2632	0.9947	3	0.0052	1.3881	0.0112
89.10	LakeBraken	Knox	1.3392	0.2697	0.9550	4	0.0038	1.1341	0.0040
265.0	Lake Springfield	Sangamon	1.7227	0.3990	0.9917	3		2.0497	0.0023
298.0	Lake Vermilion	Vermilion	1.4966	0.3556	0.9309	3	0.0193	1.5913	0.0161
925.0	Decatur Lake (old)	Macon	2.4145	0.2412	0.9578	3		2.0390	0.0057

Note: Log SA = a + b logCAP

Table 3. Surface Water Supply Systems: Water Use and Drought Yields, 1990-2020

System	*System*		*Estimated*			
number	*name*		*1990*	*2000*	*2010*	*2020*
001	Greenville*	Q_d	0.660	0.659	0.664	0.702
		$1.2\ Q_d$	0.792	0.791	0.797	0.842
		Y_{20}	5.39	5.34	5.28	5.23
		Dur.	30	30	30	30
		Y_{50}	2.92	2.90	2.86	2.83
		Dur.	58	58	58	58
002	Sorento**	Q_d	0.068	0.068	0.067	0.070
		$1.2\ Q_d$	0.082	0.082	0.080	0.084
		Y_{20}	0.060	0.060	0.060	0.060
		Dur.	20	20	20	20
		Y_{50}	0.040	0.030	0.030	0.030
		Dur.	58	18	18	18
003	Ashland*[c, s]	Q_d	0.109	0.106	0.103	0.107
		$1.2\ Q_d$	0.131	0.127	0.124	0.128
		Y_{20}	0.11	0.11	0.11	0.11
		Dur.	36	36	36	36
		Y_{50}	0.08	0.08	0.08	0.08
		Dur.	54	54	54	54
004	Virginia*[c]	Q_d	0.178	0.168	0.162	0.167
		Q_{sw}	0.062	0.059	0.057	0.058
		$1.2\ Q_{sw}$	0.068	0.065	0.081	0.083
		Y_{20}	0.19	0.18	0.18	0.17
		Dur.	32	32	32	18
		Y_{50}	0.13	0.12	0.12	0.12
		Dur.	56	56	56	56
005	Kincaid*	Q_d	0.224	0.220	0.220	0.226
		$1.3\ Q_d$	0.291	0.286	0.286	0.294
		Y_{20}	17.57	17.48	17.42	17.36
		Y_{50}	11.60	11.56	11.54	11.48
006	Pana	Q_d	1.140	1.094	1.065	1.080
		$1.2\ Q_d$	1.368	1.313	1.278	1.296
		Y_{20}	1.96	1.93	1.82	1.80
		Dur.	42	42	20	20
		Y_{50}	1.33	1.32	1.31	1.30
		Dur.	56	56	56	56
007	Taylorville*[c]	Q_d	2.546	2.530	2.510	2.536
		$1.3\ Q_d$	3.310	3.289	3.263	3.297
		Y_{20}	7.12	6.45	5.59	4.88
		Dur.	9	9	8	8
		Y_{50}	5.19	4.73	4.33	3.93
		Dur.	18	18	18	18

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
008	Clay City*, [8]	Q_d	0.100	0.099	0.098	0.103
		1.3 Q_d	0.130	0.129	0.127	0.134
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{3MD}
		20 yr	0.16	0.24	0.68	2.60
		50 yr	0.05	0.13	0.22	0.71
009	Flora**	Q_d	0.757	0.784	0.803	0.848
		1.3 Q_d	0.984	1.019	1.044	1.102
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{3MD}
		20 yr	0.15	0.23	0.67	2.59
		50 yr	0.04	0.12	0.21	0.70
010	Louisville*, [8]	Q_d	0.097	0.102	0.111	0.124
		1.3 Q_d	0.126	0.133	0.144	0.161
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{3MD}
		20 yr	0.16	0.24	0.68	2.60
		50 yr	0.05	0.13	0.22	0.71
011	Breese*	Q_d	0.616	0.660	0.679	0.704
		1.3 Q_d	0.801	0.858	0.883	0.915
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{61DLF}
		20 yr	1.16	1.29	2.20	3.49
		50 yr	0.75	0.84	1.48	2.58
012	Carlyle*	Q_d	0.725	0.752	0.761	0.783
		1.3 Q_d	0.942	0.978	0.989	1.018
		Direct:				
			Q_{7DLF}			
		20 yr	17			
		50 yr	13			
013	Keyesport*	Q_d	0.040	0.044	0.047	0.051
		1.3 Q_d	0.052	0.057	0.061	0.066
		Y_{20}	271.2	266.5	261.8	257.1
		Dur.	9	9	9	9
		Y_{50}	153.9	151.6	150.6	140.0
		Dur.	18	18	18	9
014	Charleston*	Q_d	1.865	2.043	2.289	2.580
		1.3 Q_d	2.425	2.656	2.976	3.354
		Y_{20}	9.55	Adj Y_{20}	5.97	
		Y_{50}	5.57	Adj Y_{50}	3.78	

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
015	**Mattoon***	Q_d	2.682	2.696	2.785	2.859
		1.2 Q_d	3.218	3.235	3.342	3.431
		Y_{20}	6.58	6.37	6.14	5.90
		Dur.	11	11	11	11
		Y_{50}	4.08	3.86	3.64	3.40
		Dur.	18	18	18	18
016	**Oakland****	Q_d	0.117	0.117	0.121	0.130
		1.3 Q_d	0.152	0.152	0.157	0.169
		Y_{20}	0.15	0.11	0.09	<0.05
		Dur.	7	7	7	7
		Y_{50}	<0.05	<0.05	<0.05	<0.05
		Dur.	10	10	10	10
017	**Neoga***	Q_d	0.138	0.137	0.136	0.136
		1.2 Q_d	0.165	0.164	0.163	0.163
		Y_{20}	5.53	5.37	5.18	5.00
		Dur.	18	18	18	18
		Y_{50}	3.46	3.28	3.10	2.90
		Dur.	18	18	18	18
018	**Douglas Water Co.***	Q_d	0.638	0.631	0.635	0.666
		Q_{sw}	0.345	0.341	0.343	0.356
		1.3 Q_{sw}	0.449	0.443	0.446	0.463
		Y_{20}	1.37			
		Y_{50}	0.91			
019	**Paris****	Q_d	1.237	1.241	1.245	1.286
		1.3 Q_d	1.608	1.613	1.618	1.672
		Y_{20}	1.47	1.42	1.36	1.31
		Dur.	11	11	11	11
		Y_{50}	0.93	0.89	0.84	0.82
		Dur.	18	18	18	18
020	**West Salem****	Q_d	0.118	0.130	0.141	0.154
		1.2 Q_d	0.142	0.156	0.169	0.185
		Y_{20}	0.10	0.08	0.07	0.07
		Dur.	16	16	16	16
		Y_{50}	0.06	0.05	0.05	0.04
		Dur.	18	18	18	18
021	**Altamont*, 8**	Q_d	0.261	0.268	0.272	0.285
		1.2Q_d	0.313	0.322	0.326	0.342
		Y_{20}	0.36	0.36	0.36	0.36
		Dur.	42	42	42	42
		Y_{50}	0.26	0.26	0.26	0.26
		Dur.	54	54	54	54

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
022	Effingham*	Q_d	1.407	1.424	1.439	1.500
		$1.2\ Q_d$	1.688	1.709	1.727	1.800
		Y_{20}	4.75	4.74	4.71	4.69
		Y_{50}	3.48	3.46	3.45	3.44
023	Farina**, c	Q_d	0.118	0.123	0.125	0.129
		$1.3\ Q_d$	0.153	0.160	0.162	0.168
		Y_{20}	0.078	Adj Y_{20}	0.037	
		Y_{50}	0.037	Adj Y_{50}	0.026	
024	St. Elmo*	Q_d	0.251	0.261	0.274	0.296
		$1.2\ Q_d$	0.301	0.313	0.329	0.355
		Y_{20}	0.57	0.53	0.50	0.48
		Y_{50}	0.38	0.38	0.35	0.35
025	Vandalia	Q_d	0.917	0.915	0.912	0.928
		$1.2\ Q_d$	1.100	1.098	1.094	1.114
		Y_{20}	3.97	3.91	3.84	3.78
		Dur.	18	18	18	18
		Y_{50}	2.71	2.64	2.58	2.47
		Dur.	20	20	20	18
026	Rend Lake Intercities Water System	Q_d	14.394	14.960	15.792	16.670
		$1.2\ Q_d$	17.219	17.952	18.950	20.004
		Y_{20}	110.26	106.72	103.42	100.13
		Dur.	16	16	16	16
		Y_{50}	94.60	92.78	90.20	87.36
		Dur.	30	30	30	30
027	Royalton*	Q_d	0.193	0.191	0.189	0.196
		$1.3\ Q_d$	0.251	0.248	0.246	0.255
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{61DLF}
		20 yr	15	16	19	23
		50 yr	13	14	17	20
028	Canton**	Q_d	1.548	1.448	1.384	1.380
		$1.2\ Q_d$	1.858	1.738	1.661	1.656
		Y_{20}	1.95	1.86	1.76	1.68
		Dur.	20	20	20	20
		Y_{50}	1.46	1.39	1.26	1.19
		Dur.	30	30	20	20

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
029	Vermont	Q_d	0.070	0.061	0.056	0.054
		$1.3\ Q_d$	0.091	0.079	0.073	0.070
		Y_{20}	0.19	0.16	0.14	0.10
		Dur.	18	10	10	8
		Y_{50}	0.14	0.12	0.11	0.09
		Dur.	16	12	12	11
030	Omaha	Q_d	0.042	0.043	0.042	0.043
		$1.2\ Q_d$	0.050	0.052	0.050	0.052
		Y_{20}	0.07	0.07	0.07	0.07
		Dur.	20	20	20	20
		Y_{50}	0.05	0.05	0.05	0.05
		Dur.	32	32	32	32
031	Greenfield**	Q_d	0.092	0.089	0.088	0.091
		$1.2\ Q_d$	0.110	0.107	0.106	0.109
		Y_{20}	0.24	0.23	0.23	0.22
		Dur.	22	22	22	22
		Y_{50}	0.09	0.09	0.09	0.08
		Dur.	56	56	56	56
032	White Hall**	Q_d	0.234	0.234	0.233	0.241
		$1.2\ Q_d$	0.281	0.281	0.280	0.289
		Y_{20}	0.18	0.18	0.17	0.17
		Dur.	22	22	22	22
		Y_{50}	0.07	0.07	0.07	0.07
		Dur.	56	56	56	56
033	Carthage*, c, s	Q_d	0.261	0.266	0.269	0.278
		$1.2\ Q_d$	0.313	0.319	0.323	0.334
		Y_{20}	0.33	0.31	0.30	0.29
		Dur.	18	18	18	18
		Y_{50}	0.27	0.25	0.24	0.23
		Dur.	16	16	16	16
034	La Harpe*, c, s	Q_d	0.123	0.131	0.134	0.138
		Q_{sw}	0.074	0.079	0.080	0.083
		$1.3\ Q_{sw}$	0.096	0.103	0.104	0.108
		Y_{20}	0.21	Adj Y_{20}	0.12	
		Y_{50}	0.11	Adj Y_{50}	0.06	
035	Carbondale*	Q_d	4.442	4.486	4.820	5.202
		$1.2\ Q_d$	5.330	5.383	5.784	6.242
		Y_{20}	10.64	10.55	10.44	10.32
		Y_{50}	7.70	7.56	7.46	7.34

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
036	**Kinkaid Reeds Creek Intercity Water System***	Q_d	1.923	1.961	2.102	2.243
		$1.3\ Q_d$	2.500	2.549	2.733	2.916
		Y_{20}	31.36	31.18	31.03	30.85
		Dur.	58	58	58	58
		Y_{50}	24.56	24.38	24.24	24.05
		Dur.	58	58	58	58
037	**Mt. Vernon* self-supplied**	Q_d	3.634	3.913	4.171	4.445
		Q_{sw}	0.727	0.783	0.834	0.889
		$1.3\ Q_{sw}$	0.872	0.940	1.001	1.067
		Y_{20}	1.79	1.73	1.64	1.57
		Y_{50}	1.52	1.47	1.40	1.31
038	**Vienna***	Q_d	0.233	0.253	0.265	0.287
		$1.2\ Q_d$	0.280	0.304	0.318	0.344
		Y_{20}	0.69	0.68	0.68	0.67
		Dur.	54	32	32	32
		Y_{50}	0.58	0.57	0.57	0.57
		Dur.	32	32	32	32
039	**Kankakee Water Co.***	Q_d	11.228	11.117	11.204	11.686
		$1.3\ Q_d$	14.596	14.452	14.565	15.192
		Direct:				
			Q_{7DLF}			
		20 yr	257.2			
		50 yr	221.1			
040	**Northern Illinois Water Co. (Streator)***	Q_d	2.583	2.423	2.312	2.282
		$1.3\ Q_d$	3.358	3.150	3.006	2.967
		Y_{20}	7.3	Adj Y_{20}	4.0	
		Y_{50}	6.8	Adj Y_{50}	3.84	
041	**Northern Illinois Water Co. (Pontiac)****	Q_d	1.864	1.961	2.030	2.122
		$1.3\ Q_d$	2.423	2.549	2.639	2.759
		Direct:				
			Q_{7DLF}	Q_{15DLF}	Q_{31DLF}	Q_{61DLF}
		20 yr	1.3	1.5	1.7	2.3
		50 yr	1.0	1.1	1.3	1.7
042	**Blandinsville*, c**	Q_d	0.067	0.065	0.066	0.069
		$1.3\ Q_d$	0.087	0.084	0.086	0.090
		Y_{20}	0.16	Adj Y_{20}	0.08	
		Y_{50}	0.09	Adj Y_{50}	0.05	

Table 3. (continued)

System number	*System name*		*Estimated* 1990	2000	2010	2020
043	Macomb*[c,s]	Q_d	1.866	1.886	2.027	2.186
		1.2 Q_d	2.239	2.263	2.432	2.623
		Y_{20}	2.10	2.04	1.98	1.91
		Dur.	18	18	18	18
		Y_{50}	1.71	1.65	1.60	1.51
		Dur.	16	16	16	16
044	Bloomington**	Q_d	10.146	11.993	12.735	13.481
		1.2 Q_d	12.175	14.392	15.282	16.177
		Y_{20}	13.88	13.66	13.41	13.19
		Y_{50}	10.80	10.60	10.40	10.19
		Dur.	20	20	20	20
045	Decatur**[c]	Q_d	26.027	28.242	30.301	32.266
		1.3 Q_d	33.835	36.715	39.391	41.946
		Y_{20}	31.16	29.30	28.24	26.48
		Dur.	7	7	7	6
		Y_{50}	28.58	26.16	24.71	23.66
		Dur.	8	7	7	7
046	ADGPTV Water Comm.*	Q_d	1.339	1.385	1.417	1.483
		1.2 Q_d	1.607	1.662	1.700	1.780
		Y_{20}	5.41	5.38	5.36	5.33
		Dur.	46	46	46	46
		Y_{50}	2.65	2.63	2.62	2.60
		Dur.	58	58	58	58
047	Carlinville**	Q_d	0.766	0.777	0.785	0.815
		1.2 Q_d	0.919	0.932	0.942	0.978
		Y_{20}	1.78	1.73	1.67	1.62
		Dur.	20	20	18	18
		Y_{50}	0.83	0.81	0.79	0.76
		Dur.	56	56	56	56
048	Gillespie*	Q_d	0.699	0.697	0.702	0.724
		1.2 Q_d	0.839	0.836	0.842	0.869
		Y_{20}	1.79	1.76	1.72	1.70
		Dur.	20	20	20	20
		Y_{50}	0.80	0.78	0.77	0.75
049	Hettick*	Q_d	0.020	0.020	0.020	0.021
		1.2 Q_d	0.024	0.024	0.024	0.025
		Y_{20}	0.43	0.41	0.40	0.38
		Dur.	20	20	20	20
		Y_{50}	0.19	0.18	0.18	0.17
		Dur.	56	56	56	56

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
050	Mt. Olive**	Q_d	0.250	0.245	0.240	0.243
		1.3 Q_d	0.325	0.318	0.312	0.316
		Y_{20}	0.44	0.41	0.34	0.31
		Y_{50}	0.24	0.23	0.20	0.18
051	Palmyra Modesto Water Comm.**	Q_d	0.114	0.121	0.123	0.129
		1.2 Q_d	0.137	0.145	0.148	0.155
		Y_{20}	0.26	0.26	0.25	0.24
		Dur.	20	20	20	20
		Y_{50}	0.11	0.10	0.10	0.10
		Dur.	58	58	58	58
052	Shipman**	Q_d	0.062	0.065	0.065	0.066
		1.2 Q_d	0.074	0.078	0.078	0.079
		Y_{20}	0.06	0.05	0.05	0.05
		Dur.	20	20	20	20
		Y_{50}	0.02	0.02	0.02	0.02
		Dur.	58	58	58	58
053	Staunton**	Q_d	0.515	0.522	0.540	0.568
		1.2 Q_d	0.618	0.626	0.648	0.682
		Y_{20}	0.61	0.60	0.57	0.56
		Dur.	30	30	20	20
		Y_{50}	0.35	0.35	0.34	0.34
		Dur.	42	42	42	42
054	Highland*	Q_d	0.957	1.000	1.037	1.097
		1.2 Q_d	1.148	1.200	1.244	1.316
		Y_{20}	5.32	5.06	4.82	4.58
		Dur.	18	18	18	18
		Y_{50}	3.53	3.08	2.97	2.82
		Dur.	42	14	14	14
055	Holiday Shores Subdivision*	Q_d	0.152	0.183	0.198	0.209
		1.2 Q_d	0.182	0.220	0.238	0.251
		Y_{20}	1.59	1.58	1.56	1.55
		Dur.	44	44	44	44
		Y_{50}	0.91	0.90	0.89	0.88
		Dur.	56	56	56	56
056	Centralia*, s	Q_d	3.869	4.115	4.303	4.577
		1.2 Q_d	4.643	4.938	5.164	5.492
		Y_{20}	5.98	5.84	5.69	5.55
		Y_{50}	4.76	4.63	4.50	4.36

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
057	Kinmundy*	Q_d	0.107	0.111	0.115	0.119
		$1.2\ Q_d$	0.128	0.133	0.138	0.143
		Y_{20}	0.17	0.17	0.17	0.17
		Dur.	30	30	30	30
		Y_{50}	0.14	0.14	0.14	0.14
		Dur.	56	56	56	56
058	Patoka$^{*, s}$	Q_d	0.065	0.070	0.074	0.080
		$1.3\ Q_d$	0.084	0.091	0.096	0.104
		Y_{20}	0.11	Adj Y_{20}	0.10	
		Y_{50}	0.05	Adj Y_{50}	0.05	
059	Salem*	Q_d	1.069	1.135	1.173	1.242
		$1.3\ Q_d$	1.390	1.476	1.525	1.615
		Y_{20}	271.60	266.91	262.22	257.72
		Dur.	9	9	9	9
		Y_{50}	154.26	151.98	150.94	140.29
		Dur.	18	18	18	9
060	Waterloo**	Q_d	0.504	0.579	0.621	0.663
		$1.2\ Q_d$	0.605	0.695	0.745	0.796
		Y_{20}	0.56	0.56	0.55	0.54
		Y_{50}	0.49	0.48	0.48	0.47
061	Hillsboro*	Q_d	1.024	1.045	1.061	1.108
		$1.2\ Q_d$	1.229	1.254	1.273	1.330
		Y_{20}	9.62	9.36	9.12	8.91
		Dur.	20	20	20	20
		Y_{50}	5.00	4.91	4.79	4.70
062	Litchfield*	Q_d	1.267	1.283	1.315	1.367
		$1.2\ Q_d$	1.520	1.540	1.578	1.640
		Y_{20}	10.68	10.09	9.09	8.43
		Dur.	20	20	10	10
		Y_{50}	5.78	5.29	4.76	4.19
		Dur.	18	18	18	18
063	Jacksonville$^{*, c, s}$	Q_d	3.907	3.916	3.934	4.104
		Q_{sw}	1.172	1.175	1.180	1.231
		$1.3\ Q_{sw}$	1.524	1.528	1.534	1.600
		Y_{20}	3.14	3.01	2.87	2.72
		Y_{50}	1.39	1.29	1.19	1.05

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
064	Waverly*	Q_d	0.120	0.119	0.119	0.124
		$1.2\ Q_d$	0.144	0.143	0.143	0.149
		Y_{20}	0.58	0.57	0.56	0.56
		Dur.	20	20	20	20
		Y_{50}	0.27	0.26	0.26	0.26
		Dur.	56	56	56	56
065	Camelot Water Co., Inc.*	Q_d	0.069	0.084	0.090	0.097
		$1.2\ Q_d$	0.083	0.101	0.108	0.116
		Y_{20}	0.26	0.25	0.24	0.23
		Dur.	18	18	18	18
		Y_{50}	0.21	0.20	0.19	0.18
		Dur.	20	20	20	20
066	Pinckneyville	Q_d	0.634	0.677	0.702	0.745
		$1.2\ Q_d$	0.761	0.812	0.842	0.894
		Y_{20}	1.80	1.77	1.73	1.70
		Dur.	20	20	20	20
		Y_{50}	1.40	1.39	1.37	1.36
		Dur.	44	44	44	44
067	Pittsfield	Q_d	0.435	0.428	0.426	0.440
		$1.2\ Q_d$	0.522	0.514	0.511	0.528
		Y_{20}	1.87	1.71	1.56	1.43
		Dur.	22	20	18	18
		Y_{50}	1.39	1.28	1.19	1.08
		Dur.	24	24	24	24
068	Coulterville**	Q_d	0.156	0.160	0.163	0.167
		$1.3\ Q_d$	0.203	0.208	0.212	0.217
		Y_{20}	0.11	0.11	0.11	0.11
		Dur.	16	16	16	16
		Y_{50}	0.09	0.09	0.08	0.08
		Dur.	16	16	16	16
069	Evansville*	Q_d	0.195	0.197	0.200	0.206
		$1.3\ Q_d$	0.254	0.256	0.260	0.268
		Direct:				
			Q_{7DLF}			
		20 yr	52			
		50 yr	45			
070	Sparta*	Q_d	0.619	0.661	0.695	0.722
		1.3Qd	0.805	0.859	0.904	0.939
		Y_{20}	0.28	0.24	0.22	0.19
		Y_{50}	0.21	0.19	0.18	0.16
		Direct:				
			Q_{7DLF}			
		20 yr	50			
		50 yr	44			

Table 3. (continued)

System number	System name		Estimated 1990	2000	2010	2020
071	Olney*	Q_d	1.326	1.367	1.403	1.466
		1.3 Q_d	1.724	1.777	1.824	1.906
		Y_{20}	4.54	4.52	4.46	4.41
		Y_{50}	3.54	3.52	3.48	3.46
072	Kaskaskia Water District*	Q_d	0.707	0.756	0.795	0.849
		1.3 Q_d	0.919	0.983	1.034	1.104
		Direct:				
			Q_{7DLF}			
		20 yr	46			
		50 yr	41			
073	S.L.M. Water Commission*	Q_d	1.650	1.732	1.787	1.887
		1.3 Q_d	2.145	2.522	2.323	2.453
		Direct:				
			Q_{7DLF}			
		20 yr	41			
		50 yr	37			
074	Carrier Mills	Q_d	0.211	0.217	0.228	0.240
		1.2 Q_d	0.253	0.260	0.274	0.288
		Y_{20}	0.64	0.64	0.64	0.64
		Y_{50}	0.50	0.50	0.50	0.50
075	Eldorado Water Co.*,c	Q_d	0.546	0.609	0.642	0.674
		Q_{sw}	0.137	0.152	0.161	0.169
		1.2 Q_{sw}	0.164	0.182	0.193	0.203
		Y_{20}	0.44	0.43	0.41	0.39
		Dur.	18	18	18	18
		Y_{50}	0.31	0.29	0.28	0.26
		Dur.	18	18	18	18
076	Loami**	Q_d	0.065	0.072	0.077	0.079
		1.3 Q_d	0.084	0.094	0.100	0.103
		Y_{20}	0.08	0.08	0.07	0.06
		Adj Y_{20}	0.05	0.04	0.04	0.04
		Y_{50}	0.07	0.07	0.06	0.06
		Adj Y_{50}	0.04	0.04	0.03	0.03
077	New Berlin*	Q_d	0.073	0.074	0.075	0.079
		1.3 Q_d	0.095	0.096	0.098	0.103
		Y_{20}	0.30	Adj Y_{20}	0.17	
		Y_{50}	0.23	Adj Y_{50}	0.13	

Table 3. (continued)

System number	*System name*		*Estimated*			
			1990	*2000*	*2010*	*2020*
078	Springfield*	Q_d	21.274	21.755	22.103	22.980
		1.2 Qd	25.529	26.106	26.524	27.576
		Y_{20}	41.59	41.29	40.70	40.11
		Dur.	18	18	18	18
		Y_{50}	26.56	26.16	25.67	25.18
		Dur.	20	20	20	20
079	Alto Pass*	Q_d	0.050	0.052	0.053	0.058
		1.3 Q_d	0.065	0.068	0.069	0.075
		Y_{20}	0.69	0.53	0.36	0.22
		Y_{50}	0.54	0.45	0.33	0.20
080	Dongola*, c	Q_d	0.102	0.104	0.107	0.113
		1.3 Q_d	0.133	0.135	0.139	0.147
		Y_{20}	0.71	0.62	0.50	0.40
		Dur.	9	9	7	7
		Y_{50}	0.59	0.52	0.45	0.34
		Dur.	10	10	10	7
081	Georgetown**	Q_d	0.419	0.429	0.433	0.451
		1.3 Q_d	0.545	0.558	0.563	0.586
		Y_{20}	0.35	0.26	0.17	0.10
		Y_{50}	0.16	0.10	0.06	0.04
082	Inter-State Water Co. (Danville)*	Q_d	8.041	7.814	7.691	7.800
		1.3 Q_d	10.453	10.158	9.998	10.140
		Y_{20}	20.18	19.62	19.06	18.50
		Dur.	7	7	7	7
		Y_{50}	19.02	18.46	17.75	17.19
		Dur.	8	8	7	7
083	Oakwood*	Q_d	0.139	0.141	0.142	0.146
		1.3 Q_d	0.181	0.183	0.185	0.190
		Direct:				
			Q_{7DLF}			
		20 yr	8.2			
		50 yr	5.6			
084	Ashley*	Q_d	0.045	0.044	0.044	0.046
		1.2 Q_d	0.054	0.053	0.053	0.055
		Y_{20}	0.11	0.11	0.10	0.09
		Dur.	16	16	16	16
		Y_{50}	0.09	0.08	0.08	0.07
		Dur.	16	16	16	16

Table 3. (concluded)

System number	System name		Estimated			
			1990	2000	2010	2020
085	Nashville*	Q_d	0.489	0.487	0.487	0.509
		$1.2\ Q_d$	0.587	0.584	0.584	0.611
		Y_{20}	0.90	0.89	0.88	0.88
		Y_{50}	0.86	0.86	0.84	0.84
086	Fairfield**	Q_d	1.090	1.131	1.151	1.205
		$1.3\ Q_d$	1.417	1.470	1.496	1.566
		Y_{20}	2.28	Adj Y_{20}	2.19	
		Y_{50}	1.10	Adj Y_{50}	0.91	
087	Wayne City**	Q_d	0.197	0.205	0.208	0.219
		$1.3\ Q_d$	0.256	0.266	0.270	0.285
		Y_{20}	0.201	Adj Y_{20}	0.121	
		Y_{50}	0.128	Adj Y_{50}	0.076	
088	Marion**	Q_d	1.691	1.788	1.844	1.952
		$1.2\ Q_d$	2.029	2.146	2.213	2.342
		Y_{20}	1.29	1.27	1.24	1.22
		Dur.	20	20	20	20
		Y_{50}	0.94	0.92	0.90	0.88
		Dur.	18	18	18	18
089	Southern Illinois Electric Co-op. (Lake of Egypt PWD)*	Q_d	0.789	0.872	0.933	0.998
		$1.2\ Q_d$	0.947	1.046	1.120	1.198
		Y_{20}	17.22	17.09	16.95	16.82
		Dur.	54	54	54	54
		Y_{50}	12.84	12.71	12.57	12.45
		Dur.	56	56	56	56
090	Eureka*, c, s	Q_d	0.537	0.550	0.560	0.583
		$1.3\ Q_d$	0.698	0.715	0.728	0.758
		Y_{20}	0.24	0.22	0.21	0.19
		Dur.	18	10	10	10
		Y_{50}	0.16	0.15	0.14	0.13
		Dur.	20	20	20	20

Notes

Q_d = annual average demand in millions of gallons per day (mgd).

Y_{20} = estimated sustained yield of surface water impoundment(s) during a design drought having a 1-in-20 chance of occurrence in the given year (mgd).

Y_{50} = estimated sustained yield of surface water impoundment(s) during a design drought having a 1-in-50 chance of occurrence in the given year (mgd).

Adj Y_{20} = estimated yield from a side-channel reservoir system given the current water pumping capacity(ies) in mgd during a design drought having a l-in-20 chance of occurrence in the given year. The Y_{20} value in this case is the yield if the existing pumping system is replaced by an optimal pumping system.

Adj Y_{50} = estimated yield from a side-channel reservoir system given the current water pumping capacity(ies) in mgd during a design drought having a l-in-50 chance of occurrence in the given year. The Y_{50} value in this case is the yield if the existing pumping system is replaced by an optimal pumping system.

Dur = duration of design drought in months.

Q_{7DLF}, Q_{15DLF}, Q_{31DLF}, Q_{61DLF} = lowest 7-, 15-, 31-, or 61-day average streamflow with return period as indicated in table (mgd).

Q_{3MD}, Q_{5MD}, Q_{7MD} = lowest 3-, 5-, or 7-month average streamflow with return period as indicated in table (mgd).

20 yr = 20-year return period or recurrence interval.

50 yr = 50-year return period or recurrence interval.

Superscripts

c = combined surface and ground-water source (quantity breakdowns are not shown for systems with standby or inactive wells that are seldom used).

s = supplemental source of water available to meet demand (see note at end of table).

sw = surface water portion of total demand for a combined system.

* = explanatory note follows the table and is indexed by the system number.

** = one of the most critical systems; explanatory note follows the table and is indexed by the system number.

System Notes

System number

001 **(Greenville) Eight wells, capped and sealed for emergency use only; no data on yield. Governor Bond Lake is the primary source.**

002 **(Sorento) Sorento Reservoir is the sole source of water supply for the system. The in-channel reservoir is on a tributary to Shoal Creek in the Kaskaskia River Basin. The 20-year design drought yields are only slightly lower than projected demands. However, the 50-year design drought yields will be less than half of the demand by 2000.**

003 **(Ashland) Ashland apparently operates two reservoirs, one in-channel (Reservoir No. 2 in CR 446) and one side-channel, both in Morgan County. Information regarding the drainage areas of the streams and pumping systems capacities could not be confirmed. Y_{20} and Y_{50} values are the sums of yields from the in-channel reservoir, No. 2 (drainage area = 0.26 sq mi), and the side-channel reservoir, [estimated capacity of 55 acre-feet (ac-ft)], assuming the source stream has a drainage area of 6 sq mi. On the basis of this operation the system may not have an adequate water supply for a 50-yr drought. Using both reservoirs for side-channel water storage from a drainage area of 6 sq mi would result in slightly higher yield estimates. The estimated yield for a 20-year drought would be about 0.16 mgd, and for a 50-year drought it would be about 0.12 mgd. The IEPA (1983) reports that drift wells are available as an emergency source.**

004 **(Virginia) Historically, approximately 65 percent of demand is met by ground water obtained from a single well installed in 1977. Ground water is pumped to the Virginia Reservoir. The well pump capacity is 400 gpm (0.576 mgd); 65 percent of the projected average annual demand can be met by pumping 5 hours per day. By pumping 6 hours per day, 1.2 times the average annual demand cen be met.**

005 **(Kincaid) Y_{20} and Y_{50} values are the sums of yields from two reservoirs. The 20- and 50-year drought durations for Lake Kincaid are 10 and 18 months, respectively; and for Sangchris Lake they are 28 and 54 months, respectively. Approximately 99 percent of the tabulated yields are from Sangchris Lake. There is no direct line from Sangchris Lake to the water treatment plant. Water may be pumped from Sangchris Lake to**

Lake Kincaid at the rate of 180 gpm (0.259 mgd). This rate of water transfer can supplement Lake Kincaid yields to supply 1.3 times the demand for 20- and 50-year droughts through 2020.

007 (Taylorville) Yield values are for Lake Taylorville only; five wells are available as an emergency source of water, but yields are not included in tabulated values for Y_{20} and Y_{50}.

008 (Clay City) Water is withdrawn directly from the Little Wabash River (drainage area $\simeq$ 800 sq mi). Low flows at the pumping station were estimated on the basis of a 71-year flow record (1915-1985) for USGS gage 03379500 below Clay City (drainage area = 1,131 sq mi) and gage 03378900 at Louisville (drainage area 745 sq mi), which has a 17-year record. With 2020 Qd and 50-year drought, storage of about 0.4 million gallons is required. With 1.3 Qd, storage of about 1.1 million gallons will be needed. The needed storage may be provided by system storage and storage behind a low-channel dam at the intake.

009 (Flora) Water is withdrawn directly from the Little Wabash River (drainage area $\simeq$ 750 sq mi). Low flows at the pumping station were estimated on the basis of a 71-year flow record (1915-1985) for USGS gage 03379500 below Clay City (drainage area = 1,131 sq mi) and gage 03378900 at Louisville (drainage area = 745 sq mi), which has a 17-year record. Flora's pumping station is downstream of Louisville's pumping station; flows at Flora's pumping station may be reduced depending on withdrawals and returns from Louisville.

010 (Louisville) Water is withdrawn directly from the Little Wabash River (drainage area = 745 sq mi). Low flows at the pumping station were estimated on the basis of a 71-year flow record (1915-1985) for USGS gage 03379500 below Clay City (drainage area = 1,131 sq mi) and gage 03378900 at Louisville (drainage area = 745 sq mi), which has a 17-year record. Louisville erected a temporary low-channel dam in 1988, but the storage created is undetermined. The 50-year, 7-day low flow is less than the 1990 demand. A deficit of about 1.7 million gallons may be expected during a 50-year drought with 1.3 Qd in 2020. The necessary storage may be provided from system storage behind the low in-channel dam.

011 (Breese) Low-flow values upstream of the intake were determined on the basis of a 40-year flow record (1946-1985) at USGS gage 05594000, Shoal Creek near Breese (drainage area = 735 sq mi) and adjusted for Hillsboro, Litchfield, and Greenville effluents. The demands can be met for a 20-year drought, but extra storage is needed to meet 1.3 Q_d for a 50-year drought because 7-day low flows are less than the demands. A low-level channel dam can be constructed below the intake to provide needed storage.

012 (Carlyle) Water is withdrawn directly from the Kaskaskia River (drainage area = 2,717 sq mi). The 7-day low flows tabulated are greater than the demands. Low flows were estimated on the basis of daily flow data for USGS gage 05593000 at Carlyle (drainage area = 2,719 sq mi) for the period of record 1967-1987. However, the mandatory low-flow release from the Carlyle Reservoir is 32.3 mgd.

013 (Keyesport) Y_{20} and Y_{50} values are for Carlyle Lake. System 058 (Salem) also relies on Carlyle Lake as its primary source of water, and system 056 (Centralia) may draw up to 5 mgd from the lake. The supply is more than adequate to meet the combined demands of the three system.

014 (Charleston) Charleston water supply originally relied upon an in-channel dam across the Embarras River. In 1981 an embankment was completed that partitioned the original reservoir and created a side-channel reservoir. Yield values given are for the side-channel reservoir only. Breach of the in-channel dam in 1985 resulted in increased in-channel storage when scour occurred; repairs to the dam did not change its height substantially. The estimated in-channel storage for 1990 is 935.4 ac-ft or about 160 days of supply at the projected 1990 demand. Water is pumped from this reservoir to the side-channel reservoir, which has a capacity of 3,460 ac-ft.

015 (Mattoon) Water is withdrawn from two reservoirs, Lake Paradise and Lake Mattoon. Neoga (system no. 017) relies entirely on Lake Mattoon. The yield values given in the table for Mattoon are the sum of yields from Lake Paradise and Lake Mattoon, less the demand projections for Neoga.

016 (Oakland) Oakland Lake is the sole source of supply for the system. This in-channel reservoir is located on the Hog Branch, Embarras River Basin. By 2020 the estimated water storage capacity will be less than half of the reported 1973 capacity. Gross yields for 50-year droughts are less than 2 percent of the average annual runoff, so they

cannot be estimated from available analysis of streamflow data. Tabulated yields of 0.05 mgd were calculated on the basis of a gross draft rate of 2 percent. The IEPA has rated this system as marginal for drought conditions. By 2000 the estimated 20-year drought yield will be less than demand, and the 50-year drought yield is less than demand in 1990.

017 (Neoga) Lake Mattoon, owned by the city of Mattoon, is the sole source of supply. Yields shown are the total from Lake Mattoon. However, the city of Mattoon also uses Lake Paradise. The sum of the yields from the two lakes is adequate to meet 1.2 times the demand of both systems until 2020. In 2020 the 50-year yield of Mattoon's two lakes falls just slightly below 1.2 times the total demand for both systems. [See table 3 values for system 015 (Mattoon) and notes.]

018 (Douglas Water) Approximately 60 percent of the public demand met by the Douglas Water Co. is purchased from the Quantum Chemical Corp., USI Division. Quantum withdraws water from the Kaskaskia River and stores it in a side-channel reservoir. Ground water is used to meet about 10 percent of Quantum's demand, although the water use is undisclosed. Four wells owned by the Douglas Water Co. have a combined pumping capacity of about 355 gpm (0.51 mgd). In 1986 the average daily pumpage was 0.26 mgd and the maximum average daily pumpage was 0.33 mgd. Douglas Water Company plans to further develop ground-water sources. Currently the ground water wells supply most of Tuscola's demand while water from Quantum is distributed directly to Arcola.

019 (Paris) Paris Twin Lakes are the sole source of supply for the system. The "new" lake, also referred to as the "third" lake, was constructed in 1961 and inundated the "old" lake. Twin Lakes now operate as one reservoir. Yields for a 50-year drought are only about two-thirds of demand.

020 (West Salem) Y_{20} and Y_{50} alues are the sum of yields from West Salem New and Old Reservoirs. Drought durations for 20 years and 50 years are 16 and 18 months, respectively, for the New Reservoir and 9 and 12 months, respectively, for the Old Reservoir. Reported capacity of the Salem New Reservoir ranges from 275 to 91 ac-ft. Capacity projections in CR 446 are made on the basis of a 1968 capacity of 138 ac-ft. By 1990 the storage capacity of West Salem New Reservoir is estimated to be reduced to 88 percent of its 1968 capacity. The reservoir capacity is estimated to be approximately 75

percent of the original water storage volume by 2020. West Salem New Reservoir is the primary water supply source, and yield from the Old Reservoir is expected to be essentially zero by 2000.

021 (Altamont) Y_{20} and Y_{50} values are for the Altamont New Reservoir on Turkey Creek, Little Wabash River Basin. The Old City Reservoir (estimated capacity 95 ac-ft or 31 million gallons) is available as an emergency source and should be adequate to meet demands in excess of yields from the **New** Reservoir through 2020.

022 (Effingham) Y_{20} and Y_{50} values **are** the **sum** of yields from two lakes. Drought durations for 20- and 50-year recurrence intervals are 42 and 56 months, respectively, for Lake Sara and 18 and 20 months, respectively, for CIPS Lake. A 20-inch transmission line from Lake Sara to CIPS Lake was completed in 1986.

023 (Farina) Wells, which were the only source of supply before 1982, have estimated pumping capacity of 57 gpm (0.082 mgd). On the basis of these figures, yield may be insufficient by 2000 to meet expected demand during a 50-year drought event. Facility expansion is planned to meet anticipated new business needs. Water is pumped from the East Fork of the Kaskaskia River into borrow pits, which are the primary sources of surface water. Considering them as a side-channel reservoir, the adjusted 20- and 50-year yields are 0.037 and 0.026 mgd, respectively.

024 (St Elmo) Y_{20} and Y_{50} values are combined yields from two lakes. Drought durations for 20-year and 50-year recurrence intervals are 18 and 20 months, respectively, for Lake Nellie and 7 and 8 months, respectively, for the South Reservoir for 2010-2020. Approximately 85 percent of yield is from Lake Nellie. The South Reservoir was dredged in 1986, and capacities estimated in CR 446 were adjusted accordingly.

027 (Royalton) Water is withdrawn directly from the Big Muddy River (drainage area = 926 sq mi). Apparently there is no low-channel dam. Low flows were estimated on the basis of daily flow data for USGS gage 0559700 at Plumfield (drainage area = 794 sq mi), for the period of record 1972-1987, which is after the commissioning of Rend Lake. The 20- and 50-year low flows greatly exceed the demands projected for 1990-2020. The mandatory low-flow release from Rend Lake (drainage area = 488 sq mi) is 30 cubic feet per second (cfs) or 19.4 mgd.

028 (Canton) Water demands Q_d shown are 20 percent higher than in the Water Survey Contract Report 442 (Singh et al., 1988). This is due to an increase in population over that projected by the Illinois Bureau of the Budget. A new prison has been a factor in this population increase. The dam spillway was raised 2 feet in 1972. Capacity projections reported in CR 446 were adjusted by increasing storage by 503 ac-ft Canton Lake water reserves were severely depleted during the drought of 1988-1989. The reservoir yields for a 50-year drought are less than 1.2 Q_d values. Two wells were drilled in 1989, one producing about 1 mgd, while the second well is expected to produce about 150-200 gallons per minute (gpm) or 0.22 to 0.29 mgd. The quality of water from these wells may cause problems for water treatment At present, neither Q_d nor $1.2Q_d$ demands can be met during a 50-year drought

031 (Greenfield) Greenfield Lake is the sole source of supply for the system. Between 1990 and 2020, approximately 57 ac-ft of the reservoir storage capacity is expected to be lost due to sedimentation. By 2020 water reserves may be inadequate to meet demand during a 50-year drought event for Q_d, and by 1990 reserves may be inadequate for 1.2 Q_d.

032 (White Hall) White Hall Reservoir is the sole source of supply for the system. White Hall Reservoir is an in-channel impoundment on a tributary of Wolf Run Creek, which drains to Apple Creek and then to the Illinois River. White Hall Reservoir was down to critically low levels during the drought of 1988 and again in 1989. Yields for the 20- and 50-year drought event are not adequate to meet demands for 1990-2020.

033 (Carthage) The capacities of two small sediment ponds (total 39 ac-ft) were included in yield calculations. Two wells, No. 1 and No. 3, are kept as standby. These wells have pumping capacities of 160 and 200 gpm, respectively, for a combined 0.518 mgd. Poor ground-water quality is a problem. Increased storage resulting from raising the spillway in 1962 and dredging in 1981 was added to capacity estimates given in CR 446. If ground water quality problems can be rectified, the combined surface and ground-water sources are sufficient to meet the demands.

034 (La Harpe) A low channel dam was constructed across the South Branch of Crooked Creek during the summer of 1988. The site is also labeled as "South Branch La Moine River" on USGS 7.5-minute quadrangles. Approximately 40 to 50 percent of the

system's water is obtained from one well with 165 gpm (0.24 mgd) pumping capacity. The well yield in itself is sufficient to meet demands through 2020.

035 (Carbondale) Y_{20} and Y_{50} values are the sum of yields from two reservoirs. Drought durations for 20- and 50-year intervals are 54 and 56 months, respectively, for Cedar Lake (which accounts for approximately 95 percent of yield) and 20 and 30 months, respectively, for Carbondale Reservoir, which is considered an emergency source. Carbondale PWS is an emergency source for Murdale Water District, De Sota, and Elkville, all of which purchase water from Kinkaid Reeds Creek Intercity Water System (system 036). Kinkaid Reeds Creek has an ample water supply, so the demand from these communities was not included in figures for Carbondale PWS.

036 (Kinkaid) Carbondale PWS is available as a backup supply to some communities, although Kinkaid Lake has a sufficient supply.

037 (Mt. Vernon) Mt Vernon PWS obtains approximately 80 percent of its water supply from Rend Lake Intercities Water Corp. Values for Y_{20} and Y_{50} are the sum of yields from three lakes: 20 and 50-year drought durations for Miller Lake are 16 and 18 months, respectively; for Lake Jaycee they are 20 and 32 months, respectively; and for L & N Reservoir they are 16 and 18 months, respectively.

038 (Vienna) Y_{20} and Y_{50} values were computed on the basis of available storage in both the Vienna City Reservoir (in-channel) and a side-channel reservoir (estimated capacity = 92 ac-ft).

039 (Kankakee) Water is withdrawn directly from the Kankakee River (drainage area = 4,555 sq mi), and the 7-day low flows tabulated are greater than the demands. Flows were estimated on the basis of daily flow data from USGS gage 05527500 (drainage area = 5,150 sq mi), for a period of record 1915-1985.

040 (Streator) Y_{20} and Y_{50} values listed were calculated for the operation of a rock quarry, side-channel reservoir of 920 ac-ft Additional storage is created by the in-channel dam (drainage area = 1,074 sq mi), which can also provide additional water.

041 (Northern Illinois Water Co., Pontiac) Water is withdrawn from the Vermilion River (drainage area = 579 sq mi). A low channel dam creates approximately 153 ac-ft of

storage. By 2020 this storage will be approximately equal to 18 days of supply at 1.3 times the average annual demand. Low flows were determined on the basis of a 41-year period of record (1942-1985) for USGS gage 05554500, Vermilion River at Pontiac. These were adjusted for water withdrawals upstream of the gage for Pontiac. The 20- and 50-year, 7-day and 31-day low flows are less than demands for 1990-2020. At times during the summer of 1988, net inflow to the small reservoir created by the low channel dam was virtually zero due to evaporation and other losses. The small volume of reserve water was augmented by creating a temporary dam further downstream to capture both runoff from the city and pumping water from an abandoned quarry.

042 (Blandinsville) Water is pumped from La Harpe Creek (drainage area = 13.5 sq mi) and Little Creek (drainage area = 3.4 sq mi) to a side-channel reservoir. Yield from Little Creek is approximately zero during severe drought conditions. A transmission line was constructed in 1988 from the "old school" well (1,180 feet deep) to the reservoir. Pumping capacity is 140 gpm (0.20 mgd), but water quality is poor. Water quality can be taken care of by suitable treatment. Provision of an optimal pumping system for the side-channel reservoir will make it adequate to meet demands.

043 (Macomb) Spring Lake, an in-channel reservoir on Spring Creek in the La Moine River Basin, is the primary source of supply. Yields for a 20-year drought will be less than demand by 2010. Yields for a 50-year drought are already less than demand in 1990. Spring Lake experienced extreme drawdown during the 1988-89 drought Two emergency sources of water are available: direct withdrawals from the East Fork of the La Moine River; and two wells, each with a pumping capacity of 750 gpm. Pumping at a rate of 750 gpm daily for the duration of a 50-year drought would provide sufficient water to meet 1.3 times the demand for 2020. The emergency water supply sources appear to be adequate to meet demand through 2020.

044 (Bloomington) Y_{20} and Y_{50} values are the sums of yields from Lake Bloomington and Lake Evergreen. The 20-year drought durations are 18 and 20 months for the two lakes, respectively, and the 50-year drought duration is 20 months for both. Yields for the 50-year drought event will be less than demand from 2000 to 2020. During the 1988-89 drought these lakes were drawn down to critically low levels. Demand during 1988 was around 10 mgd. Water use may have been considerably higher if mandatory water use restrictions had not been imposed. The almost continuous drawdown of the

lakes began in June 1988. Seventeen months later, in October 1989, they were at record low levels. Access to water from the Mackinaw River to augment Lake Evergreen is planned, and facility construction was scheduled to be completed within a few months. Bloomington is cross-connected with the city of Normal, which uses ground water for its supply.

045 (Decatur) Two wells located near Cisco produce 4.5 to 5 mgd, and ground water is discharged to the Sangamon River and thus conveyed to Lake Decatur. Some losses are expected due to conveyance through open channels. Other emergency water sources (such as gravel quarries) were accessed in 1988. Although they provided as much as 11 mgd, their long-term reliability is unknown. Sedimentation has created a significant loss of water storage capacity.

046 (ADGPTV) This system uses Otter Lake, and for emergency purposes it has access to water from Springfield PWS via Chatham.

047 (Carlinville) The dam spillway was raised 3 feet in 1981. Capacity projections in CR 446 were adjusted to include increased storage volume. The 50-year drought yields are less than the 2010 Q_d and 1.2 Q_d values from 1990 to 2020.

048 (Gillespie) Y_{20} and Y_{50} values are the sums of yields from two lakes. The 20- and 50-year drought durations are 20 and 58 months, respectively, for New Gillespie Lake and 20 and 56 months, respectively, for Old Gillespie Lake. The 50-year drought yields are less than the 1.2 Q_d values for 1990 to 2020.

049 (Hettick) The source of water qupply is Fresson Lake.

050 (Mt. Olive) Y_{20} and Y_{50} values are the sums of yields from two lakes. The 20- and 50-year drought durations for Mt. Olive Lake are 11 and 14 months, respectively, for 1990-2000 and 6 and 10 months, respectively, for 2010-2020. Old Mt Olive Reservoir has 30- and 56-month drought durations for the respective drought recurrence intervals. Yield for a 50-year drought is less than demand for 1990-2020. Sedimentation in Mt Olive Lake is expected to reduce the water storage capacity from 249.5 ac-ft in 1990 to 148.2 ac-ft by 2020. These estimates corroborate the waterworks superintendent's report of siltation problems in this lake. Old Mt Olive Reservoir is not experiencing the same rate of sedimentation.

051 (Palmyra-Modesto Water Comm.) The Palmyra-Modesto Lake, an in-channel impoundment on a tributary to Nassa Creek, Macoupin River Basin, is the sole source of supply for the system. The 50-year drought yield is less than demands.

052 (Shipman) Shipman Reservoir, an in-channel impoundment on a tributary of Coop Branch, Macoupin Creek is the sole source of supply for the system. Yields for both 20- and 50-year droughts are less than demands.

053 (Staunton) Staunton Reservoir, an in-channel impoundment on East Creek, Kaskaskia River, is the sole source of supply for the system. Yields for a 50-year drought are less than the demands for 1990-2020. A study was conducted in 1986-1987 to evaluate the cost of dredging and dam repair versus raising the level of the dam.

054 (Highland) Old City Lake is available as an emergency water source, and capacity is estimated at 121 million gallons. The primary source is Highland Silver Lake. The 20- and 50-year drought yields are much higher than demands.

055 (Holiday Shores) Capacity estimates are somewhat uncertain because the extent of periodic dredging of Holiday Lake is unknown.

056 (Centralia) Y_{20} and Y_{50} values are the sums of yields from two lakes. The 20- and 50-year drought durations are both 16 months for Raccoon Lake, and 20 and 32 months, respectively, for Centralia Lake. A 5-mgd water line from Carlyle Lake was installed in 1985 (see system number 013 for Carlyle Lake yields). Water from Carlyle Lake is more than adequate to ensure a reliable supply through 2020. Carlyle Lake also supplies system 013 (Keyesport) and system 059 (Salem).

057 (Kinmundy) Y_{20} and Y_{50} values were calculated on the basis of the capacities of both the in-channel Kinmundy Reservoir and a borrow pit (estimated capacity 200 ac-ft). Water is pumped from the Kinmundy Reservoir to the borrow pit

058 (Patoka) Water is withdrawn from the North Fork Branch of the Kaskaskia River (drainage area = 39.1 sq mi). Two side-channel reservoirs with combined capacity of 34 million gallons are used. Analysis of this system indicates that during a 50-year drought the yield would be 0.05 mgd, 0.054 less than 1.3 times the 2020 demand. Two

in-channel reservoirs on the North Fork Branch of the Kaskaskia River, Shell Recreation Lake, and Club-100 Lake, can be accessed in an emergency situation. These reservoirs have estimated capacities of 6.5 and 52 million gallons, respectively. The reserve supply appears adequate to meet demand.

059 (Salem) Y_{20} and Y_{50} values are the sums of yields from two lakes. Less than 0.5 mgd can be obtained from Salem Reservoir. The remainder of the yield is from Carlyle Lake. Drought durations given are for Carlyle Lake. Carlyle Lake also supplies system 013 (Keyesport) and system 056 (Centralia).

060 (Waterloo) Waterloo uses three lakes. Schorr and Bement ("Old") Lakes are on the same Fountain Creek tributary, and Bement Lake is gravity-fed from Schorr Lake. Korte Lake is on another Fountain Creek tributary. Water from Fountain Creek can be pumped to both Schorr and Korte Lakes. Without pumping water from Fountain Creek, the combined yields from Schorr and Korte Lakes are projected to be 0.19 mgd for a 20-yr drought and 0.16 mgd for a 50-year drought The Y_{20} and Y_{50} values shown in the table were determined by assuming that all three lakes were functioning as side-channel reservoirs for Fountain Creek. The decrease in values reflects siltation from natural runoff. Adjusting the yield values for the present pumping system would reduce them by more than one-half, but natural runoff to the lakes tends to compensate since the system reports no apparent problems with supply. On the basis of the tabulated values, water could be insufficient to meet demand in 2000 for a 20-year drought event and in 1990 for a 50-year drought

061 (Hillsboro) Y_{20} and Y_{50} values are the sum of yields from two lakes (Glen Shoals Lake and Lake Hillsboro). Both have 20-year drought durations of 20 months; the 50-year drought duration for Lake Hillsboro is 58 months, and for Glenn Shoals Lake it is 18 months. Both 20- and 50-year drought yields are much higher than the demands.

062 (Litchfield) Water is pumped from Lake Lou Yaeger, an in-channel reservoir, to a side-channel reservoir. The yield projections were made on the basis of the combined capacities of both reservoirs.

063 (Jacksonville) Ground water from three wells (rated pumping capacities 700,1,250, and 1,200 gpm) supplies about 70 percent of demand. Withdrawals from wells can be increased to meet demand during drought years.

064 (Waverly) By raising the dam 7 feet in 1984 more storage was added to capacity projections given in CR 446. Both 20- and 50-year drought yields are sufficient to meet demands.

065 (Camelot) Capacities reported in CR 446 reflect maximum storage. Yield projections were computed on the basis of normal pool storage, which is 202.6 ac-ft less than maximum storage. Yields are sufficient to meet demands.

068 (Coulterville) Coulterville Reservoir is the sole source of supply for the system. It is an in-channel impoundment on a tributary of the South Fork Mud Creek, Kaskaskia River Basin. The reservoir was constructed in 1938. The water depth at the intake tower has decreased from 30 feet to 17 feet due to sedimentation. Between 1954 to 1990 reservoir capacity is estimated to decrease by about 25 ac-ft, and by 2020 an additional 19 ac-ft of storage capacity will be lost Yields are inadequate to meet demands.

069 (Evansville) Direct water withdrawals are made from the Kaskaskia River (drainage area = 5,718 sq mi). The 7-day low flows for 20- and 50-year return periods at this site are greater than demands. Low-flow values were estimated on the basis of 7-day low flows computed from daily flow data recorded at USGS gage 05593000 at Carlyle (drainage area = 2,719 sq mi) for the period of record 1968-1987. Daily flow data were recorded at USGS gage 05594100 near Venedy Station (drainage area = 4,393 sq mi) for the period of record 1970-1987. Mandatory low-flow release of 50 cfs from Lake Carlyle was also considered.

070 (Sparta) Y_{20} and Y_{50} values are the sums of yields from two reservoirs. The Old Reservoir has 20- and 50-year design drought durations of 16 months. The North or "New" Reservoir has 20- and 50-year drought durations of 8 and 10 months, respectively, in 2020. Facilities are available to withdraw water directly from the Kaskaskia River (drainage area = 5,513 sq mi). The 7-day low flows tabulated are greater than demands. They were estimated on the basis of 7-day low flows computed from daily flow data recorded at USGS gage 05593000 at Carlyle (drainage area = 2,719 sq mi) for the period of record 1968-1987. Daily flow data were recorded at USGS gage 05594100 near Venedy Station (drainage area = 4,393 sq mi) for the period of record 1970-1987. Mandatory low-flow release of 50 cfs from Lake Carlyle was also considered.

071 (Olney) Y_{20} and Y_{50} values are the sums of yields from three lakes. The 20- and 50-year drought durations for East Fork Lake are 56 months. For Borak Reservoir they are 20 months, and for Vernor Lake they are 56 months. Direct water withdrawals from the Fox River (tributary to Little Wabash River) serve as an emergency water source but are not included in Y_{20} and Y_{50} values.

072 (Kaskaskia Water District) Water is withdrawn directly from the Kaskaskia River (drainage area = 5,181 sq mi). The tabulated 7-day low flows are greater than the demands. The flows were estimated on the basis of 7-day low flows computed from daily flow data recorded at USGS gage 05593000 at Carlyle (drainage area = 2,719 sq mi) for the period of record 1967-1987. Daily flow data were recorded at USGS gage 05594100 near Venedy Station (drainage area = 4,393 sq mi) for the period of record 1970-1983. Mandatory low-flow release of 50 cfs from Lake Carlyle was also considered.

073 (S.L.M. Water Commission) Water is pumped directly from the Kaskaskia River (drainage area = 4,509 sq mi). Estimates of the 7-day low flows for 20- and 50-year return periods for the Kaskaskia at this location are greater than demand. Values tabulated were estimated on the basis of 7-day low flows computed from daily flow data recorded at USGS gage 05593000 at Carlyle (drainage area = 2,719 sq mi) for the period of record 1968-1987. Daily flow data were recorded at USGS gage 05594100 near Venedy Station (drainage area = 4,393 sq mi) for the period of record 1970-1987. A side-channel reservoir is also used. Its capacity is estimated as 20 million gallons.

074 (Carrier Mills) Two former mining strip pits and one pond provide storage. Y_{20} and Y_{50} values are the sums of yields for these storage facilities. The Peabody Strip Pit has a 50-year drought duration of 56 months, and the Doc Mac Strip Pit has a 50-year drought duration of 18 months. The yields are sufficient to meet projected demands.

075 (Eldorado) About 25 percent of the demand is met from the Eldorado Reservoir, and 75 percent is met by ground water from Saline Valley PWS.

076 (Loami) The embankment of the side-channel reservoir was extended in 1979 to impound water from a tributary to Lick Creek. Future capacities used in yield calculations were determined from sedimentation rates reported by Bogner (1987).

Operated as an in-channel reservoir only, the 20- and 50-year drought yields are 0.02 and 0.01 mgd, respectively, for 1990-2020. Water is pumped from Lick Creek (drainage area = 32.7 sq mi) to the reservoir. Y_{20} and Y_{50} values shown in the table were determined by assuming that the side-channel reservoir was in operation. Yields may be somewhat greater because the reservoir receives direct surface runoff from the natural watershed of 0.083 sq mi.

077 (New Berlin) Information on the present pumping system was not available, so adjusted Y_{20} and Y_{50} values were computed by assuming one fixed-speed pump with a capacity approximately three times the demand. Water treatment plant capacity was reported as 145 gpm or 0.21 mgd, which is on the order of three times demand.

078 (Springfield) Water is also withdrawn from the South Fork of the Sangamon River and discharged to Lake Springfield. The pump intakes are located upstream of the USGS gage 05576000 near Rochester (drainage area = 867 sq mi). On the basis of daily flow data recorded at Rochester for the period 1950-1983, the 20- and 50-year 5-month average low flows are about 2.35 mgd and 0.82 mgd, respectively. Dredging of Lake Springfield began in 1987, and yields were calculated on the basis of the estimated storage capacity after dredging. By 2010 the 50-year drought yield will be less than 1.2 Q_d. The ADGPTV Public Water Supply (number 046) is cross-connected with Springfield.

079 (Alto Pass) Y_{20} and Y_{50} values are the sums of yields from two lakes. The 20- and 50-year drought durations for 2020 for Little Cedar Lake are 7 and 8 months, respectively, and for Alto Pass Old City Reservoir they are 8 and 10 months, respectively.

080 (Dongola) Emergency ground water is available from a city well with a pumping capacity of 100 gpm (0.14 mgd). Repairs of main leaks and direct metering of water use may result in some decline in raw water use from values projected on the basis of past water use.

081 (Georgetown) Georgetown obtains its water from an in-channel reservoir on the Little Vermilion River. The reservoir was dredged in 1983, and at that time the estimated capacity was 193 ac-ft. Both 20- and 50-year drought yields are much less than demands.

082 (Inter-State Water Co., Danville) The reservoir spillway was raised 5 feet in 1988; capacity projections from CR 446 were increased by 4,200 ac-ft before yield calculations were performed. The yields are sufficient to meet the projected demands.

083 (Oakwood) Water is withdrawn directly from the Salt Fork Vermilion River (drainage area = 489 sq mi). Two small ponds are also used. Their combined capacity is about 1.8 million gallons, which is approximately 12 days of supply for the projected demands. Low flows were estimated on the basis of daily flow data for USGS gage 3336900 near St Joseph (drainage area = 134 sq mi) for the period of record 1958-1983.

084 (Ashley) Dam rehabilitation planned in 1987 is expected to reduce or eliminate a leakage problem.

085 (Nashville) Y_{20} and Y_{50} values are the sums of the yields from the city reservoirs plus 0.65 mgd, which can be purchased from the Washington County Conservation Lake. The city impoundment, Nashville Reservoir, has 20- and 50-year drought durations of 16 and 20 months, respectively. Yield from the reservoir for a 20-year drought for 1990, 2000, 2010, and 2020 are 0.25, 0.24, 0.23, and 0.23 mgd, respectively. Currently the city has an agreement with the Washington County Conservation District to purchase up to 0.65 mgd, and the lake can sustain this yield during the design droughts.

086 (Fairfield) Water is pumped from the Little Wabash River (drainage area = 1,792 sq mi) to a side-channel reservoir with estimated capacity of 276 ac-ft Yield estimated for a 50-year drought is less than demand in 1990.

087 (Wayne City) A low channel dam across the Skillet Fork (drainage area = 464 sq mi) creates approximately 17 ac-ft (5.5 million gallons) of storage. Water is pumped from behind the dam to a side-channel reservoir with estimated capacity of 34.7 ac-ft. Y_{20} and Y_{50} values presented in table 3 refer to the side-channel reservoir yield only. The tabulated drought yields are less than demand for most years. At a draft rate of 0.128 mgd (Y_{50}), the side-channel reservoir has approximately 80 days of supply. The difference between water use equal to 1.3 times the 2020 demand and a safe yield of 0.128 mgd over an 80-day period is about 13 million gallons, which is greater than the estimated in-channel storage.

088 (Marion) Marion City Lake spillway was raised in 1970, and capacity projections reported in CR 446 were updated to include an increase in storage. Prior to 1985 Crab Orchard Lake provided a backup water supply, but it has been found to be contaminated with PCBs, which make it unusable. Yields for 20- and 50-year drought events are less than demands for 1990-2020. A supplemental or alternative water source is reportedly being investigated.

089 (Southern Illinois Electric Co-op) Y_{20} and Y_{50} yields shown are for the Lake of Egypt. However, the system is contractually limited to 1 mgd.

090 (Eureka) Surface water is supplemented by pumping from two wells at 700 gallons per minute (gpm). These wells typically run 10 hours per day, thus supplying 0.42 mgd. Pumping at 700 gpm for approximately 14 hours per day would provide enough water to meet demand during design droughts through 2020.

Table 4. Systems that May Experience Drought-Related Water Shortages

System number	*System name*	*Drought-recurrence interval (years)*	*Year supply <Q_d*
002	Sorento	20&50	1990
009	Flora	20&50	1990
020	West Salem	20 & 50	1990
032	White Hall	20&50	1990
041	No. Ill. Water Corp. (Pontiac)	20&50	1990
052	Shipman	20&50	1990
068	Coulterville	20&50	1990
076	Loami	20&50	1990
081	Georgetown	20&50	1990
088	Marion	20&50	1990
016	Oakland	20&50	2000,1990
023	Farina	20&50	2000,1990
060	Waterloo	20&50	2000,1990
087	Wayne City	20&50	2000,1990
045	Decatur	20&50	2010,2000
044	Bloomington	20&50	2020,1990
028	Canton	50	1990
019	Paris	50	1990
050	Mt. Olive	50	1990
053	Staunton	50	1990
086	Fairfield	50	1990
051	Palmyra-Modesto Water Comm.	50	2000
047	Carlinville	50	2010
031	Greenfield	50	2020

Table 5. Systems that May Not Be Able to Meet Maximum Demands During a Drought

System number	*System name*	*Drought-recurrence interval (years)*	*Year supply < (1.2 or 1.3 Q_d)*
002	Sorento	20&50	1990
009	Flora	20&50	1990
016	Oakland	20&50	1990
019	Paris	20&50	1990
020	West Salem	20&50	1990
023	Farina	20&50	1990
032	White Hall	20&50	1990
041	No. Ill. Water Corp. (Pontiac)	20&50	1990
045	Decatur	20&50	1990
052	Shipman	20&50	1990
053	Staunton	20&50	1990
060	Waterloo	20&50	1990
068	Coulterville	20&50	1990
076	Loami	20&50	1990
081	Georgetown	20&50	1990
087	Wayne City	20&50	1990
088	Marion	20&50	1990
044	Bloomington	20 & 50	2000,1990
028	Canton	50	1990
031	Greenfield	50	1990
047	Carlinville	50	1990
048	Gillespie	50	1990
050	Mt. Olive	50	1990
051	Palmyra-Modesto Water Comm.	50	1990
086	Fairfield	50	1990
078	Springfield	50	2010
057	Kinmundy	50	2020