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WATER RESOURCES FOR THE SSC SITE IN NORTHEASTERN ILLINOIS: WATER SUPPLY, WASTE DISPOSAL, STREAMFLOW VARIABILITY, AND FLOODPLAIN DELINEATION

by Krishan P. Singh, H. Vernon Knapp,
Ganapathi S. Ramamurthy, and Sally M. Broeren

Prepared for the
Illinois Department of Energy and Natural Resources

Champaign, Illinois

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INTRODUCTION

The SSC will be the world's most powerful particle accelerator. Approximately 10,000 superconducting magnets will focus and guide two beams of protons in opposite directions around a racetrack-shaped tunnel approximately 53 miles in circumference and 10 feet in cross-section diameter. The beams will be accelerated to nearly the speed of light and made to collide head-on with an energy of 40 trillion electron volts. The collisions are expected to create new subatomic particles that will be detected and analyzed, thus adding to our understanding of the fundamental nature of matter and energy. Such knowledge will not only answer questions about the physical world that have fascinated mankind since the earliest times, it will benefit society in the areas of technology, education, and industry." (U.S. Department of Energy, 1988).

Research on the feasibility of the Superconducting Super Collider (SSC) was initiated by the U.S. Department of Energy (DOE) in 1983. The Central Design Group at the Lawrence Berkeley Laboratory was established to explore the potential of an SSC and to design the project. The final design was a project of large physical scale. The proposed SSC consists of a 53-mile elliptical ring; the ring structure is a tunnel 10 to 12 feet in diameter. The design calls for an injector for initial acceleration of the particles. Complementing the collider ring and injector are laboratories, large experiment halls, facilities for offices, housing for visiting scientists, and various other support structures. The SSC tunnel and related structures are shown in Figure 1.

Numerous factors were involved in determining the most suitable location for the SSC in the United States. The availability of resources to support the various needs of the SSC as well as the impact of such a project on the region in which it would be located are two important aspects of evaluating any potential location. In Illinois, the proposed site for the SSC was in the northeast part of the state, adjacent to Fermi National Laboratory. Fermilab's unique Tevatron, the world's most powerful accelerator system, could have been used as the injector for the SSC. In Illinois, the SSC would have to be built by tunneling through bedrock. The depth of the tunnel would range from 330 to 610 feet below the earth's surface. This report presents

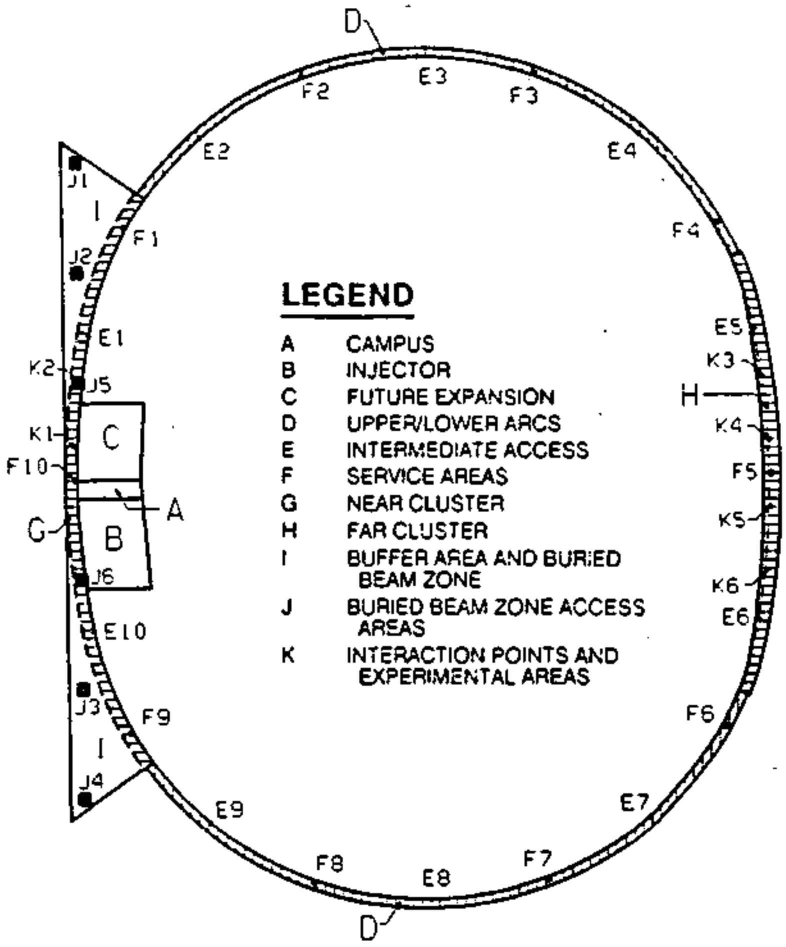


Figure 1. SSC tunnel and related structures (DOE, 1988)

the extensive information and research developed to evaluate the suitability of the Illinois site in terms of available water resources.

Operation of the SSC will require industrial cooling water as well as potable water. Wastewater from the facility will require treatment and disposal. Tunnel seepage water must be collected and used or disposed of, and some cooling water may require disposal. Industrial cooling water is needed primarily in the heat exchangers that cool the magnets for the SSC. Cooling water must be supplied at experimental areas located at the east and west sides of the ring and at ten major service areas equally spaced along the ring. Potable water must be supplied for general domestic needs of staff working at experimental sites along the east and west sides of the ring as well as for their living colonies. Wastewater generated will require treatment.

Ground-water and surface water characteristics of the area will affect the supply of needed water, disposal of wastewater, location of facilities to avoid flood hazards, and integration of the SSC water requirements with existing and future water needs of the area. The total water resources, both ground water and surface water, of the area encompassing the SSC site must be assessed in terms of availability, quality, location, current uses, remaining capacity, and cost of development.

Data and analyses on the water resources of the 16-township region proposed for the SSC underground ring and surface facilities in Illinois (Figure 2) are presented in this report. The existing Fermilab tunnel is shown by a circle lying within areas A, B, and C. Several ground-water and surface water sources in the region are more than adequate to supply the water demands of the SSC. Potential water supply sources as well as existing water supply systems are described. The utility and feasibility of each water source are discussed in terms of adequacy, reliability, quality, economy, and potential social or environmental impacts of supplying SSC demand. Recommendations are made for the most promising water supply source for each site. Wastewater disposal options, including use of existing wastewater treatment facilities and construction of new facilities, are presented. The fate of tunnel seepage water and cooling water is also discussed.

Part of the information presented in this report was compiled in the course of preparing of the Illinois Site Proposal for the SSC submitted to the U. S. Department of Energy. Some data collection and analyses were conducted in preparation of the Environmental Impact Statement for siting the SSC in Illinois. Additional information was collected as part of the ongoing planning and economic evaluation of the best strategy for satisfying the SSC water needs. Relevant data and analyses are presented in this report

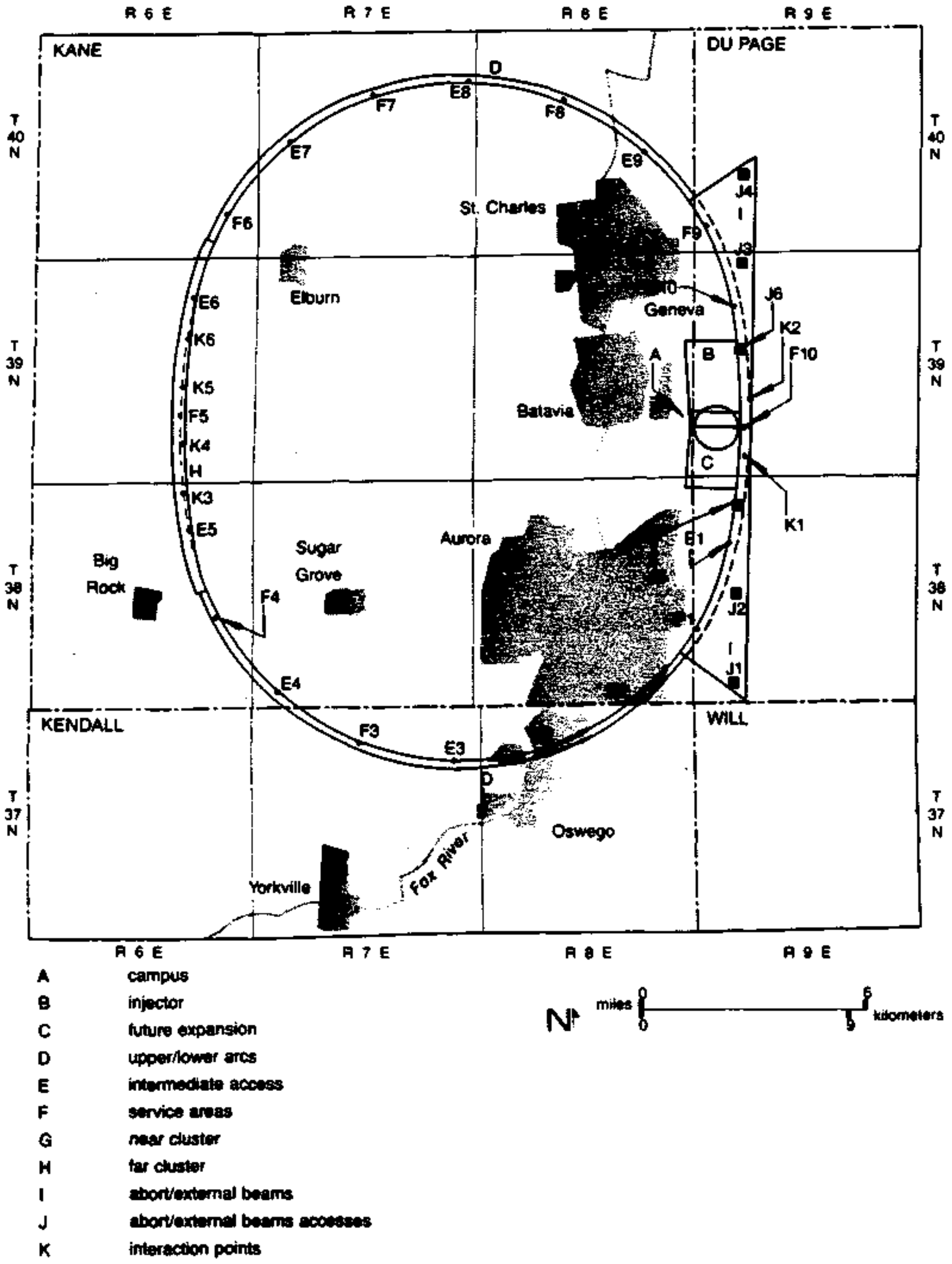


Figure 2. Proposed SSC ring, surface facilities, and 16-township study area

SSC Components

The location of the proposed SSC tunnel ring and the accompanying facilities are shown in Figure 2. The township and range lines delineating the study area are also shown. Several types of support facilities, shown on the map, would have been constructed as part of the SSC. With some modifications, the present Fermilab facilities could function as the injector complex, which consists of a series of accelerators used to impart to the particles the energy necessary for injection into the collider ring. A central laboratory, auditorium, industrial buildings, warehouses, and other support buildings would be constructed at the main campus located at or near the present Fermilab complex. Six interaction-point experimental areas, designated K1 through K6, would contain the structures and equipment to monitor the collision of the accelerated particles. Areas Kl and K2 are near the main campus. Areas K3 through K6 are along the west side of the ring and are referred to as the "far experimental areas." Sites K3 and K6 are for future expansion; sites K4 and K5 would have been constructed initially. Ten major service areas for access to the ring tunnel and surface storage structures are labeled F1 through F10. Intermediate access areas are located midway between adjacent service areas, and these sites are labeled E1 through E10. Other support facilities are labeled J1 through J6.

Scope of the Study

The proposed Illinois SSC site was in the best qualified list (BQL) of seven sites prepared by the U.S. Department of Energy. In November 1988, the DOE announced the selection of the Texas site for the SSC. Accordingly, the scope of work was modified 1) to complete any unfinished analyses, 2) to compile the developed information in proper formats, and 3) to prepare a final report containing a concise description of pertinent water resources studies that can be used by Kane and neighboring counties for water supply, waste disposal, and other developments in this rapidly urbanizing region. The information presented in this report can be considered under the following main heads:

SSC Water Needs and Wastewater Loads. The potable and cooling water needs for the SSC are defined, together with the locations where such needs can be met Wastewater loads from the main campus and the far experimental areas (near Kaneville) are estimated.

Study Area. It comprises 16 townships enclosing the proposed SSC ring and auxiliary structures.

Ground-Water Resources. Existing hydrogeologic systems and their potential to provide adequate quantities of water are discussed, together with their water quality.

Surface Water Resources. The region has been divided into two hydrologically homogeneous areas. Streamflow parameters such as mean flow, flow duration, drought flows, and flood flows have been developed for the area streams, and regional regressions have been derived for estimating the parameters for any ungaged area in the two subregions. Hundred-year floodplains have been delineated. Detailed information on the surface water quality in area streams as well as water quality trends and seasonal variations have been analyzed.

Existing Water Supply Systems. Existing public and industrial water supply systems have been tabulated, together with their sources of water. Ground-water use in the 16-township area has been projected for the years 1990, 2000,2010, and 2020.

Development of Potential Water Supply Sources. Water supply for the potable and cooling water needs of the SSC could have been easily met from the ground water. Potential reservoir sites exist but the cost of water will be much higher than that for ground water. Other storage mechanisms are the off-channel storage and impoundment of local surface drainage.

Evaluation of Water Supply Source Options. The local availability, distances to some sources, quantity and quality requirements, and relative costs have been used in identifying the best water sources for different SSC needs around the tunnel, the campuses, and other facilities. Economics becomes the deciding factor because multiple sources are available and adequate at several sites. Relevant cost functions have been developed and economic analyses carried out to locate adequate and economical water sources.

Wastewater Disposal Options. The existing wastewater treatment facilities nearby could have handled the wastewater generated by various SSC facilities with the exception of the far experimental areas. From an analysis of various treatment alternatives, a multicell aerated lagoon system was considered economical and practical for these areas. The major stream channels crossing the projected ring have been reviewed regarding any impacts from seepage water discharges from the tunnel and blow-down water from the air-cooling systems.

Location of the SSC Facilities Relative to 100-Year Floodplains. As far as possible, the SSC facilities would not be located in the 100-year floodplain. Only a portion of site J6 of the SSC would have been located in the floodway. Flexibility in location of buildings and other mitigating measures could have counteracted any adverse effects on the floodplain.

Summary and Conclusion. A summary of these studies is presented to give a brief insight into the various issues addressed in this report.

Acknowledgments

The study was conducted under the general guidance of Richard G. Semonin, Chief, Illinois State Water Survey; Richard J. Schicht, Assistant Chief; and Michael L. Terstriep, Head, Surface Water Section. Raman K. Raman provided historical water quality information and its interpretation in terms of time trends and suitability of water for SSC use. J. Rodger Adams provided information on sediments in the area streams; G. Michael Bender helped in

floodplain studies and provided FIRMs (flood insurance rate maps); Robin King surveyed the intersections of the area streams with the projected ring; and Adrian P. Visocky helped with ground-water quantity evaluations. Their help and suggestions are gratefully appreciated.

John W. Brother supervised the preparation of illustrations. Laurie McCarthy edited the report and Kathleen J. Brown typed it.

SSC WATER NEEDS AND WASTEWATER LOADS

Industrial Cooling Water

Operation of the SSC will require industrial-grade cooling water. Cooling water is used in heat exchangers for the magnets that direct and accelerate the beam. The proposed cooling system will use cooling towers and recirculate the cooling water through the network. The efficiency of the cooling towers is a function of the ambient temperature and humidity. The cooling water requirements will be greater during hot and humid weather than during cold, dry conditions. The Central Design Group has estimated total peak cooling water needs of 2,200 gallons per minute (gpm). Given the seasonal variability of the cooling water needs, the average annual demand is estimated to be about 64% of the peak demand.

Cooling water would be needed at ten different locations around the proposed ring. The distribution of the peak cooling water demand is estimated as follows: the main campus, including two experimental areas and one major service area, would require 700 gpm; the far (west) experimental areas, including one major service area, would require 500 gpm; and each of eight remaining major service areas would require 125 gpm.

The chemical and physical properties required of the cooling water have not been specified. However, the water currently used for cooling at Fermilab is supplied by both local surface drainage and pumping from the Fox River and does not receive any treatment. Both of these sources have highly variable chemical and physical properties. Surface water quality in the study area is generally inferior to the water quality of other potential supply sources, e.g., ground water. On the basis of current Fermilab practice, no treatment of the cooling water would have been required.

Potable Water

The maximum potable water demand was estimated at 250 gpm. The needs of the SSC main campus and the far experimental areas were estimated at 208 gpm and 42 gpm, respectively, in proportion to the number of persons to be served at each site: 2,500 and 500 persons, respectively. The annual average demand would be less than the peak demand.

Potable water supplied to the SSC would have to meet the water quality standards defined by U.S. Environmental Protection Agency (USEPA) Health Standards and Illinois state standards set by the Illinois Pollution Control Board (IPCB). IPCB standards conform to USEPA standards.

Wastewater

Conventional domestic wastewater requiring treatment and disposal will be generated at the SSC main campus and the far experimental areas. The SSC specifications indicate that sewage disposal and treatment capability of 0.150 million gallons per day (mgd) will be needed. However, a possible laboratory staff and visitor population of 2,500 at the main campus and 500 at the far experimental areas may produce as much as 0.150 mgd at the main campus and 0.030 mgd at the far experimental areas.

The proposed cooling system for the SSC magnets is essentially a closed recirculation system. The need to dispose of or discharge significant quantities of cooling water is not anticipated. Given the closed circulation system design, the water used would qualify as noncontact cooling water and probably would not require treatment.

Tunnel Seepage Water

The SSC tunnel was to be constructed at an average depth of 300 to 500 feet below the ground in a deposit of semi-impervious Galena-Platteville dolomite. The maximum rate of inflow was estimated to be 50 gallons per minute per mile (gpm/mi) on the basis of seepage rates in the TARP tunnel below Chicago. Water would be collected and discharged at ten sites along the tunnel perimeter. Using the maximum inflow rate of 50 gpm/mi, water collected over about a five-mile stretch of tunnel is estimated to be 250 gpm. Thus, the maximum rate of pumpage from each station would be approximately 250 gpm or 0.56 cubic feet per second (cfs). The minimum seepage rate was estimated to be 10 gpm/mi, corresponding to a pumping rate of 50 gpm (0.11 cfs). The quality of the seepage water is anticipated to be similar to the water in shallow dolomite and limestone aquifers in the region. Information on the quality characteristics of the ground water in the region was extracted from various Illinois State Water Survey published reports and may be summarized as follows:

total dissolved solids	600	milligrams per liter (mg/L)
chloride	15	mg/L
iron	1	mg/L
sulfate	150	mg/L
hardness	400	mg/L
nitrate	5	mg/L

Water Distribution Network

Northeastern Illinois has an abundance of water resources. Thus the deciding factors in determining the best water source for a site are reliability, quality, and cost The capital costs of the distribution network between sites and local on-site networks at the main campus and the far experimental area were found to be a major factor in the total cost of supplying the proposed SSC water needs.

The various locations that would have required cooling and or potable water are widely dispersed, so the cost of a single water supply system would have been prohibitive because of transmission lines and pumping costs. This conclusion is supported by the following sample calculation. The costs of developing the conveyance system were estimated from equations given in Singh and Adams (1980) and updated to 1985 dollars using the cost indexes in the Engineering News Record (1985). The construction and easement costs for a 6-inch pipe in 1985 dollars is given by the equation Cp = $73,300 L, where L= length of pipe in miles. The approximate distance between proposed service areas is five miles, so a 6-inch pipe laid over this distance alone could cost about $366,500. Therefore, independent water supplies were planned for most of the sites. The main campus, experimental areas K1 and K2, and major service area F10 are sufficiently close that they could have been served by a single system. The far experimental areas, K3, K4, K5, and K6, as well as major service area F5 are clustered at the west side of the ring and could have been served by a single system. Each of the remaining eight major service areas would have its own water supply source. Thus, ten locations required a source of water supply.

The various facilities located within the main campus and those located at the far experimental areas would have required delivery of both cooling water and potable water. There are two options for the local distribution networks within each of these areas: 1) construct two separate, parallel distribution networks for the cooling and potable water; or 2) construct a single distribution network, which would require treating the cooling water to potable water standards. The Central Design Group of the SSC evaluated various scenarios of local distribution networks for the two sites and determined that the cost of a dual-distribution network would far exceed the additional cost of treating the volume of cooling water required. Thus, on the basis of the Central Design Group recommendations, the cooling and potable water needs at each of these locations would have been served by a single distribution network, supplying treated water that met the standards for potable water. The maximum demand rates for cooling and potable water needs at each of the ten sites are summarized in Table 1.

Pumping Rates

The total demand at each site listed in Table 1 represents the maximum anticipated demand. There may be considerable seasonal variation in demand for cooling water. However, because extended periods of high temperature and humidity are common in Illinois, it is highly probable that maximum water requirements would have to have been met for long periods of time during the summer months. Therefore, the peak demand rate was used to evaluate the most economical pump size and pipe diameters, given the head loss and conveyance distance for each water supply source. The Central Design Group specified a 12-inch diameter water main for the main campus and the west experimental area. For these sites only the pump size required for the various supply sources was determined.

Table 1. Maximum Demand for Cooling and Potable Water at Ten SSC Sites

Site	*Cooling water (gpm)*	*Potable water (gpm)*	*Total*		
			gpm	*mgd*	*cfs*
SSC main campus (including experimental areas K1 and K2 and major service area F10)	700	208	908	1.31	2.03
Far experimental areas (K3-K6 and major service area F5)	500	42	542	0.78	1.21
Eight major service areas (F1-F4, and F6-F9)	125 each	-	125 each	0.18 each	0.28 each

STUDY AREA

The 16-township study area that was proposed for the SSC lies in parts of DuPage, Kane, Kendall, and Will Counties in northeastern Illinois (Figure 2). The area is delineated by the north line of T40N (Township 40 North); the south line of T37N; the east line of R9E (Range 9 East); and the west line of R6E. Three townships (T40N, T39N, and T38N, R9E) on the east edge of the study area are in DuPage County. Nine townships (T40N, R6-8E; T39N, R6-8E; and T38N, R6-8E) form the northwest and central portion of the study area, which is in Kane County. Three townships (T37N, R6-8E) on the south edge of the study area lie in Kendall County. One township (T37N, R9E) forms the southeast corner of the study area, which is in Will County. Township and range lines are relative to the third Principal Meridian and Centralia Base Line.

The east side of the area is highly urbanized, while the west side of the area is primarily agricultural. The population of the area is generally increasing. For the most part this is due to the urban sprawl extending from the Chicago area on the east. DuPage County on the east side of the ring is one of the fastest growing counties in Illinois.

Presently, all of the communities within the boundaries of the study area rely on ground-water sources for their public water supplies, with the exception of Elgin, which uses both the Fox River and ground-water aquifers. However, urban areas just east of the proposed SSC site are gaining access to Lake Michigan water for their potable water needs, which will reduce dependence on ground-water resources. Communities located along the Fox River in Kane County are exploring the possibility of withdrawing river water for public supply.

Wastewater from area communities is treated and discharged to streams. Over the years, receiving streams have grown as wastewater discharges from growing communities increase. There are also numerous individual residential septic systems.

GROUND-WATER RESOURCES

Five major hydrogeologic systems are present in the 16 townships of the SSC area. These are: 1) the glacial drift aquifer system, i.e. sands and/or gravels within the glacial drift and alluvium; 2) the upper bedrock aquifer, mainly fractured dolomite (e.g., Silurian) and shale directly below the glacial drift; 3) the Ordovician aquitards, the Maquoketa and Galena-Platteville; 4) the Midwest sandstone aquifers, mainly the St. Peter (Ancell group) and Ironton-Galesville sandstones; and 5) the Mt. Simon aquifer, including the basal sandstone member of the Eau Claire Formation. These units are defined and described in detail by Visocky, et al. (1985). Figure 3 shows a stratigraphic column of bedrock units in northeastern Illinois. Within this geologic structure three aquifer systems serve as significant sources of ground water in the study area, having a sufficiently high yield to serve municipal water supply systems and potentially the SSC. Localized sand and gravel aquifers are present in the glacial drift deposited throughout the area. Along the eastern side of the study area, Silurian dolomite forms a productive shallow bedrock aquifer system. The Cambrian-Ordovician aquifer system, composed of the Galena-Platteville, St. Peter, and Ironton-Galesville units, is a regional system extending throughout most of northeastern Illinois, including the study area.

Sand and Gravel Aquifers

Several advances of continental glaciers of the Illinoian and Wisconsinan age have left deposits of glacial materials greater than 50 feet thick over most of Kane County, and some local deposits exceed thicknesses of 250 feet (Willman, 1971; Kempton et al., 1985). Sand and gravel deposits in the glacial drift supply several public water supply systems and have the potential of supplying moderate to large quantities of water. Shallow sands and gravels are widespread, and wells in these aquifers have flow rates of 100 to 1,000 gpm.

Buried bedrock valleys recently identified in Kane County may serve as a significant hydrologic resource (McFadden et al., 1989). A regional exploration program to locate sand and gravel layers in buried bedrock valleys was conducted jointly by the Illinois State Geological Survey and the Illinois State Water Survey (ISWS) and was completed recently. High water yields may be obtained when deposits of sand and gravel are in open hydraulic connection with the dolomite that forms the sides and bottom of the valleys. Several buried bedrock valleys have been identified in Kane County. Aquifer tests have been conducted west of Geneva, west of Aurora, and on the west side of Montgomery. Results of these preliminary tests indicate that wells tapping this resource may have yields ranging from several hundred to more than 1,500 gpm. Along the west side of the study area a shallow sand and gravel aquifer has been identified in a buried bedrock valley known as the Newark Buried Bedrock Valley. The

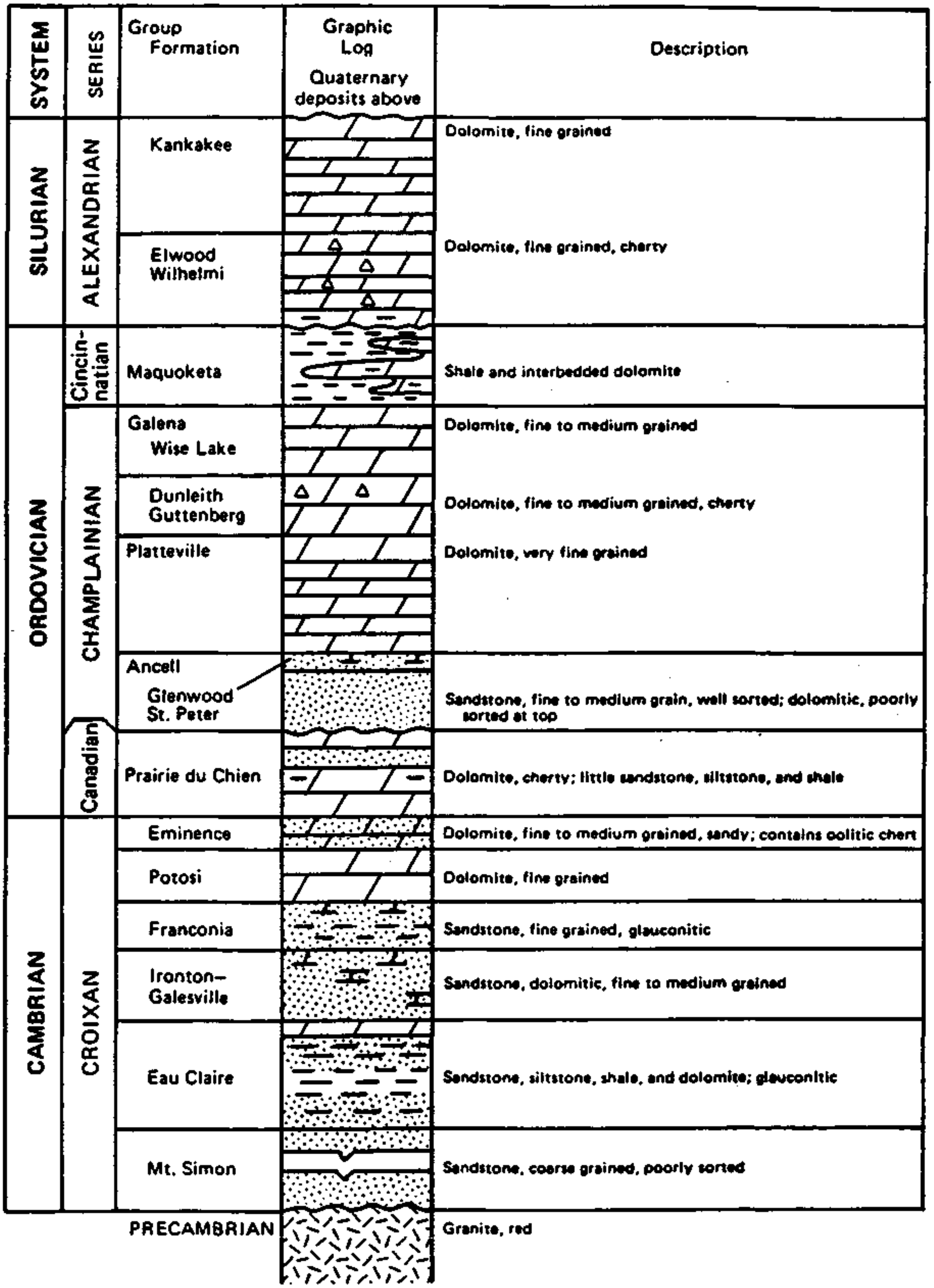


Figure 3. Stratigraphic column of bedrock units in northeastern Illinois

Newark Valley is the largest buried bedrock valley known in Kane County, with an estimated width of 2,700 feet and a maximum drift thickness of 250 feet. Test wells within four miles of the far experimental areas have produced yields in excess of 1,200 gpm. Regional yield from this aquifer is estimated as 10 mgd.

Shallow Bedrock Aquifer System

The Silurian dolomite aquifer is located at an approximate depth of 200 feet along the eastern side of the area, but it thins out west of the DuPage-Kane boundary and ceases to be a significant water supply source. The wells in the Silurian aquifer yield up to 500 gpm in DuPage County.

Deep Aquifer System

The Galena-Platteville dolomite is about 300 feet thick; the depth of the top of the aquifer varies from less than 200 feet in western Kane County to 400 feet in DuPage County. Wells in the Galena-Platteville aquifer usually have very low yields, particularly in the study area. The productivity of the aquifer varies according to the fracture structure of local deposits. On the basis of well drilling experience, there is much less chance of drilling a productive well at any given location in this aquifer than in the other aquifer units.

Significant aquifers within the deep sandstone deposits are the St Peter, Ironton-Galesville, and Mt. Simon sandstones. The St. Peter sandstone aquifer is between 200 and 250 feet thick and is located approximately 500 feet below land surface in the southern portion of the study area, and in the northern portion of the study area it is 800 feet or more below land surface. Dependable yields of up to 200 gpm can be expected from this aquifer. The Ironton-Galesville sandstone is the most consistently permeable and productive unit of the deep sandstone system. The top of the formation lies at a depth of approximately 1,150 feet below the land surface. This sandstone aquifer is approximately 150 to 200 feet thick. Most wells tapping the deep aquifer system are finished at the base of the Ironton-Galesville sandstone at a total depth of 1,200 to 1,400 feet. Some wells extending to depths of 2,300 feet draw water from the Mt. Simon sandstone.

Withdrawals from the deep aquifer system have exceeded the practical sustained yield of the system since about 1958 (Sasman et al., 1977). Subsequently the pumping water levels in supply wells have dropped dramatically. However, many communities that have relied on this system are now availing themselves of alternative water sources. Cities in DuPage County are turning to Lake Michigan water. Elgin in Kane County is currently using the Fox River as its primary source of water. Aurora, located within the study area in Kane County, is proceeding with plans to develop the Fox River as a source of public water supply.

The SSC tunnel was to have been excavated in the Galena-Platteville dolomite. This unit is overlaid by the nonwater-bearing shales and dolomites of the Maquoketa group throughout most of the study area. The Maquoketa group and Galena-Platteville dolomite serve as an aquitard between the shallow aquifers and the deep aquifers. Because of the great length of the proposed tunnel, a sufficient volume of seepage water might have been collected to supplement primary sources of water supply at the various sites.

Ground-Water Quality

Ground water in the area is generally of high quality. Variations in water quality from one aquifer to another exist, but there is not a large variation in quality characteristics in the region. The variation in quality of the ground water sources is illustrated by the data given in Table 2, which lists average concentration levels of eight different water quality parameters and the applicable USEPA Health Standard for drinking water. The concentrations reported were measured in individual samples taken from eight different water supply systems in the area.

On the basis of U.S. Geological Survey (USGS) water resources data and several ISWS reports (Visocky et al., 1985; Sasman et al., 1982) the general quality characteristics of the ground-water sources are summarized as follows: the amount of total dissolved solids varies from 400 to 600 milligrams per liter (mg/L) in the shallow sand and gravel aquifers to 300 to 400 mg/L in the deeper sandstone. The distribution of hardness is similar, ranging from 300 to 400 mg/L at shallow depths down to 200 to 400 mg/L at greater depths. Water quality deteriorates rapidly at depths of 2,000 feet or more below mean sea level, and total dissolved solids rise from 1,000 mg/L to more than 50,000 mg/L. The concentration of most undesirable constituents is generally low; chloride, sulfate, and nitrate levels, for example, are usually below 15, 50, and 5 mg/L, respectively. However, high concentrations of radium and barium are found in some waters from the deep sandstone aquifers.

Table 2. Quality of Ground-Water Sources Available to the SSC

Water source	*SSC use area*	*Bacterial (fecal coliform counts per 100 milliliters)*	*Iron[1] (mg/L)*	*Sulfates (mg/L)*	*Chloride (mg/L)*	*Total dissolved solids (mg/L)*	*Barium (mg/L)*	*Hardness[2] (mg/L)*	*Temp.[3] (°F)*
Silurian dolomite aquifer	A,B,C,F10,K1,K2	0	<0.3	155	15	505	0	300	52-58
Sand and gravel aquifer[4]	F5,K3-K6								
Example A		0	0.5	12.0	2.0	350	0	260	50-64
Example B		0	1.3	4.0	3.0	398	0.2	271	50-64
Example C		0	0.2	0	1.0	296	0.1	228	50-64
Example D		0	0	120	87.0	642	0.1	528	50-64
St. Peter sandstone aquifers	F1-F4,F6-F9								
Example E		0	0.2	0.0	1.5	304	2.3	283	-
Example F		0	0.1	13	6	335	0.1	272	-
Example G		0	0.05	5	5	304	1.0	252	-
USEPA Health Standards		500	1.0	250	250	500	1.0	NA	NA

[1] Depending on local conditions, iron may require treatment.

[2] It is not common practice for public water supplies in northeastern Illinois to treat water at these hardness levels.

[3] Temperatures vary seasonally and by depth.

[4] Examples A, B, C, and D represent four different public water supplies in western Kane County to illustrate the concentrations in the area that characterize the sand and gravel aquifer.

[5] Examples E, F, and G represent three different public water supplies in Kane County to illustrate the concentrations in the area that characterize the St. Peter sandstone aquifer.

[6] Illinois Pollution Control Board standards conform to the U.S. Environmental Protection Agency Health Standard for drinking water.

Note: Each of these figures represents an individual sample. The Silurian dolomite sample was taken from the Fermilab well. Sand and gravel values and St. Peter sandstone values are taken from local water supply systems. The quality of ground water from sample to sample at any one location can show some variation, but not a significant amount.

SURFACE WATER RESOURCES

The surface waters of the study area are important to several aspects of the SSC water needs. Surface water could have served as a source of supply, streams and rivers could have been used to receive effluents, and flooding hazards had to be avoided in the siting of any new facilities. The flow characteristics of area streams will determine their reliability as sources of supply. The low-flow characteristics of streams and rivers will govern their potential for receiving and assimilating wastewater. Similarly, flooding potential and flood magnitudes had to be determined for the best location of various facilities and any mitigatory measures needed.

River basins with drainage areas inside the 16-township region are the Fox River, the east branch of the South Branch of the Kishwaukee River, and the West Branch of the DuPage River. The central and major portion (over 70% of the total area) of the study area lies within the Fox River Basin. The eastern fringe of the study area drains eastward to the West Branch of the DuPage River. The northwest corner of the study area drains northwest toward the east branch of the South Branch of the Kishwaukee River. Figure 4 shows the streams, rivers, and gaging stations in the general area. Drainage areas at various gaging locations are given in Table 3.

The Fox is a major river in northeastern Illinois. It drains an area of 870 square miles in Wisconsin before entering Illinois at McHenry County. The Fox River enters Kane County with a drainage area of 1,402 square miles and flows southward along the eastern side of the county, draining approximately 320 square miles in Kane and small portions of Cook and DuPage Counties. The Fox leaves Kane County at its southern border. The Fox River joins the Illinois River at Ottawa with a drainage area of 2,658 square miles at its mouth. The proposed SSC ring would have intersected the Fox River at two locations: near the northern arc, where the drainage area is about 1,592 square miles and near the southern arc, where the drainage area is 1,738 square miles. The average flow in the Fox River near the proposed SSC site is approximately 1,100 cfs. There is a considerable amount of lake and channel storage in the Fox River Basin upstream of the SSC site. This causes the range between the magnitude of low flows and high flows to be relatively small. The mean annual low flows along the Fox River are around 200 cfs, while the mean annual flood is approximately 5,000 cfs. The river has a shallow slope, with velocities less than 1.5 feet per second (fps) during average flows and less than 4 (fps) during peak flows. The river is typically about 300 feet wide. Within the study area, tributaries of the Fox River tend to be smaller, with watershed areas of less than 70 square miles. Average widths and depths of these tributaries are typically less than 30 feet and 3 feet, respectively. The average flow of these tributaries is approximately 0.7 cfs per

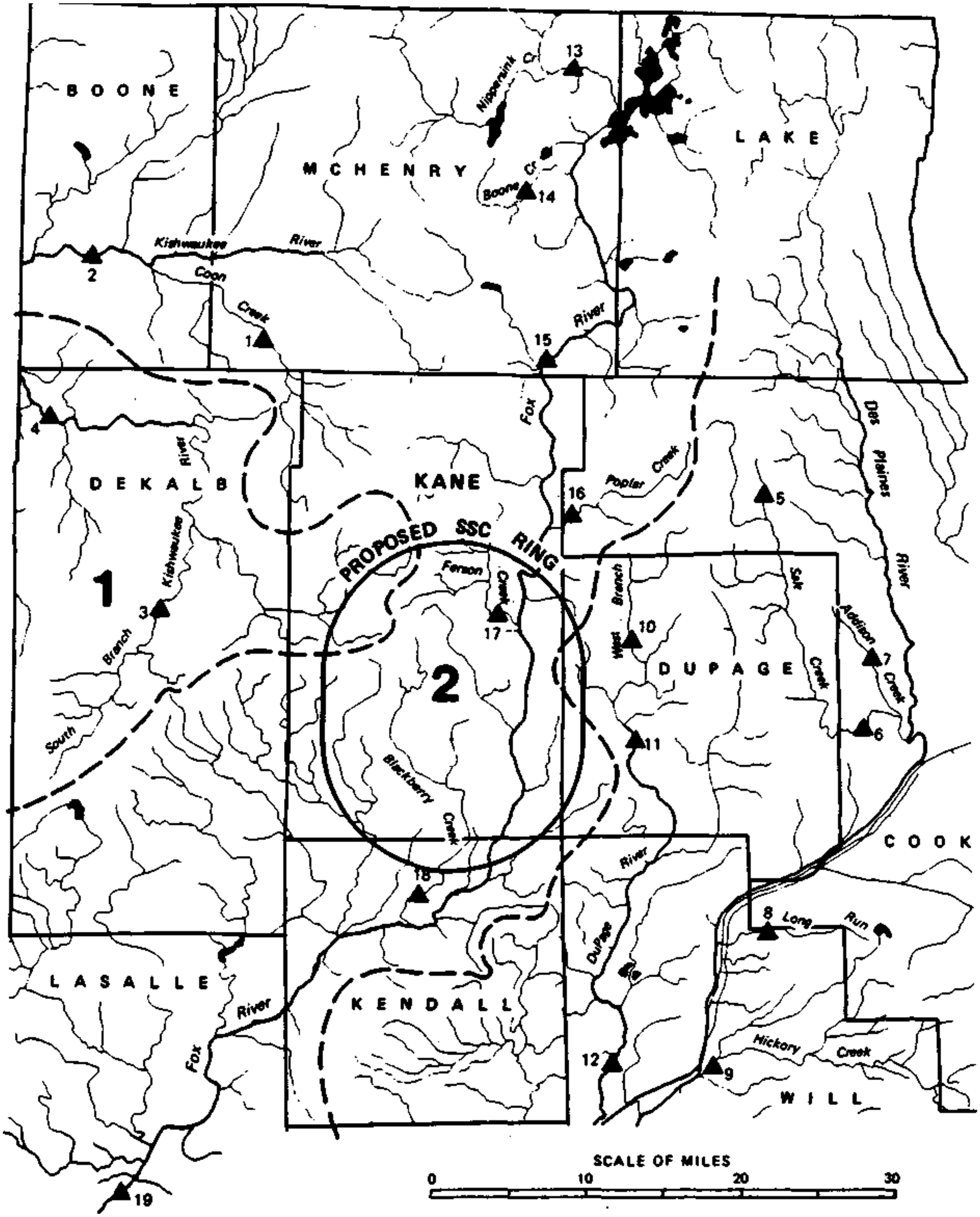


Figure 4. Area streams, USGS gaging stations, and hydrologically homogeneous regions

Table 3. Streamgage Stations in Figure 4 and Drainage Areas

Stream and gage location	*UGSS number*	*Number in fig. 5*	*Drainage area (sq mi)*
Coon Creek at Riley	**05438250**	**1**	**85.1**
Kishwaukee River at Belvidere	**05438500**	**2**	**538**
S. Br. Kishwaukee River at DeKalb	**05439000**	**3**	**77.7**
S. Br. Kishwaukee River near Fairdale	**05439500**	**4**	**387**
Salt Creek near Arlington Heights	**05531000**	**5**	**32.1**
Salt Creek at Western Springs	**05531500**	**6**	**114**
Addison Creek at Bellwood	**05532000**	**7**	**17.9**
Long Run near Lemont	**05537500**	**8**	**20.9**
Hickory Creek at Joliet	**05539000**	**9**	**107**
W. Branch DuPage River near West Chicago	**05539900**	**10**	**28.5**
W. Branch DuPage River near Warrenville	**05540095**	**11**	**90.4**
DuPage River at Shorewood	**05540500**	**12**	**324**
Nippersink Creek near Spring Grove	**05548280**	**13**	**192**
Boone Creek near McHenry	**05549000**	**14**	**15.5**
Fox River at Algonquin	**05550000**	**15**	**1,403**
Poplar Creek at Elgin	**05550500**	**16**	**35.2**
Ferson Creek near St Charles	**05551200**	**17**	**51.7**
Blackberry Creek near Yorkville	**05551700**	**18**	**70.2**
Fox River at Dayton	**05552500**	**19**	**2,642**

square mile (cfs/sq mi) of drainage area. Low flows in these streams are frequently less than 2 cfs.

The West Branch of the DuPage River rises near the northern border of DuPage County and flows south and slightly east, leaving DuPage County at its southern border. The drainage area at its mouth near Naperville is 125 square miles. The projected SSC ring would not intersect the DuPage River, but it would have intersected Kress Creek, a tributary of the DuPage River, in two locations. The drainage areas of Kress Creek at the intersections are 10.09 and 12.55 square miles, respectively. The ring projection would also have intersected a small tributary of Kress Creek with a drainage area of 3.57 square miles at the intersection. Part of the main campus area lies in the Kress Creek watershed.

The east branch of the South Branch of the Kishwaukee River rises in Kane County and flows approximately eastward where it crosses the Kane-DeKalb county line. It then flows northwest and joins the South Branch of the Kishwaukee River in DeKalb County, with a drainage area of 122 square miles. A small portion of the study area lies in the uplands of the basin. The proposed plan of the ring intersects one small tributary, Virgil Ditch #1. The drainage area at the intersection is 2.9 square miles. The SSC drainage area would have been a very small fraction of the total watershed of the South Branch of the Kishwaukee River.

Extensive data from a number of streamgaging stations in and around the proposed site for the SSC were used to determine streamflow regime, seasonal streamflow variability, and relationships between flow parameters and basin factors. Mean flows, low flows and flood flows, and other flow statistics were computed for each station. Regression equations relating mean flow and flow duration to drainage area, and information on seasonal variability of streamflow at various gaging stations were developed. This information can be used to evaluate the flow regimen of most of the ungaged streams in the area proposed for the SSC. Regression models for 7-, 15-, 31-, and 61-day low flows and for 5-, 9-, and 13-month droughts were developed to predict natural low flows and droughts. Similarly, estimates of floods for various return intervals were determined from regression equations relating discharge to drainage area and channel length.

Gaging Station Data

There are 19 USGS gaging stations within 20 miles of the proposed SSC site. Daily flow data at these stations is available for about 8 to 59 years. Information on the USGS number, stream and station name, period of record and basin factors such as drainage area in square miles, main stream slope in feet per mile (fpm), and main stream length in miles (Sieber, 1970; Curtis, 1977) is given in Table 4. Figure 4 shows the location of the gages, which are numbered 1 through 19. Main stream slope in feet per mile is the difference in elevation in feet at points

Table 4. Streamgaging Stations and Relevant Information

*Station no.**	*USGSNo.*	*Daily flow record*	*Drainage area (sq mi)*	*Stream slope (ft/mi)*	*Stream length (mi)*
1	05438250	21(1961-82)	85.10	5.72	16.45
2	05438500	44(1939-83)	538.00	4.59	41.30
3	05439000	8(1925-33)	77.70		
4	05439500	44(1939-83)	387.00	2.27	40.29
5	05531000	21(1950-71)	32.10	13.39	11.30
6	05531500	38(1945-83)	114.00	2.85	36.38
7	05532000	32(1951-83)	17.90	6.21	8.97
8	05537500	32(1951-83)	20.90	7.81	8.17
9	05539000	39(1944-83)	107.00	7.55	23.13
10	05539900	22(1961-83)	28.50	6.58	14.06
11	05540095	15(1968-83)	90.40	4.97	24.25
12	05540500	43(1940-83)	324.00	4.38	52.58
13	05548280	17(1966-83)	192.00	7.68	32.15
14	05549000	34(1948-82)	15.50	7.34	8.90
15	05550000	68(1915-83)	1,403.00	.90	117.27
16	05550500	32(1951-83)	35.20	9.08	16.43
17	05551200	22(1961-83)	51.70	13.31	13.45
18	05551700	23(1960-83)	70.20	5.60	31.53
19	05552500	59(1924-83)	2,642.00	1.64	193.87

Sources: Sieber, 1970; and Curtis, 1977.
*As per figure 4.

10 and 85% of the distance along the stream from the gage to the watershed divide. This figure is then divided by the stream length in miles between these two points.

Of the 19 gaging stations within the region, 12 have data records of relatively natural flows that have not been significantly affected by human activities. Streamflows recorded at six of the remaining seven stations have been artificially altered over the years. A review of flows recorded at stations 6, 10, 11, and 12 reveals that flows at these stations have been increasing. The streams at these gaging stations drain rapidly urbanizing areas, primarily in the Des Plaines and DuPage River Basins. The increase in flow is attributable to more effluents being discharged to the streams from the communities in the area. Two gaging stations, 15 and 19, are located on the Fox River. Flows in the Fox River are controlled by the operation of gates at an upstream dam at McHenry. Fox River flows are also affected by the discharge of effluents from nearby communities. The trends in the data from station 14 were dissimilar to the general hydrological data from the other stations. These seven stations were not included in the development of regional regression equations for the prediction of flow parameters.

The hydrological homogeneity of the remaining stations' data was evaluated through statistical analysis and flow-versus-area figures. The analysis indicates that these stations represent two different hydrologic regions. Stations 3, 4, 5, and 8 lie in one region and stations 1, 2, 7, 9, 13, 16, 17, and 18 in another. The first four stations (in region 1) are located in the South Branch of the Kishwaukee River and tributaries of the Des Plaines River. The South Branch of the Kishwaukee River drains the northwest corner of the 16-township study area; the Des Plaines River is east of the SSC area. Most of the eight stations in region 2 are located in the Fox Basin. Regions 1 and 2 are shown by the enlarged numbers in figure 4. More than 70% of the 16-township study area lies in the Fox River Basin. The drainage areas of the stations in region 1 range from 20.9 to 387.0 square miles. The stations that constitute region 2 have drainage areas between 17.9 and 538.0 square miles. With the exception of the Fox River, streams in and around the proposed SSC site have drainage areas of about 100 square miles or less. These streams are well represented by the range of drainage areas of the station data.

Mean Streamflow and Seasonal Variations

Monthly and annual mean streamflows were computed for each of the 19 gaging stations, which are listed in Table 5. The computed flows represent long-term average flow conditions for the periods of record. The computed mean annual flow serves as a datum from which to assess the seasonal variation in flow patterns. The seasonal variation in flow patterns is exhibited by the ratio of the mean monthly flow to the mean annual flow. These ratios are

Table 5. Monthly and Annual Mean Flows for Streamgaging Stations

Station	Flow (cfs)												
no.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	37.1	39.1	43.6	47.1	53.5	119.5	115.4	79.4	81.0	50.3	34.0	47.0	62.2
2	230.9	245.4	258.2	268.7	350.1	679.8	620.1	440.2	376.7	265.1	187.4	238.8	346.8
3	29.1	60.3	43.7	40.4	62.7	90.6	112.9	64.9	63.0	33.7	7.5	14.1	51.9
4	167.1	153.9	166.4	199.4	262.4	521.7	497.5	373.8	331.1	201.3	131.9	154.8	263.4
5	10.7	13.4	13.6	18.6	26.2	48.8	51.8	26.1	28.5	16.5	5.3	11.2	22.6
6	60.4	66.8	89.7	94.9	107.2	204.2	229.3	144.6	121.0	84.2	69.1	71.7	111.9
7	9.4	10.1	12.8	11.1	12.6	21.8	26.7	18.1	15.7	13.7	12.8	12.9	14.8
8	10.5	8.7	14.9	13.1	17.5	35.9	38.7	23.7	16.8	9.1	4.5	6.9	16.7
9	38.8	41.6	73.0	75.3	94.2	173.6	184.6	130.8	100.5	54.7	29.3	40.2	86.4
10	19.2	21.4	30.7	23.1	28.2	52.2	62.9	42.2	35.1	24.8	22.8	24.7	32.3
11	53.1	58.9	97.1	72.2	83.3	165.1	199.1	141.7	108.5	75.9	76.1	80.6	101.0
12	166.3	154.6	195.0	207.6	261.9	457.4	502.2	394.0	287.1	199.4	143.9	154.4	260.3
13	100.5	111.8	144.4	108.6	145.4	260.0	290.7	195.6	171.1	111.4	101.9	126.5	155.7
14	9.7	11.1	11.6	11.2	14.0	19.0	20.1	15.3	13.7	11.9	10.0	10.0	13.1
15	565.5	717.7	713.7	664.0	782.4	1,648.7	1,709.9	1,085.8	744.2	560.3	431.1	469.9	841.1
16	10.7	13.4	19.6	18.4	22.8	49.4	54.5	33.5	27.4	16.0	8.5	13.2	23.9
17	22.2	27.0	35.6	31.1	38.9	73.8	77.6	52.6	48.0	26.3	24.4	29.5	40.6
18	30.6	32.7	42.3	38.4	46.9	89.2	96.3	79.4	63.8	42.2	26.2	37.1	52.1
19	1,073.7	1,291.3	1,351.6	1,398.3	1,895.0	3,170.6	3,325.5	2,369.5	1,832.9	1,197.6	821.9	962.3	1,724.2

reported in Table 6. The ratio is less than 1.0 for the months July through January and greater than 1.0 for March through June. Low flows usually occur in August, September, or October.

A comparison of the ratio of monthly mean flow to yearly mean flow for each of the two regions shows somewhat different patterns of seasonal flow variability. Lowest ratios occur in region 1 in the month of August, and they are much lower than the lowest ratios in region 2. The highest ratios in region 1 are also higher than any in region 2. Seasonal variations in streamflow are less pronounced in region 2 (which contains most of the proposed SSC ring) than in region 1.

Annual flow duration analysis provides a perspective on the percentage of time that various flow levels may be expected over the course of a year. A daily flow corresponding to the 90% flow duration is that flow that is equaled or exceeded 90% of the time; in other words, for about 329 days a year, flows are greater than the 90% duration flow. Low flows correspond to high-flow durations, high flows correspond to low-flow durations. For example, the 10% duration flow is equaled or exceeded only 10% of the time; thus it represents a relatively high flow. Daily flows corresponding to various flow durations between 95 and 5% are given in Table 7 for the 19 gaging stations.

Regional Relationships for Mean Annual Flow and Flow Duration

In a hydrologically homogeneous region, discharge Q for a given return period varies in a consistent manner with drainage area A; this relationship may be mathematically expressed as:

$$\log Q = a + b \log A, \quad \text{or } Q = C\,A^b \quad \text{where } a = \log C \tag{1}$$

Regression analyses were performed to evaluate the coefficients of this expression for mean annual flow and flows of various durations. Flow parameters were derived from daily flow data from the 12 gaging stations and used in the regression analysis to evaluate relations for discharge in each of the two regions. In addition to drainage area (equation 1), two other basin factors-main channel slope and length-were included in the initial regression analyses. However, inclusion of these factors did not significantly improve the correlation between various flow parameters. Therefore, these factors were not used in the final analyses. The final regression equations are given in Table 8, in which the subscript for Q relates to percentage flow duration; α_1 and α_2 are the constants (a in equation 1) for regions 1 and 2; A is drainage area; and β is the coefficient of log A, which was found to be practically the same for both regions. Given the drainage area in square miles, these equations may be used to compute the natural flow corresponding to flow durations of 95, 90, 85, 80, 75, 70, 60, 50, 40, 30, 25, 20,

Table 6. Ratio of Mean Monthly Flow to Mean Annual Flow for 19 Stations

Station	*Flow ratios*											
no.	***Oct***	***Nov***	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***
1	**.60**	**.63**	**.70**	**.76**	**.86**	**1.92**	**1.85**	**1.28**	**1.30**	**.81**	**.55**	**.75**
2	**.67**	**.71**	**.74**	**.77**	**1.01**	**1.96**	**1.79**	**1.27**	**1.09**	**.76**	**.54**	**.69**
3	**.56**	**1.16**	**.84**	**.78**	**1.21**	**1.75**	**2.18**	**1.25**	**1.21**	**.65**	**.14**	**.27**
4	**.63**	**.58**	**.63**	**.76**	**1.00**	**1.98**	**1.89**	**1.42**	**1.26**	**.76**	**.50**	**.59**
5	**.48**	**.59**	**.60**	**.83**	**1.16**	**2.16**	**2.30**	**1.16**	**1.26**	**.73**	**.23**	**.50**
6	**.54**	**.60**	**.80**	**.85**	**.96**	**1.82**	**2.05**	**1.29**	**1.08**	**.75**	**.62**	**.64**
7	**.64**	**.68**	**.86**	**.75**	**.85**	**1.47**	**1.80**	**1.22**	**1.06**	**.93**	**.86**	**.87**
8	**.63**	**.52**	**.89**	**.78**	**1.05**	**2.15**	**2.32**	**1.42**	**1.01**	**.54**	**.27**	**.41**
9	**.45**	**.48**	**.85**	**.87**	**1.09**	**2.01**	**2.14**	**1.51**	**1.16**	**.63**	**.34**	**.46**
10	**.59**	**.66**	**.95**	**.71**	**.87**	**1.62**	**1.95**	**1.31**	**1.09**	**.77**	**.71**	**.76**
11	**.53**	**.58**	**.96**	**.71**	**.83**	**1.64**	**1.97**	**1.40**	**1.07**	**.75**	**.75**	**.80**
12	**.64**	**.59**	**.75**	**.80**	**1.01**	**1.76**	**1.93**	**1.51**	**1.10**	**.77**	**.55**	**.59**
13	**.65**	**.72**	**.93**	**.70**	**.93**	**1.67**	**1.87**	**1.26**	**1.10**	**.72**	**.65**	**.81**
14	**.74**	**.85**	**.88**	**.85**	**1.06**	**1.45**	**1.53**	**1.17**	**1.04**	**.90**	**.76**	**.76**
15	**.67**	**.85**	**.85**	**.79**	**.93**	**1.96**	**2.03**	**1.29**	**.88**	**.67**	**.51**	**.56**
16	**.45**	**.56**	**.82**	**.77**	**.95**	**2.06**	**2.28**	**1.40**	**1.14**	**.67**	**.35**	**.55**
17	**.55**	**.67**	**.88**	**.77**	**.96**	**1.82**	**1.91**	**1.30**	**1.18**	**.65**	**.60**	**.73**
18	**.59**	**.63**	**.81**	**.74**	**.90**	**1.71**	**1.85**	**1.52**	**1.22**	**.81**	**.50**	**.71**
19	**.62**	**.75**	**.78**	**.81**	**1.10**	**1.84**	**1.93**	**1.37**	**1.06**	**.69**	**.48**	**.56**

Table 7. Flow Duration Information for 19 Streamgaging Stations

Station	Flow at percent duration (cfs)												
no.	*95*	*90*	*85*	*80*	*70*	*60*	*50*	*40*	*30*	*20*	*15*	*10*	*5*
1	5.1	7.3	9.0	12.0	18.0	23.0	31.0	40.0	55.0	80.0	101.1	138.0	221.5
2	52.0	62.0	73.0	87.0	119.0	153.0	191.0	242.0	322.0	458.0	567.3	744.0	1,161.0
3	.2	.6	1.1	2.2	6.0	11.0	19.0	31.0	46.0	76.0	100.0	136.0	221.9
4	14.0	17.0	21.0	27.0	45.0	75.0	113.0	160.0	230.0	352.0	452.3	640.0	1,030.9
5	.1	.3	.7	1.0	2.1	3.7	6.8	11.0	17.0	30.0	42.1	59.0	97.2
6	6.0	11.0	16.0	20.0	31.0	44.0	57.0	74.0	102.0	154.0	196.0	266.0	434.0
7	1.1	1.9	2.7	3.3	4.5	5.7	7.1	9.1	12.0	18.0	23.0	32.0	54.0
8	0.0	.1	.1	.3	.9	2.1	3.8	6.7	12.0	20.0	27.0	41.0	75.0
9	5.2	6.9	8.1	9.5	13.0	19.0	26.0	38.0	55.0	90.0	123.0	184.0	339.0
10	2.0	4.6	6.6	8.5	12.0	15.0	19.0	25.0	32.0	44.0	53.0	70.0	101.1
11	16.0	21.0	25.0	28.0	35.0	44.0	56.0	74.0	99.0	137.1	168.1	216.1	331.2
12	34.0	41.0	48.0	56.0	80.1	106.1	138.1	179.1	245.1	355.1	441.9	580.2	863.9
13	34.0	43.0	51.0	58.0	70.0	83.0	99.0	120.0	155.0	211.0	253.8	319.0	445.8
14	4.8	5.5	6.1	6.7	7.9	9.1	10.0	12.0	14.0	17.0	19.0	23.0	30.0
15	123.0	173.0	212.0	253.0	329.1	415.1	540.1	699.1	920.1	1,300.1	1,570.1	1,950.2	2,560.0
16	.7	1.0	1.4	2.0	3.4	5.3	8.9	14.0	21.0	34.0	44.0	61.0	97.0
17	1.7	3.2	4.8	6.8	11.0	15.0	20.0	27.0	38.0	54.0	67.0	89.1	136.2
18	7.0	9.1	12.0	14.0	18.0	23.0	29.0	37.0	50.0	70.0	86.0	110.0	164.0
19	269.0	342.0	406.1	465.0	605.1	798.1	1,070.1	1,400.1	1,880.1	2,570.0	3,199.2	4,010.0	5,279.5

Table 8. Regional Relationships for Mean Flow and Flow Duration

Variable	*Estimated parameters*			*Regression statistics*		
Q	α_1	a_2	β	R^2	*SE*	*F*
Qmean	**-0.076**	**-0.049**	**0.961**	**0.995**	**0.034**	**951.3**
Q95	**-3.335**	**-2.323**	**1.579**	**0.900**	**0.307**	**36.0**
Q90	**-2.938**	**-2.011**	**1.497**	**0.921**	**0.282**	**52.3**
Q85	**-2.460**	**-1.665**	**1.376**	**0.909**	**0.274**	**44.9**
Q80	**-2.049**	**-1.393**	**1.285**	**0.927**	**0.220**	**57.1**
Q75	**-1.729**	**-1.201**	**1.225**	**0.936**	**0.188**	**65.7**
Q70	**-1.472**	**-1.037**	**1.179**	**0.942**	**0.168**	**72.5**
Q60	**-1.116**	**-0.825**	**1.132**	**0.956**	**0.132**	**98.8**
Q50	**-0.790**	**-0.605**	**1.082**	**0.971**	**0.100**	**149.0**
Q40	**-0.503**	**-0.394**	**1.037**	**0.983**	**0.072**	**258.7**
Q30	**-0.249**	**-0.191**	**1.004**	**0.989**	**0.056**	**392.8**
Q25	**-0.119**	**-0.077**	**0.987**	**0.992**	**0.045**	**571.4**
Q20	**-0.048**	**-0.036**	**0.973**	**0.995**	**0.034**	**982.8**
Q15	**0.179**	**0.167**	**0.957**	**0.998**	**0.023**	**2156.8**
Q10	**0.365**	**0.332**	**0.940**	**0.998**	**0.019**	**3036.5**
Q5	**0.639**	**0.583**	**0.912**	**0.993**	**0.041**	**603.1**

Note: Log Q = α_i + β log A; A = drainage area in square miles.
R2 = R square statistic or coefficient of determination.
SE = standard error of estimate.
F = F statistic.
Q = flow in cfs.
α_i = constants for regions 1 and 2.

15, 10, and 5%, as well as the mean flow, for any location in these regions. Flows at durations of 95, 90, 85, 80, and 70% are much lower in region 1 than corresponding flows in region 2, as shown by the a values in Table 8.

Low Flows and Droughts

Daily flow data from each of the 19 stations were used to determine the 7-, 15-, 31-, and 61-day low flows for each station at various recurrence intervals. The 7-day low flow is the minimum average daily flow over a single 7-day period. The 15-, 31-, and 61-day low flows are similarly defined. Monthly flow data were used to identify continuous droughts. Low-flow and drought regression analyses were performed independently for each region using the station data from the two groups of homogeneous stations (stations 3, 4, 5, and 8; and stations 1, 2, 7, 9, 13, 16, 17, and 18).

Low flows and droughts at each station for various recurrence intervals were estimated using standard statistical analyses. For the purpose of evaluating the low flows, a low-flow year was defined beginning April 1 and ending March 31. Values of the minimum 7-, 15-, 31-, and 61-day and 5-, 9-, and 13-month flows were computed for each year. The number of 13-month periods is smaller than the number of years of record because the months considered in one period are excluded from other 13-month periods. The minimum flows calculated for the period of record were ranked in an ascending order of magnitude, and the associated nonexceedance probabilities for each series containing N values were determined using the relation $p=i/(N+l)$, where i is the rank order of a particular flow. Flow values were plotted on log-normal probability paper, and smooth curves were drawn for each of the durations. Recurrence interval, T, in years is related to the nonexceedance probability, p, by the relation $T = 1/p$. Flow corresponding to recurrence intervals of 2, 5, 10, and 25 years (probabilities of 0.5, 0.2, 0.1, and 0.04, respectively) were obtained from the plots. The estimated values of the four low-flow and three drought variables at 2-, 5-, 10-, and 25-year recurrence intervals are given in Table 9 for each of the 19 stations.

A regression model was developed to estimate natural low flows at any location along a stream in the proposed SSC area. Parameters initially included in the regression equation are drainage area, main channel slope, and channel length. Including the main channel slope and channel length did not improve the coefficient of determination (square of correlation coefficient), and these parameters were deleted from the regression model. A dummy variable, D, was used to distinguish between the two regions. The regression equation used to model low flows and drought flows is given by:

$$\log Q = a_1 D + a_2 + b \log A \qquad (2)$$

Table 9. Low Flows and Drought Flows at 19 Stations

			Flow (cfs)						
No.	***USGS no.***	***T***	***7DLF***	***15DLF***	***31DLF***	***61DLF***	***5MD***	***9MD***	***13MD***
1	05438250	2	7.40	8.10	9.20	12.00	25.00	35.50	60.00
		5	3.00	3.30	7.40	4.30	6.90	15.30	28.50
		10	2.60	2.70	3.20	4.00	6.30	10.50	15.60
		25	2.40	2.55	2.80	3.65	4.50	7.60	11.30
2	05438500	2	59.00	69.00	83.00	96.00	150.00	225.00	350.00
		5	45.00	49.00	52.00	58.00	70.00	111.00	180.00
		10	34.00	36.00	40.00	45.00	58.00	94.00	125.00
		25	29.00	30.00	33.00	40.00	50.00	77.00	101.00
3	05439000	2	.20	.40	.66	1.10	15.30	32.00	59.00
		5	.03	.10	.20	.62	5.40	13.30	25.00
		10	.01	.04	.09	.35	2.10	5.90	10.20
		25		.01	.04	.13	.60	1.50	3.70
4	05439500	2	17.50	19.20	21.50	27.50	53.00	150.00	250.00
		5	10.10	10.80	12.00	14.50	18.80	57.00	118.00
		10	9.00	9.60	10.20	12.20	16.00	39.00	85.00
		25	6.90	7.50	7.90	10.40	14.00	31.00	60.00
5	05531000	2	.50	.70	.90	1.60	5.40	12.30	24.00
		5			.07	.30	1.10	4.60	8.80
		10			.01	.08	.32	2.50	6.40
		25				.01	.08	1.10	3.50
6	05531500*								
7	05532000	2	2.55	2.90	3.20	5.00	7.10	11.80	16.20
		5	.81	1.10	1.60	2.20	3.30	5.40	8.60
		10	.10	.40	.60	.70	1.70	3.00	5.60
		25		.04	.15	.24	.71	1.30	3.80
8	05537500	2	.02	.03	.08	.30	2.30	8.30	16.00
		5				.03	.30	3.20	7.60
		10					.04	1.50	4.10
		25						.52	1.70
9	05539000	2	5.40	6.20	7.50	9.60	18.60	51.00	81.00
		5	3.70	4.60	5.10	6.20	9.80	25.50	51.00
		10	2.50	3.20	3.80	4.30	6.80	16.00	28.50
		25	1.30	1.80	2.60	3.50	5.50	9.80	19.00
10	05539900*								

Table 9. (Concluded)

			Flow (cfs)						
No.	*USGS no.*	*T*	*7DLF*	*15DLF*	*31DLF*	*61DLF*	*5MD*	*9MD*	*13MD*
11	05540095*								
12	05540500*								
13	05548280	2	50.00	53.00	58.00	64.00	77.00	118.00	166.00
		5	25.00	28.50	32.00	37.00	47.00	60.00	100.00
		10	22.00	25.00	27.00	29.50	39.00	48.00	64.00
		25	19.00	22.00	24.00	27.00	34.00	42.00	48.00
14	05549000	2	5.20	5.50	5.80	6.40	8.00	10.00	13.00
		5	4.20	4.40	4.70	5.40	6.40	7.40	9.20
		10	4.00	4.20	4.40	4.70	5.20	6.30	7.40
		25	3.60	3.80	4.10	4.40	4.90	5.40	6.60
15	05550000	2	185	235	250	290	485	730	1,000
		5	105	132	150	185	280	390	685
		10	68	110	122	142	228	316	460
		25	60	94	107	121	155	202	300
16	05550500	2	.80	1.20	1.70	2.20	6.50	13.00	25.00
		5	.40	.50	.64	.95	1.50	5.40	11.30
		10	.20	.24	.42	.64	1.00	3.20	7.00
		25	.10	.15	.22	.35	.60	1.70	4.80
17	05512000	2	4.30	4.80	5.80	8.00	17.00	28.00	37.00
		5	.70	1.00	1.30	2.00	4.00	10.20	18.00
		10	.40	.67	1.00	1.75	2.80	6.50	11.30
		25	.27	.56	.90	1.60	2.40	3.90	7.10
18	05551700	2	10.00	11.80	13.60	14.80	22.50	33.50	50.00
		5	5.30	5.80	6.90	7.90	10.50	16.80	26.00
		10	3.50	4.00	4.70	5.50	7.10	11.70	16.50
		25	1.40	1.70	3.00	4.70	5.50	10.60	13.70
19	05552500	2	400	435	500	580	1,000	1,460	2,050
		5	295	325	355	405	530	790	1,060
		10	236	270	300	350	470	535	780
		25	215	235	255	300	395	480	610

Note: cfs = cubic feet per second.
T = recurrence interval in years.
DLF = day low flow.
MD = month drought flow.
* Rapidly changing low flows - no estimates developed.

where

Q is the low-flow or drought variable, in cubic feet per second
A is the drainage area, in square miles
D = 1 for region 1 (stations 3,4,5, and 8);
0 for region 2 (stations 1,2,7,9,13,16,17, and 18); and
a_1, a_2, and b are coefficients.

The coefficients of the model were determined using ordinary least-squares regression, which are given in Table 10. Here $a_1 = a_1 + a_2$ and $a_2 = a_2$ are the constants for regions 1 and 2; $\beta = b$ is the coefficient of log A for both regions; R is the correlation coefficient; SE is the standard error of estimate in log units; and F denotes the value of the F statistic. The statistical analyses and flow-versus-area figures support the division of the area into two hydrologically homogenous regions.

The regression model can be used to estimate low flows at any location along a stream in the SSC area for either region 1 or region 2 with the appropriate coefficients. Low flows and droughts at 2- and 10-year recurrence intervals for streams with drainage areas of 25, 50, and 100 square miles were computed and are listed in Table 11.

The statistical analyses provide information on the expected frequency with which low flows of various magnitudes may occur. To understand fully the nature or character of low-flow and drought events in the area, the temporal distributions of low-flow periods were investigated for each of five stations in the immediate vicinity of the proposed SSC site. The five most severe low flows, corresponding to the seven flow parameters (7-, 15-, 31-, and 61-day and 5-, 9-, and 13-month low flows), were tabulated for each station. The common period of record for the five stations is 1960-1983. Two indicators were examined; the month in which the event occurred and the overlap or temporal concurrence of the various durations of the low flows.

The month(s) in which each low-flow event typically occurs is summarized for the five stations. Severe low flows for each designated duration typically occur in the same year, and the rank of the event is about the same for each flow duration. The 7- and 15-day low flows occur mostly in September. These are embedded in 31- and 61-day low flows, which in turn may be embedded in 5- and 9-month drought flows. The temporal distribution demonstrates the persistence of low-flow events in the area During severe dry periods or droughts, most area streams suffer low-flow conditions.

Table 10. Regional Relationships for Low Flows and Droughts

Variable	*Estimated parameters*			*Regression statistics*		
Q	α_1	α_2	β	R^2	*SE*	*F*
2-year						
7DLF	-3.117	-2.014	1.508	0.916	0.449	23.6
15DLF	-2.852	-1.840	1.453	0.923	0.405	26.0
31DLF	-2.486	-1.593	1.363	0.940	0.325	33.9
61DLF	-1.895	-1.173	1.197	0.938	0.282	33.0
5MD	-0.834	-0.553	1.004	0.971	0.136	74.5
9MD	-0.348	-0.253	0.970	0.989	0.076	203.0
13MD	-0.046	-0.029	0.949	0.997	0.039	695.5
5-year						
7DLF	-4.263	-2.905	1.788	0.893	0.479	13.8
15DLF	-3.629	-2.517	1.628	0.908	0.389	16.5
31DLF	-3.367	-2.267	1.559	0.938	0.346	29.4
61DLF	-3.020	-2.098	1.504	0.945	0.333	37.7
5MD	-1.850	-1.138	1.222	0.943	0.248	36.1
9MD	-0.822	-0.660	1.004	0.984	0.096	139.1
13MD	-0.473	-0.376	0.984	0.988	0.080	186.8
10-year						
7DLF	-5.575	-4.058	2.257	0.922	0.489	19.9
15DLF	-4.780	-3.470	2.000	0.915	0.426	18.0
31DLF	-4.050	-2.880	1.740	0.947	0.386	34.7
61DLF	-3.356	-2.451	1.605	0.965	0.247	53.7
5MD	-2.876	-2.108	1.525	0.950	0.305	41.4
9MD	-1.321	-1.064	1.125	0.986	0.102	160.4
13MD	-0.761	-0.640	1.013	0.983	0.098	132.8
25-year						
7DLF	-5.540	-4.450	2.250	0.940	0.343	19.1
15DLF	-5.080	-3.960	2.110	0.940	0.442	26.5
31DLF	-4.737	-3.502	2.004	0.943	0.359	28.3
61DLF	-4.605	-3.333	1.996	0.960	0.339	47.1
5MD	-3.319	-2.462	1.635	0.966	0.244	55.4
9MD	-2.088	-1.647	1.338	0.976	0.169	89.6
13MD	-1.232	-0.953	1.101	0.972	0.145	78.1

Note: $\log Q = \alpha_i + \beta \log A$; A is the drainage area in square miles.
R = correlation coefficient.
SE = standard error of the estimate.
F = F statistic.
DLF = day low flow.
MD = month drought flow.

Table 11. Low Flows and Droughts at 2-year and 10-year Recurrence Intervals for Drainage Areas of 25, 50, and 100 Square Miles

	Flow for given drainage areas (cfs)					
	Region 1			*Region 2*		
Q	*25 sq mi*	*50 sq mi*	*l00 sq mi*	*25 sq mi*	*50 sq mi*	*100 sq mi*
2-year						
7DLF	**0.10**	**0.28**	**0.79**	**1.24**	**3.53**	**10.01**
15DLF	**0.15**	**0.41**	**1.13**	**1.55**	**4.25**	**11.64**
31DLF	**0.26**	**0.68**	**1.74**	**2.05**	**5.28**	**13.58**
61DLF	**0.60**	**1.38**	**3.16**	**3.16**	**7.26**	**16.63**
5MD	**3.71**	**7.44**	**14.93**	**7.09**	**14.22**	**28.51**
9MD	**10.19**	**19.95**	**39.08**	**12.7**	**24.8**	**48.6**
13MD	**19.08**	**36.84**	**71.12**	**19.84**	**38.31**	**73.96**
10-year						
7DLF	**0.00**	**0.02**	**0.09**	**0.13**	**0.60**	**2.86**
15DLF	**0.01**	**0.04**	**0.17**	**0.21**	**1.85**	**3.39**
31DLF	**0.03**	**0.08**	**0.27**	**0.36**	**1.19**	**3.98**
61DLF	**0.08**	**0.23**	**0.71**	**0.62**	**1.89**	**5.74**
5MD	**0.18**	**0.52**	**1.49**	**1.06**	**3.04**	**8.75**
9MD	**1.79**	**3.89**	**8.49**	**3.23**	**7.04**	**15.35**
13MD	**4.52**	**9.12**	**18.41**	**5.97**	**12.05**	**24.32**

Note: cfs = cubic feet per second.
DLF = day low flow.
MD = month drought flow.

Low flow duration	*Month(s) with highest frequency of occurrence*
7-day	September
15-day	September
31-day	August-September
61-day	August-October
5-month	July-January
9-month	June-March

Low Flows of the Fox River

Fox River flows have been altered over the years by human activities. Low and medium flows are controlled by the operation of gates at the Wilmot Dam in Wisconsin and the McHenry Dam in northern Illinois, both upstream of the study area. In addition to the flow regulation, the flow quantity has also been increased as area communities discharge wastewater effluents into the Fox River and its tributaries. Analysis of low flows in the Fox River must take these factors into consideration.

The volume and rate of effluent discharges are significant relative to the estimated natural low flows of the Fox River. The original source of the wastewater discharge is ground water that has been pumped to meet public water supply demands. Until 1983, most of this public water supply (ultimately discharged to the Fox River as treated wastewater) was obtained from the deep sandstone aquifer. This aquifer is hydrologically independent of the river system, so the effluent discharges represent an additive component to the river flow. The quantity of effluents discharged to the river system has increased over time (Singh and Stall, 1973; Singh, 1983). Along the river in Kane County in 1984, the additive component of effluents contributed 30 to 50% of the total flow when the flow was equal to the 7-day 10-year low flow for the 1984 conditions-natural flow plus 1984 effluents (Broeren and Singh, 1987). In other words, effluent discharges are nearly of the same order as the natural 7-day 10-year low flow in the river.

A methodology for deriving low-flow statistics for streams receiving significant effluent inflows was developed by Singh and Stall (1973). The time-varying component of the effluent flows is subtracted from the daily flow data. The estimated natural flows thus calculated are statistically analyzed to determine various naturally occurring low-flow parameter values (e.g., 7-day 10-year low flow). Then, for any given year the effluent discharges along the river are incrementally added to the natural flow values to determine the expected actual flow value. Using this methodology, 7-, 31-, and 61-day low-flow and 5- and 9-month drought statistics for the Fox River were calculated using known 1984 effluent conditions and projected effluent values for 1990 and 2000 (Broeren and Singh, 1987). Figure 5 shows a portion of the Fox River

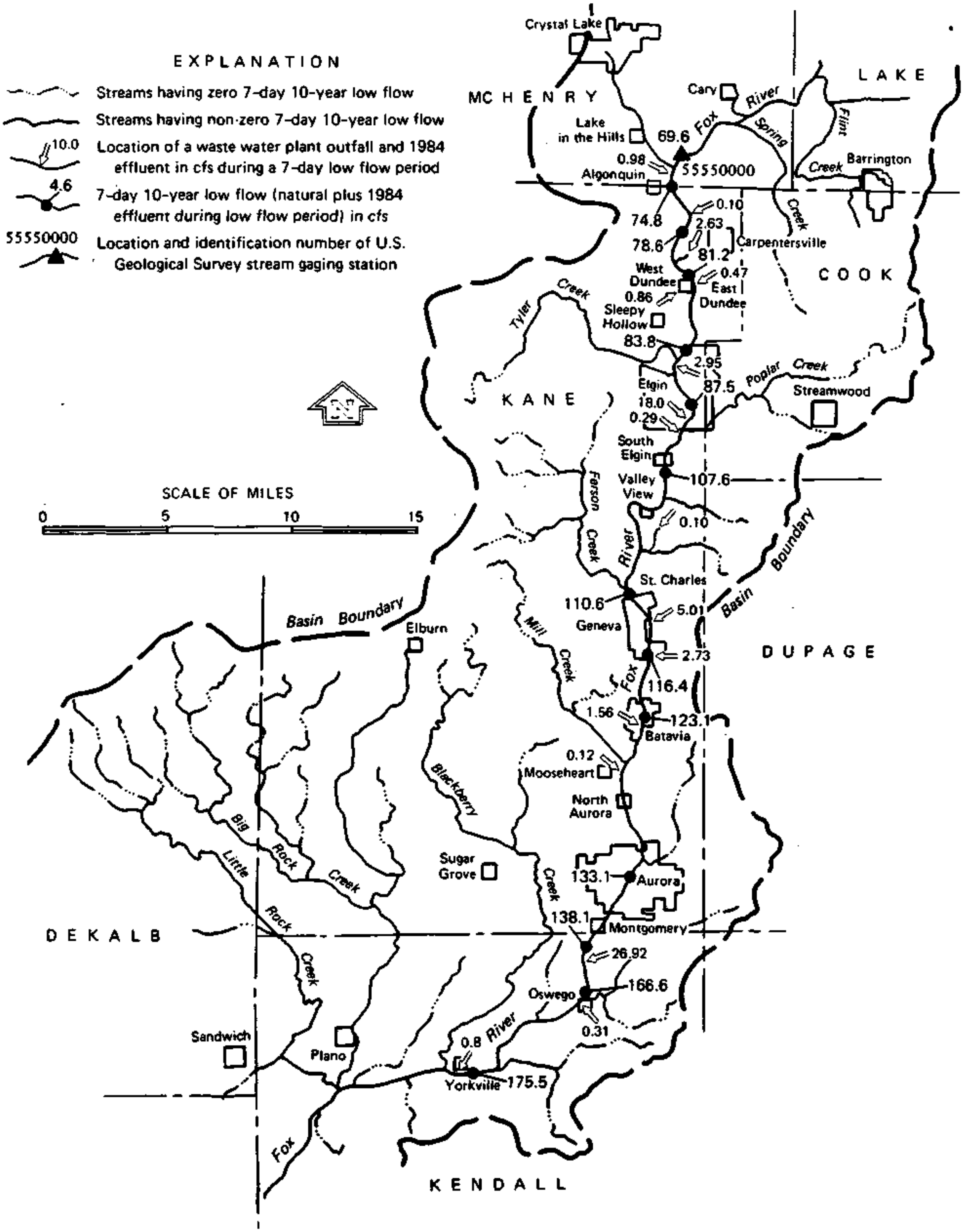


Figure 5. 7-day 10-year low flows at selected locations along the Fox River

Basin from around Algonquin in McHenry County to just below Yorkville in Kendall County. The 7-day 10-year low flow (natural plus 1984 effluent during low-flow periods) is shown for various locations along the Fox River. Figure 6 shows a schematic diagram of the river and effluent discharge locations. The numbers in the figure represent sites just below the effluent outfalls. Projected 7-day 10-year low flows are listed in Table 12, and the numbers correspond to the numbered sites in Figure 6.

Flood Frequency and Expected Flood Levels

. The observed annual peak flows and basin characteristics, such as drainage area and stream slope at the 19 gaging stations, were used to estimate floods at various recurrence intervals. The magnitudes of floods having 2-, 25-, 50-, and 100-year recurrence intervals were estimated for each station and are listed in Table 13 (Curtis, 1977; Allen and Bejcek, 1979), along with flow depths at the 19 stations. The regression equation for the 500-year flood and an estimated weighting factor were used to determine the best estimate of the 500-year flood. The depth of flow at these locations for a 25-, 50-, and 100-year flood is determined using the following equations developed by Prugh (1976):

$$D_{25} = 1.52\, Q_2^{0.267} \qquad (3)$$

$$D_{50} = 1.66\, Q_2^{0.263} \qquad (4)$$

$$D_{100} = 1.80\, Q_2^{0.259} \qquad (5)$$

where

D_{25}, D_{50}, and D_{100} = the depth of flow in the channel (feet) for 25-, 50-, and 100-year floods, respectively

Q2 = the 2-year flood (cfs)

The magnitude of floods with recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years may be estimated from developed regression equations for streams with small- to medium-sized drainage areas. The drainage area, A, and channel length, L, are needed to evaluate the following flood frequency regression equations for the SSC area:

$$\log Q_2 = 1.743 + 1.087 \log A - 0.626 \log L \qquad (6)$$

$$\log Q_5 = 1.956 + 1.206 \log A - 0.821 \log L \qquad (7)$$

$$\log Q_{10} = 2.066 + 1.261 \log A - 0.917 \log L \qquad (8)$$

$$\log Q_{25} = 2.172 + 1.302 \log A - 0.992 \log L \qquad (9)$$

$$\log Q_{50} = 2.235 + 1.336 \log A - 1.047 \log L \qquad (10)$$

$$\log Q100 = 2.291 + 1.361 \log A - 1.092 \log L \qquad (11)$$

$$\log Q500 = 2.386 + 1.417 \log A - 1.181 \log L \qquad (12)$$

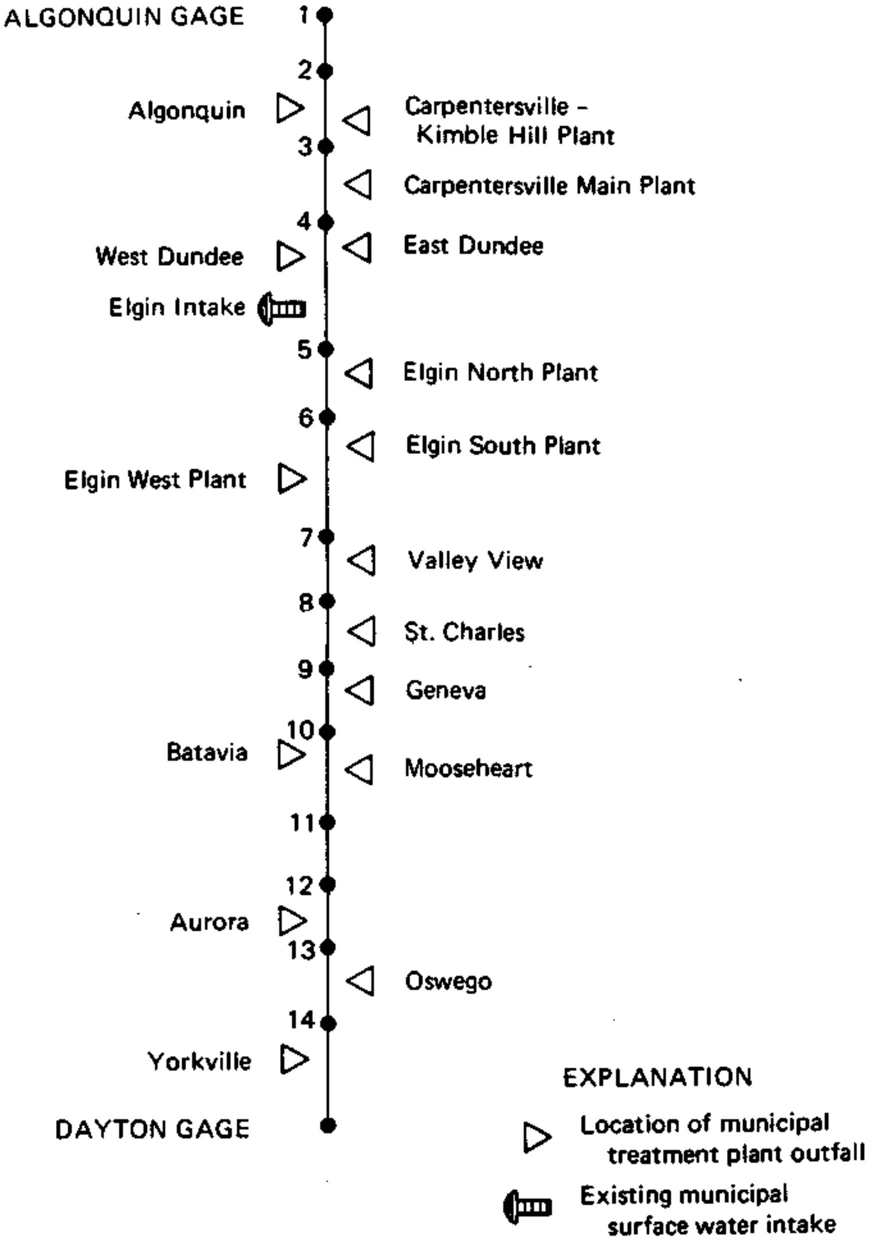


Figure 6. Schematic of Fox River wastewater treatment plant outfalls and existing municipal surface water intakes

Table 12. 7-day 10-year Low Flows, Fox River

Site	*1984*	*1990*	*2000*
1	69.64	75.17	85.32
2	74.81	80.72	92.51
3	78.60	84.64	96.95
4	81.24	87.23	99.95
5	83.84	89.98	102.86
6	87.51	94.04	107.36
7	107.69	116.63	132.65
8	110.64	119.65	135.68
9	116.35	125.17	142.82
10	123.08	132.61	149.93
11	133.14	142.84	160.42
12	138.14	147.84	165.42
13	166.56	178.78	199.28
14	175.46	187.74	208.32

Table 13. Estimates of Floods and Flow Depths at 19 Gaging Stations

Station no.	*USGS no.*	*Observed maximum flow (cfs)*	*Flood estimates (cfs) for T equal to*					*Flow depth estimates (ft)*		
			2	*25*	*50*	*100*	*500*	*25*	*50*	*100*
1	**05438250**	**5,090**	**1,100**	**3,330**	**3,920**	**4,500**	**5,890**	**9.86**	**10.5**	**11.0**
2	**05438500**	**10,300a**	**3,660**	**11,300**	**13,300**	**15,400**	**19,700**	**13.6**	**14.4**	**15.1**
3	**05439000b**	**3,500**	-	-	-	-	-	-	-	-
4	**05439500**	**8,460a**	**3,590**	**8,520**	**9,730**	**10,800**	**13,300**	**13.5**	**14.3**	**15.0**
5	**05531000**	**1,060a**	**547**	**1,220**	**1,360**	**1,510**	**1,790**	**8.18**	**8.71**	**9.21**
6	**05531500**	**2,070a**	**1,140**	**1,920**	**2,080**	**2,220**	**2,530**	**9.95**	**10.6**	**11.1**
7	**05532000**	**839a**	**440**	**736**	**793**	**847**	**963**	**7.72**	**8.23**	**8.71**
8	**05537500**	**3,160**	**591**	**1,780**	**2,100**	**2,400**	**3,080**	**8.35**	**8.89**	**9.40**
9	**05539000**	**20,500**	**2,740**	**7,370**	**8,610**	**9,730**	**12,300**	**12.6**	**13.3**	**14.0**
10	**05539900**	**984a**	**441**	**839**	**924**	**1,000**	**1,160**	**7.73**	**8.23**	**8.71**
11	**05540095**	**2,160**	**1,100**	**2,050**	**2,250**	**2,430**	**2,820**	**9.86**	**10.5**	**11.0**
12	**05540500**	**12,000**	**3,350**	**8,260**	**9,400**	**10,600**	**12,800**	**13.3**	**14.0**	**14.7**
13	**05548280**	**3,980a**	**1,450**	**4,510**	**5,370**	**6,210**	**7,830**	**10.6**	**11.3**	**11.9**
14	**05549000**	**276a**	**130**	**321**	**366**	**411**	**523**	**5.58**	**5.97**	**6.35**
15	**05550000c**	**6,610a**	**3,140**	**6,090**	**6,690**	**7,240**	-	-	-	-
16	**05550500**	**896a**	**422**	**850**	**941**	**1,030**	**1,210**	**7.73**	**8.24**	**8.72**
17	**05551200**	**1,970a**	**804**	**2,000**	**2,300**	**2,580**	**3,170**	**9.07**	**9.64**	**10.2**
18	**05551700**	**2,060**	**617**	**1,390**	**1,570**	**1,740**	**2,100**	**8.03**	**8.99**	**9.51**
19	**05552500c**	**47,100**	**11,700**	**28,800**	**33,000**	**37,100**	-	-	-	-

a Observed maximum flow is less than 100-year flood estimate.

b Insufficient data for estimating flood frequency.

c Flood estimates from individual station frequency curves. No regional flood estimates are available at these locations.

Floodplain Delineation

Floodplain management regulations generally require new construction in a floodplain to be elevated above the 100-year flood level. From 1978 to 1987, flood insurance studies for the communities of Aurora, St. Charles, and West Chicago and for the unincorporated areas of DuPage, Kane, and Kendall Counties were conducted under the auspices of the National Flood Insurance Program. The studies employed detailed hydrologic and hydraulic methods to determine the flow volume and water surface elevations of the base flood, or 100-year flood, on streams of primary importance within their scopes of study. The flood profiles were used with the best available topographic information to delineate Flood Insurance Rate Maps (FIRMs) for each community and county. For streams that have been studied in detail for the National Flood Insurance Program, elevations may be read from the flood profiles produced in the flood insurance studies. For the streams not studied in detail, approximate methods were used to calculate the 100-year floodplain depicted on the FIRMs.

A composite map of 100-year floodplains was developed for an expanded 36-township region encompassing the proposed SSC site. The study area was expanded from 16 to 36 townships to afford a more thorough review of flood parameters. The composite 100-year floodplain map is available on the Geographical Information System (GIS). The study region covers all or parts of Cook, DeKalb, DuPage, Kane, Kendall, and Will Counties. Township and range lines delineating the study region are: the north line of T42N, the south line of T37N, the west line of R4E, and east line of R9E, relative to the Third Principal Meridian and Centralia Base Line. The 36-township region is shown in Figure 7.

Federal Insurance Rate Maps published prior to January 1985 by the Federal Insurance Administration of the Federal Emergency Management Agency (FEMA) are the source of stream centerline and floodplain information for the composite map. FIRMs are published as a series of maps for each county and cover all unincorporated areas of the county. The maps are referred to as "panels." Each county uses an individual numbering system, and incorporated areas are separated from unincorporated areas. The FIRM for each incorporated area will consist of one or more panels, and each incorporated area has its own panel numbering system. County and city panels are not numbered consecutively. More than 137 FIRM panels were needed to compose the floodplain information for the 36-township study region. The FIRMs used are published at five different scales. The level of detail of each flood hazard study used to develop the maps also varies considerably. Some of the FIRMs are published at scales that allow even very narrow floodplains to be shown. It was not possible to preserve this level of detail for the GIS coverage. The minimum floodplain width that can be reproduced from the information on the GIS is about 200 feet. In order to show all areas where floodplains have

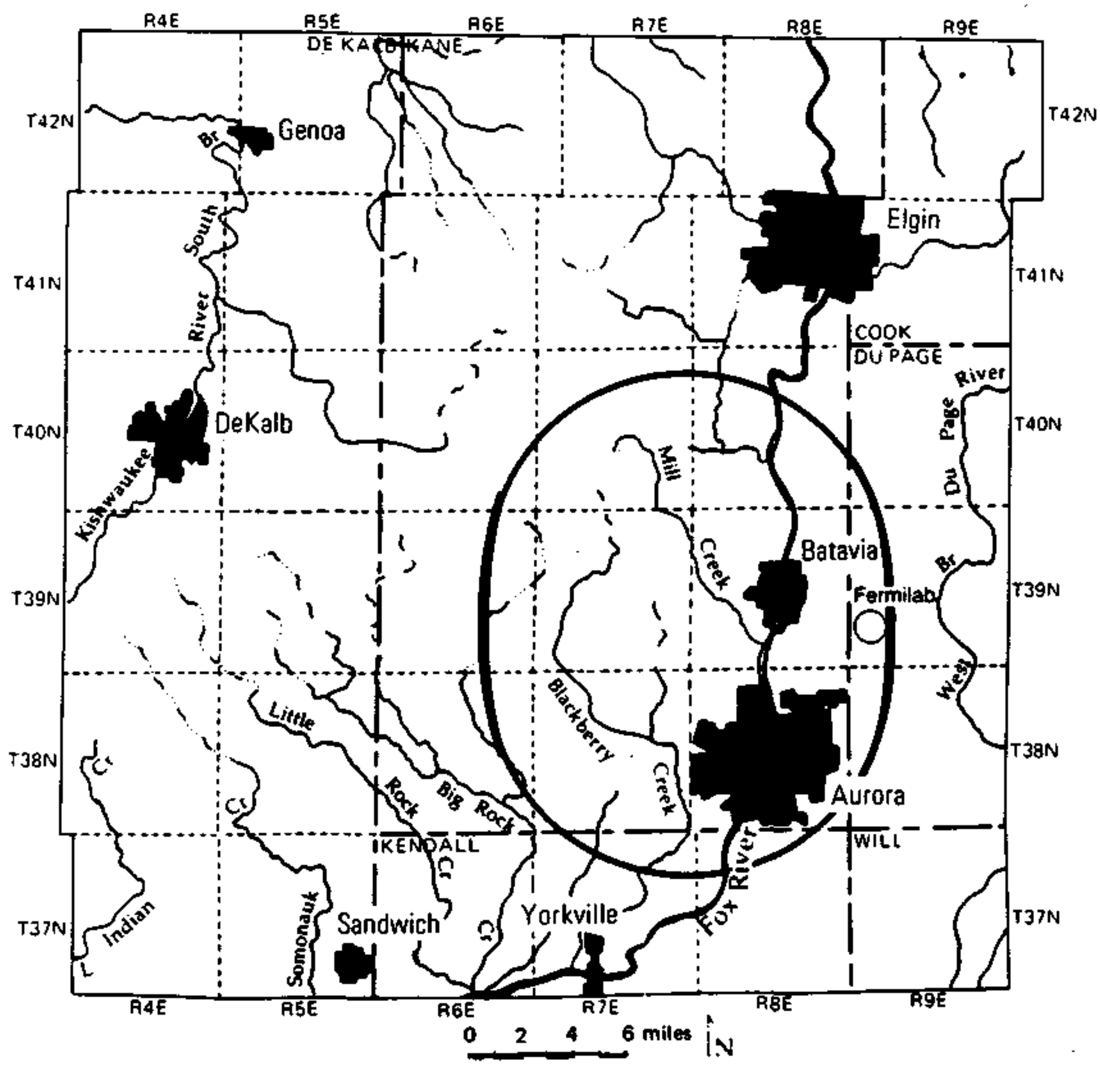


Figure 7. Floodplain delineation for the 36-township region

been identified, all floodplains on the FIRMs that are up to 200 feet wide are represented at a width of 200 feet in the GIS coverage. A list of the FIRMs used is presented in Table 14.

The extent of the 100-year floodplain for the proposed SSC area is shown on the map in Figure 8. This is a composite of 137 FIRM maps produced for the various counties and communities. The composite map was generated by drafting the floodplains shown on the FIRMs to a coverage with a scale of 1 inch = 2,000 feet. This information was digitized and stored on the Geographic Information System at the Illinois State Water Survey.

Sustained flooding in the proposed SSC area is most likely to occur along the Fox River. Overbank flooding is frequent on the Fox River, especially when saturated soil conditions are combined with snowmelt and/or heavy rainstorms. Ice jams and accumulation of floating debris at bridges often impede flow and cause higher flood levels upstream than might be expected without such impediments. While minor flooding events are frequent, major floods with severe consequences are rare, due mostly to the controlling effects of the Chain-of-Lakes and man-made structures installed downstream. Most of the study area consists of flat to moderately sloping agricultural lands. These upland areas are not generally susceptible to sustained flooding, although depressions and low-lying areas collect water at times and hold it for many days.

Surface Water Quality

The water quality of potential supply sources determines the need for treatment and the level required for use as industrial cooling water or potable water. The type of treatment affects the cost of using each particular source. Also, the comparative quality of SSC tunnel seepage water relative to potential receiving streams was determined to assess the impact of the discharge of the seepage water. Similarly, the water quality conditions of streams and rivers had to be known to evaluate the impact of wastewater discharges from the main campus and the far experimental areas.

The Illinois Pollution Control Board promulgates one standard of surface water quality that applies to streams designated for general use and a second, stricter standard for public supplies. The general-use standards are intended to protect aquatic life, contact recreation, and agricultural and industrial uses. The public water supply standard applies only at locations where water is withdrawn for public supply. Surface water quality was evaluated according to these standards, which are listed in Table 15.

In order to assess the general water quality characteristics of the surface water resources in the study area, existing data in either published form (USGS water data reports) or machine-readable form [Illinois Environmental Protection Agency's (IEPA) Ambient Water Quality Monitoring Network (AWQMN)] were used. The AWQMN was initiated in 1974 and

Table 14. FEMA Federal Insurance Rate Maps (FIRMs)

County	*Unincorporated areas*	*Incorporated areas*
Cook	**county panels**	**Barrington**
	30	**Barrington Hills 1-4**
	55	**Bartlett 3,5,7**
	60	**Hanover Park**
	85	**Hoffman Estates 4,6,7**
	90	**Schaumburg 5,10**
		South Barrington 2,3,4
		Streamwood 1,4
DeKalb	**county panels***	
	1	**Kingston**
	3-12	**Kirkland**
	14-16	**Sycamore**
	18-20	
	22	
	24	
	26-28	
	31-32	
	34-44	
DuPage	**5**	**Carol Stream**
	10	**Naperville 7,8,9**
	15	**Warrenville**
	20	**West Chicago**
	25	**Wheaton**
	35	**Winfield**
	40	
	50	
	55	
Kane	**10**	**Algonquin 1,2**
	20	**Aurora 10,15,20**
	30	**Batavia 1-4**
	35	**Carpentersville 1,2**
	40	**East Dundee**
	45	**Elgin 3,4,6,7,8,10,13**
	55	**Geneva 2**
	60	**Hampshire**
	65	**Montgomery**
	70	**North Aurora 1,2**
	100	**St. Charles 1,4,5**
	125	**Sleepy Hollow**
	130	**South Elgin 2**
	135	**Wayne 2,4**
	140	**West Dundee**
	145	

Table 14. (Concluded)

County	*Unincorporated areas*	*Incorporated areas*
Kendall	5	Oswego
	10	Yorkville 1
	15	
	20	
	30	
	35	
	40	
	55	
Will	15	
	20	
	55	
	60	

Note: FIRMs used were published prior to January 1985.

* Only flood hazard boundary maps available.

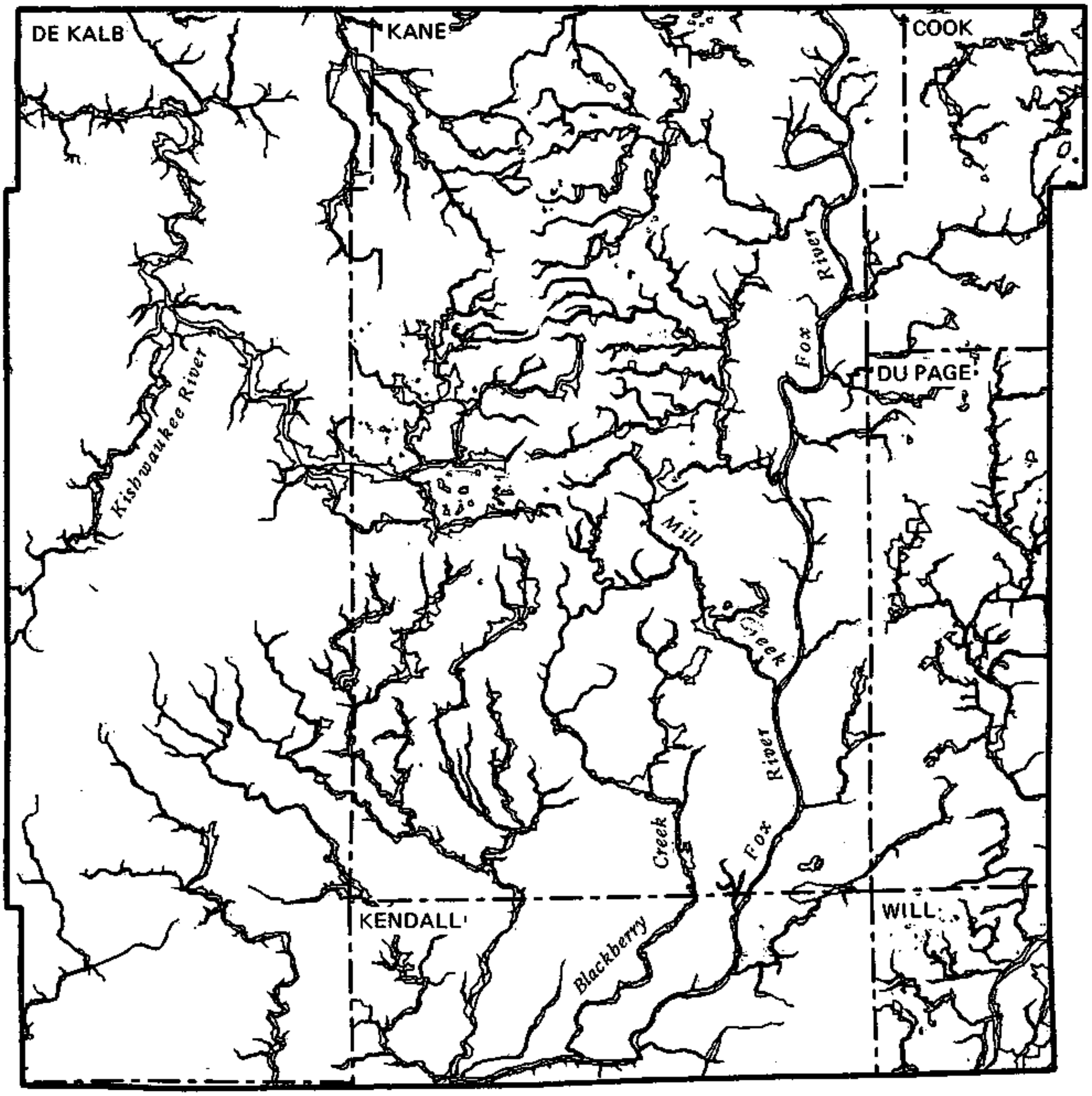


Figure 8. Map of the 100-year floodplain of the 36-township study region (Areas within the red lines constitute the 100-year floodplain.)

Table 15. Illinois Water Quality Standards

Parameter	*Units*	*General use*	*Public and food processing water supply*	*Secondary contact and indigenous aquatic life*
pH	SU	6.5 minimum 9.0 maximum	6.5 minimum 9.0 maximum	6.0 minimum 9.0 maximum
Dissolved oxygen	mg/L	5.0 minimum	5.0 minimum	4.0 minimum
Arsenic	µg/L	1,000	50	1,000
Barium	µg/L	5,000	1,000	5,000
Boron	µg/L	1,000	1,000	—
Cadmium	µg/L	50	10	150
Chloride	mg/L	500	250	—
Chromium	µg/L	1,050	50	1,300
Copper	µg/L	20	20	1,000
Cyanide	mg/L	0.025	0.025	0.10
Fluoride	mg/L	1.4	1.4	15.0
Iron (total)	µg/L	1,000	1,000	2,000
Iron (dissolved)	µg/L	-	—	500
Lead	µg/L	100	50	100
Manganese	µg/L	1,000	150	1,000
Mercury	µg/L	0.5	0.5	0.5
Nickel	µg/L	1,000	1,000	1,000
Phenols	µg/L	100	1.0	300
Selenium	µg/L	1,000	10	1,000
Silver	µg/L	5.0	5.0	100
Sulfate	mg/L	500	250	—
Total dissolved solids	mg/L	1,000	500	1,500
Zinc	µg/L	1,000	1,000	1,000
Fecal coliform	#/100 ml	200	200	1,000a
Ammonia nitrogen	mg/L	1.5/15[b]	1.5/15[b]	2.5 April-Oct. 4.0 Nov.-March
Un-ionized ammonia	mg/L	0.04	0.04	—
Nitrate nitrogen	mg/L	—	10.0	—
Oil and grease	mg/L	—	0.1	15.0
Total phosphorus	mg/L	0.05c	0.05c	—

a Standard repealed August 1, 1985.

b The allowable concentration varies in accordance with water temperature and pH values. In general, as both temperature and pH decrease, the allowable value of ammonia nitrogen increases.

c Standard applies to lakes and reservoirs and at the point at which any stream enters a lake or reservoir.

data from 1974 to 1985 are available for six stations in or near the SSC study area. Stations in the Fox River Basin include sites on the Fox River at South Elgin and at Montgomery and on Blackberry Creek near Yorkville. Three stations are located on the West Branch of the DuPage River: near West Chicago, near Naperville, and near Warrenville. Thirty water quality parameters, including mean daily flows at three existing monitoring stations in each of the river systems, were considered in developing general water quality information.

The number of measurements made at each station varies from station to station and from year to year. The number of measurements made during the last ten to eleven years ranges from about 30 to 70 for heavy metals such as barium, iron, and zinc, and from about 50 to 90 for such parameters as dissolved oxygen, pH, chloride, phosphorus, and nitrogen. The data were grouped into three sets, one spanning the entire period 1974-1985, one for the period 1974-1980, and one for the period 1981-1985. Each data set was statistically analyzed for range and mean values. Summaries of the data collected at each station are presented in Tables 16-21. Any changes, improvement or otherwise, in ambient water quality characteristics between the two time periods can be discerned by comparing average parameter values.

The water quality characteristics of the Fox and DuPage Rivers are typical of those of northern Illinois streams: well buffered and high in alkalinity, hardness, conductivity, and dissolved solids. Water quality in the Fox River Basin varies from fair to good. Trends in water quality indexes developed by the IEPA indicated that water quality in the Fox River improved over the period 1978 to 1985 (IEPA, 1986). On the basis of water quality indexes, the Fox River Basin was rated second highest in water quality in the state. The status for the DuPage River had improved from severe water quality problems in 1972 to intermediate or minor water quality problems in 1983 (IEPA, 1984). The general improvement in water quality over the period of record is also shown by the dramatic decrease in fecal coliform counts at the three Fox River Basin stations and the Naperville station on the DuPage River. The fecal coliform count is an indicator of the presence of wastewater in a river or stream.

The mean dissolved oxygen (DO) values in the two streams were found to be well above the desirable levels of 6 mg/L for game fish populations. However, a few observations found DO levels below the desired minimum level, including occasional observations of anoxic conditions. The mean fecal coliform counts were much higher than the IPCB's recommended standard of 200 counts/100 milliliters (mL) for general use and public water supply stream quality. The maximum observed fecal coliform counts in these streams were two to three times higher than the limits for fecal coliform.

The mean values for ammonia-N, nitrate-N, and organic nitrogen observed in these streams are typical of most of the streams in Illinois. Even though the ammonia and nitrate

Table 16. Water Quality of the Fox River at South Elgin

	1974 -1985			*1974 - 1980*			*1981 - 1985*		
Parameters	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*
Flows, cfs	309	7,220	1,430	309	7,220	1,383	315	5,180	1,471
Turbidity, FTU	1	49	16	-	-	-	1	49	16
pH, units	6.8	8.8	8.0	7.7	8.8	8.3	6.8	8.3	7.7
Conductivity, µmho/cm	560	1,040	733	560	1,040	769	587	879	702
Dissolved oxygen	0.0	17.3	10.4	0.0	14.8	10.8	4.1	17.3	10.2
Suspended sediments	1	100	37	2	100	36	1	100	37
Volatile suspended sediments	0	30	14	0	30	14	1	28	14
Dissolved solids	326	520	441	-	-	-	326	520	441
Fecal coliform, counts/100 ml	10	4,400	569	10	4,400	747	10	2,200	430
Alkalinity	180	366	279	180	366	279	-	-	-
Hardness	282	423	333	330	330	330	282	423	334
Chloride	29	230	58	33	230	59	29	84	57
Sulfate	40	110	59	44	110	67	40	66	52
Ammonia-N	0.02	20.0	0.68	0.02	20.0	1.12	0.02	1.3	0.27
Nitrate-N	0.10	10.0	1.75	0.10	3.50	1.35	0.30	10.0	2.11
Kjeldahl-N	0.69	3.70	1.94	0.90	3.60	1.91	0.69	3.70	1.96
Total phosphorus-P	0.06	3.20	0.26	0.06	3.20	0.30	0.06	0.52	0.22
Dissolved phosphorus P	0.00	0.44	0.10	0.00	0.33	0.06	0.00	0.44	0.12
Grease and oil	0.0	6.0	0.89	0.0	6.0	1.05	0.0	4.0	0.70
Arsenic (total)	0	3	1	0.0	1.0	0.8	2	3	2.5
Barium (total)	0	161	93	-	-	-	0	161	93
Cadmium (total)	0	7	2	0	0	0	0	7	2
Chromium (total)	0	12	4	0	0	0	0	12	4
Copper (total)	0	70	6	0	70	6	0	43	6
Iron (total)	71	1,995	621	100	1,000	512	71	1,995	640
Lead (total)	0	340	31	0	340	13	0	100	47
Manganese (total)	19	132	65	20	120	67	19	132	65
Nickel (total)	0	22	6	-	-	-	0	22	6
Silver (total)	0	10	3	-	-	-	0	10	3
Zinc (total)	0	647	79	0	100	17	0	647	96

Note: Heavy metal concentrations (arsenic to zinc) are expressed in µg/L.
All other measurements are in mg/L except as indicated.

Table 17. Water Quality of the Fox River at Montgomery

Parameters	*1974 -1985*			*1974 - 1980*			*1981 - 1985*		
	Min	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*
Flows, cfs	105	8,020	1,652	105	8,020	1,620	300	6,420	1,688
Turbidity, FTU	1	100	21	-	-	-	1	100	21
pH, units	6.6	8.7	8.0	7.5	8.7	8.2	6.6	8.7	7.9
Conductivity, µmho/cm	547	1,030	738	550	1,030	764	547	980	716
Dissolved oxygen	7.0	15.2	10.9	7.0	15.2	10.9	7.2	14.7	10.9
Suspended sediments	1	200	52	1	200	58	1	190	48
Volatile suspended sediments	0	77	19	0	42	20	1	77	18
Dissolved solids	222	486	385	-	-	-	222	486	385
Fecal coliform, counts/100 ml	30	42,000	2,368	30	42,000	3,848	91	8,500	1,338
Alkalinity	180	366	254	200	366	267	180	320	245
Hardness	242	415	317	310	310	310	242	415	317
Chloride	33	95	59	33	95	59	36	87	60
Sulfate	35	116	58	41	116	64	35	76	53
Ammonia-N	0.00	2.20	0.30	0.00	2.20	0.40	0.02	0.96	0.20
Nitrate-N	0.00	12.0	1.81	0.00	4.90	1.67	0.20	12.0	1.93
Kjeldahl-N	1.00	4.00	1.88	1.00	3.10	1.83	1.10	4.00	1.91
Total phosphorus-P	0.09	2.30	0.29	0.09	2.30	0.33	0.12	1.20	0.27
Dissolved phosphorus P	0.00	0.74	0.12	0.00	0.31	0.10	0.00	0.74	0.13
Grease and oil	0.0	63.0	1.9	0.0	5.0	0.9	0.0	63.0	2.72
Arsenic (total)	0	5	2	0	5	1.9	1	5	2.4
Barium (total)	51	148	91	-	-	-	51	148	91
Cadmium (total)	0	10	2	0	0	0	0	10	2
Chromium (total)	0	33	3	0	10	0.3	0	33	6
Copper (total)	0	288	12	0	10	3	0	288	19
Iron (total)	0	2,886	848	0	1,600	709	79	2,886	884
Lead (total)	0	100	30	0	100	10	0	100	49
Manganese (total)	12	175	76	20	140	58	12	175	81
Nickel (total)	0	38	7	-	-	-	0	38	7
Silver (total)	0	5	3	-	-	-	0	5	3
Zinc (total)	0	581	81	0	100	15	0	581	100

Note: Heavy metal concentrations (arsenic to zinc) are expressed in µg/L.
All other measurements are in mg/L except as indicated.

Table 18. Water Quality of Blackberry Creek near Yorkville

	1974 - 1985			*1974 -1980*			*1981 - 1985*		
Parameters	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***
Flows, cfs	4	1,250	89	4	1,250	88	9	913	92
Turbidity, FTU	1	110	23	-	-	-	1	110	23
pH. units	6.8	8.5	7.8	7.3	8.5	8.0	6.8	8.2	7.6
Conductivity, µmho/cm	190	1,120	747	190	1,120	763	340	860	733
Dissolved oxygen	3.8	15.5	10.2	3.8	15.2	10.2	6.5	15.5	10.1
Suspended sediments	1	340	53	1	210	51	1	340	54
Volatile suspended sediments	1	70	12	2	36	11	1	70	12
Dissolved solids	280	562	466	.	.	.	280	562	466
Fecal coliform, counts/100 ml	9	12,000	1,192	70	8,000	1,348	9	12,000	1,072
Alkaliniry	80	355	272	80	355	272	-	-	-
Hardness	146	470	386	340	340	340	146	470	389
Chloride	8	53	33	8	53	33	-	-	-
Sulfate	18	124	85	18	124	86	52	95	80
Ammonia-N	0.00	1.10	0.09	0.00	1.10	0.11	0.01	0.74	0.06
Nitrate-N	0.90	6.80	3.08	0.90	5.30	2.84	1.00	6.80	3.30
Kjeldahl-N	0.10	3.70	0.95	0.40	1.90	0.86	0.10	3.70	1.00
Total phosphorus-P	0.02	0.61	0.13	0.02	0.51	0.14	0.02	0.61	0.13
Dissolved phosphorus P	0.00	0.42	0.05	0.00	0.16	0.04	0.00	0.42	0.06
Grease and oil	0.0	6.0	1.5	0.0	6.0	1.6	1.0	1.0	1.0
Arsenic (total)	0	4	1	0	1	0.6	1	4	2
Barium (total)	59	139	81	64	64	64	59	139	82
Cadmium (total)	0	8	2	0	8	1	0	4	3
Chromiun (total)	0	54	5	0	10	1	0	54	6
Copper (total)	0	31	4	0	20	3	0	31	5
Iron (total)	112	9,311	1,571	200	3,600	1,519	112	9,311	1,585
Lead (total)	0	100	28	0	100	4	0	100	47
Manganese (total)	37	651	121	50	200	103	37	651	127
Nickel (total)	0	13	6	13	13	13	0	12	6
Silver (total)	0	5	3	5	5	5	0	4	3
Zinc (total)	0	365	67	0	10	1	0	365	89

Note: Heavy metal concentrations (arsenic to zinc) are expressed in µg/L.
All other measurements are in mg/L except as indicated.

Table 19. Water Quality of the West Branch of the DuPage River near West Chicago

	1974 -1985			*1974 - 1980*			*1981 - 1985*		
Parameters	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***
Flows, cfs	**7**	**813**	**60**	**7**	**498**	**61**	**11**	**813**	**58**
Turbidity, FTU	**2**	**140**	**23**	-	-	-	**2**	**140**	**23**
pH, units	**6.8**	**8.5**	**7.7**	**7.6**	**8.2**	**8.0**	**6.8**	**8.5**	**7.5**
Conductivity, µmho/cm	**778**	**1,950**	**1,254**	**800**	**1,950**	**1,323**	**778**	**1,700**	**1,220**
Dissolved oxygen	**4.6**	**15.8**	**9.6**	**6.6**	**13.8**	**9.9**	**4.6**	**15.8**	**9.5**
Suspended sediments	**5**	**180**	**42**	**16**	**180**	**44**	**5**	**140**	**42**
Volatile suspended sediments	**2**	**72**	**11**	**2**	**30**	**10**	**2**	**72**	**11**
Dissolved solids	**504**	**1,000**	**702**	-	-	-	**504**	**1000**	**702**
Fecal coliform, counts/100 ml	**10**	**53,000**	**2,132**	**91**	**3,200**	**654**	**10**	**53,000**	**2,792**
Alkalinity	-	-	-	-	-	-	-	-	-
Hardness	**242**	**480**	**367**	**480**	**480**	**480**	**242**	**429**	**359**
Chloride	**72**	**300**	**161**	**72**	**300**	**155**	**72**	**300**	**164**
Sulfate	**68**	**235**	**135**	**115**	**235**	**172**	**68**	**210**	**119**
Ammonia-N	**0.04**	**1.60**	**0.34**	**0.60**	**1.60**	**0.23**	**0.04**	**1.30**	**0.38**
Nitrate-N	**3.0**	**12.0**	**6.9**	**3.00**	**12.0**	**6.4**	**3.1**	**12.0**	**7.3**
Kjeldahl-N	**1.0**	**2.7**	**1.5**	-	-	-	**1.0**	**2.7**	**1.5**
Total phosphorus-P	**0.47**	**5.10**	**1.92**	**2.00**	**5.10**	**2.90**	**0.47**	**3.0**	**1.69**
Dissolved phosphorus P	**0.32**	**3.60**	**1.67**	**3.20**	**3.20**	**3.20**	**0.32**	**3.60**	**1.61**
Grease and oil	**0.0**	**8.0**	**0.8**	**0.0**	**8.0**	**0.9**	**0.0**	**2.0**	**0.7**
Arsenic (total)	**0**	**3**	**1**	**1**	**2**	**1.3**	**0**	**3**	**2**
Barium (total)	**79**	**284**	**188**	**150**	**150**	**150**	**79**	**284**	**188**
Cadmiun (total)	**0**	**5**	**3**	**0**	**5**	**2**	**0**	**5**	**3**
Chromium (total)	**0**	**12**	**5**	**0**	**10**	**3**	**0**	**12**	**5**
Copper (total)	**0**	**30**	**8**	**0**	**30**	**9**	**0**	**14**	**7**
Iron (total)	**300**	**4,200**	**1,390**	**560**	**4,200**	**2,380**	**300**	**4,132**	**1,344**
Lead (total)	**0**	**100**	**34**	**0**	**100**	**9**	**0**	**100**	**46**
Manganese (total)	**34**	**160**	**94**	**50**	**150**	**100**	**34**	**160**	**94**
Nickel (total)	**0**	**43**	**10**	**20**	**20**	**20**	**0**	**43**	**10**
Silver (total)	**0**	**7**	**3**	**5**	**5**	**5**	**0**	**7**	**3**
Zinc (total)	**0**	**227**	**83**	**0**	**10**	**3**	**0**	**227**	**88**

Note: Heavy metal concentrations (arsenic to zinc) are expressed in ug/L.
All other measurements are in mg/L except as indicated.

Table 20. Water Quality of the West Branch of the DuPage River near Warrenville

	1974 -1985			*1974 - 1980*			*1981 - 1985*		
Parameters	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***
Flows, cfs	13	1,490	116	13	1,490	110	21	990	126
Turbidity, FTU	4	78	23	4	70	21	4	78	35
pH, units	6.8	8.8	7.7	7.4	8.1	7.7	6.8	8.8	8.0
Conductivity, µmho/cm	0	2,450	1,346	670	2,400	1,425	0	2,450	1,266
Dissolved oxygen	4.8	16.0	9.0	4.8	16.0	8.7	5.6	13.5	9.3
Suspended sediments	5	230	43	5	123	41	8	230	45
Volatile suspended sediments	0	79	13	0	70	14	2	79	12
Dissolved solids	371	1,368	853	371	1,368	854	512	1,320	831
Fecal coliform, counts/100 ml	35	8,400	1,650	-	-	-	35	8,400	1,650
Alkalinity	168	398	274	168	398	274	260	260	260
Hardness	154	558	403	180	558	409	154	472	384
Chloride	58	520	205	70	410	207	58	520	202
Sulfate	54	245	134	76	245	156	54	180	112
Ammonia-N	0.01	10.24	0.84	0.01	10.24	1.03	0.17	3.50	0.69
Nitrate-N	2.6	12.0	6.1	5.3	6.4	5.8	2.6	12.0	6.1
Kjeldahl-N	0.6	11.4	2.0	0.6	11.4	2.1	0.9	3.4	2.0
Total phosphorus-P	0.28	2.74	1.39	0.32	2.74	1.40	0.28	2.50	1.37
Dissolved phosphorus P	0.21	2.60	1.21	0.21	2.60	1.20	0.25	2.50	1.22
Grease and oil	0	13	1	0	3	1	0	13	1
Arsenic (total)	2	2	2	-	-	-	2	2	2
Barium (total)	52	277	126	-	-	-	52	277	126
Cadmium (total)	0	20	4	0	20	5	0	5	3
Chromium(total)	0	20	8	0	20	11	0	20	6
Copper (total)	0	41	14	0	30	18	0	41	11
Iron (total)	50	5,148	1,354	200	4,600	1,424	50	5,148	1,282
Lead (total)	0	200	45	0	200	41	0	100	48
Manganese (total)	37	600	101	40	600	117	37	190	85
Nickel (total)	0	27	7	-	-	-	0	27	7
Silver (total)	0	4	3	-	-	-	0	4	3
Zinc (total)	0	632	82	10	80	39	0	632	109

Note: Heavy metal concentrations (arsenic to zinc) are expressed in ug/L.
All other measurements are in mg/L except as indicated.

Table 21. Water Quality of the West Branch of the DuPage River near Naperville

Parameters	*1974 -1985*			*1974 - 1980*			*1981 - 1985*		
	Min	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*
Flows, cfs	**65**	**1,620**	**255**	**92**	**1,620**	**304**	**65**	**931**	**210**
Turbidity, FTU	**1**	**38**	**12**	**-**	**-**	**-**	**1**	**38**	**12**
pH, units	**5.9**	**8.7**	**7.7**	**7.4**	**8.7**	**8.0**	**5.9**	**8.4**	**7.5**
Conductivity, µmho/cm	**0**	**2,250**	**1,343**	**200**	**2,250**	**1,350**	**0**	**1,907**	**1,339**
Dissolved oxygen	**3.3**	**16.2**	**9.5**	**3.3**	**16.2**	**9.0**	**4.9**	**15.2**	**10.0**
Suspended sediments	**2**	**270**	**37**	**2**	**270**	**43**	**4**	**100**	**33**
Volatile suspended sediments	**1**	**48**	**11**	**1**	**48**	**11**	**1**	**23**	**10**
Dissolved solids	**680**	**828**	**761**	**-**	**-**	**-**	**680**	**828**	**761**
Fecal coliform, counts/100 ml	**9**	**110,000**	**2,573**	**10**	**110,000**	**4,873**	**9**	**3,700**	**724**
Alkalinity	**120**	**376**	**280**	**120**	**376**	**282**	**260**	**260**	**260**
Hardness	**327**	**465**	**407**	**420**	**420**	**420**	**327**	**465**	**406**
Chloride	**63**	**370**	**225**	**63**	**370**	**226**	**190**	**240**	**215**
Sulfate	**52**	**175**	**136**	**52**	**175**	**142**	**94**	**130**	**115**
Ammonia-N	**0.08**	**7.90**	**1.59**	**0.10**	**7.90**	**2.16**	**0.08**	**4.40**	**1.07**
Nitrate-N	**2.0**	**12.0**	**4.6**	**2.0**	**8.0**	**3.7**	**3.1**	**12.0**	**5.4**
Kjeldahl-N	**1.0**	**2.2**	**1.6**	**-**	**-**	**-**	**1.0**	**2.2**	**1.6**
Total phosphorus-P	**0.07**	**3.00**	**1.46**	**0.90**	**3.00**	**2.02**	**0.07**	**2.30**	**1.18**
Dissolved phosphorus P	**0.06**	**2.30**	**1.13**	**-**	**-**	**-**	**0.06**	**2.30**	**1.13**
Grease and oil	**0.0**	**11.0**	**1.3**	**0.0**	**11.0**	**1.3**	**0.0**	**4.0**	**1.3**
Arsenic (total)	**1**	**12**	**2**	**1**	**12**	**3**	**1**	**3**	**2**
Barium (total)	**44**	**100**	**74**	**70**	**70**	**70**	**44**	**100**	**74**
Cadmium (total)	**0**	**5**	**2**	**0**	**5**	**0.5**	**0**	**0**	**32.8**
Chromium (total)	**0**	**18**	**4**	**0**	**10**	**1**	**0**	**18**	**5**
Copper (total)	**0**	**40**	**9**	**0**	**40**	**11**	**0**	**31**	**8**
Iron (total)	**139**	**6,000**	**1,011**	**300**	**6,000**	**1,500**	**139**	**2,600**	**903**
Lead (total)	**0**	**180**	**41**	**0**	**180**	**22**	**0**	**141**	**49**
Manganese (total)	**33**	**367**	**73**	**40**	**110**	**73**	**33**	**367**	**73**
Nickel (total)	**0**	**14**	**6**	**14**	**14**	**14**	**0**	**12**	**6**
Silver (total)	**0**	**5**	**3**	**5**	**5**	**5**	**0**	**5**	**3**
Zinc (total)	**0**	**262**	**75**	**0**	**100**	**10**	**0**	**262**	**93**

Note: Heavy metal concentrations (arsenic to zinc) are expressed in µg/L.
All other measurements are in mg/L except as indicated.

concentrations were occasionally found to exceed the stream standards, as indicated by the maximum values reported in Tables 16-21 for these parameters, they are generally well within the general-use and the public water supply stream standards for Illinois surface waters.

The mean total phosphorus values for the DuPage River are much higher than those for the Fox River. The high concentrations of total phosphorus combined with the fact that the dissolved phosphorus constitutes about 80% of the total phosphorus clearly indicates the impact of municipal waste discharges into the DuPage River. Dissolved phosphorus constitutes only about 35% of the total phosphorus in the Fox River at South Elgin and at Montgomery. This value is typical of Illinois streams without major point sources of waste discharges.

With the exception of iron, the heavy metal concentrations reported in Tables 16-21 are generally within the standards stipulated by the IPCB for general-use water quality. The mean concentrations of iron in all three stations in the DuPage River and in Blackberry Creek are higher than the standard of 1.0 mg/L. Iron found in the Fox River is principally derived from geochemical ferrous iron that is dissolved in ground water and seeps into the streams as part of the baseflow. Iron concentration levels increase with discharge. This may be attributed to iron being flushed from the streams as a result of high surface runoff and velocities sufficient to scour the stream bed. The iron concentration violations are a high-flow problem. Measured concentrations of various constituents in the Fox River have periodically violated the general-use and water supply standards but the data do not suggest a persistent or continuing problem.

The dissolved mineral content in the DuPage River is much higher than that in the Fox River. The higher dissolved mineral content in the DuPage River is reflected in its higher conductivity values as compared to the values for the Fox River. The percentage fraction of volatile suspended sediments in these two streams varied from 20 to 39 with an average value of 30. Thus the suspended sediments are predominantly inorganic in nature.

Seasonal variations in water quality in the DuPage River near Warrenville and in the Fox River at Montgomery are given in Tables 22 and 23, respectively. The seasonal effects on water quality are minor.

Historical sediment load data (Adams, et al., 1984) are available for five gaging stations for the years 1981 and 1982: Ferson Creek near St. Charles, South Branch Kishwaukee River at DeKalb, South Branch Kishwaukee River near Fairdale, Kishwaukee River at Belvidere, and DuPage River at Shorewood. The first station is within the proposed SSC ring area, the three stations in the Kishwaukee Basin are 15 to 25 miles west or northwest of the ring, and the last station is about 15 miles southeast of the ring. For Ferson Creek at St. Charles, which is representative of the project area, the annual load ranges from 91 to 116 tons per square mile (tsm) of the drainage area and has a mean value of 104 tsm (Table 24). The long-term average annual sediment load for this station is estimated at 105 tsm or 0.156 tons per acre.

Table 22. Seasonal Variation in Water Quality in the Fox River (Montgomery Reporting Station)

Parameters	/EPA* *standards*	*December-February*	*March-May*	*June-August*	*September-November*
Flow (cfs)	-	1,353	2,854	1,200	1,013
Turbidity (FTU)	-	12	18	42	19
pH	6.5-9.0	8.0	8.1	8.1	8.1
Temperature, °C	-	1.0	9.8	24.2	13.1
Conductivity (µmho/cm)	-	852	674	735	686
Dissolved oxygen (mg/L)	5.0 min	13.4	11.2	8.2	10.2
Suspended sediments (mg/L)	-	13	66	75	47
Volatile suspended sediment (mg/L)	-	5	17	26	18
Dissolved solids (mg/L)	1,000	-	-	-	-
Fecal coliform (cts/100 ml)	200	1,133	2,205	3,073	4,038
Alkalinity (mg/L)	-	322	227	235	230
Hardness (mg/L)	-	384	309	300	313
Chloride (mg/L)	500	67	53	56	55
Sulfate (mg/L)	500	69	58	52	55
Ammonia-N (mg/L)	1.5-15	0.66	0.29	0.06	0.17
Nitrate-N (mg/L)	-	2.58	2.28	0.95	1.34
Kjeldahl-N (mg/L)	-	1.47	1.99	2.03	1.84
Total phosphorus-P (mg/L)	-	0.20	0.24	0.45	0.31
Dissolved phosphorus-P (mg/L)	-	0.14	0.06	0.11	0.12
Grease and oil (mg/L)	-	1.55	0.81	1.06	1.10
Arsenic (µg/L)	1,000	1	2	3	2
Barium (µg/L)	5,000	81	78	105	90
Cadmium (µg/L)	50	1	1	2	2
Chromium (µg/L)	1,050	2	2	3	4
Copper (µg/L)	20	4	5	5	4
Iron (µg/L)	1,000	413	810	1,061	930
Lead (µg/L)	100	22	29	26	36
Manganese (µg/L)	1,000	30	81	107	70
Nickel (µg/L)	1,000	6	4	7	7
Silver (µg/L)	5	3	2	3	3
Zinc (µg/L)	1,000	69	89	56	67

*** IEPA, 1986.**

Table 23. Seasonal Variation in Water Quality in the DuPage River (Warrenville Reporting Station)

Parameters	IEPA* *standards*	*December-February*	*March-May*	*June-August*	*September-November*
Flow (cfs)	-	70	217	100	84
Turbidity (FTU)	-	13	25	32	23
pH	6.5-9.0	7.7	7.7	7.7	7.8
Temperature, °C	-	1.6	9.7	22.1	12.4
Conductivity (µmho/cm)	-	1,518	1,119	1,312	1,461
Dissolved oxygen (mg/L)	5.0 min	11.7	9.4	6.2	11.9
Suspended sediments (mg/L)	-	24	49	62	42
Volatile suspended sediment (mg/L)	-	7	17	19	11
Dissolved solids (mg/L)	1,000	1,070	663	766	892
Fecal coliform (cts/100 ml)	200	1,276	3,767	1,624	1,862
Alkalinity (mg/L)	-	314	231	258	294
Hardness (mg/L)	-	423	379	387	438
Chloride (mg/L)	500	249	153	183	226
Sulfate (mg/L)	500	145	114	130	154
Ammonia-N (mg/L)	1.5-15	1.95	0.52	0.29	0.49
Nitrate-N (mg/L)	-	6.97	4.12	5.9	7.59
Kjeldahl-N (mg/L)	-	3.8	1.6	1.4	1.4
Total phosphorus-P (mg/L)	-	1.79	0.76	1.35	1.72
Dissolved phosphorus-P (mg/L)	-	1.60	0.63	1.12	1.55
Grease and oil (mg/L)	-	0.7	0.7	1.9	0.7
Arsenic (µg/L)	1,000	2	2	2	2
Barium (µg/L)	5,000	148	89	137	137
Cadmium (µg/L)	50	4	4	4	5
Chromium (µg/L)	1,050	7	10	8	9
Copper (µg/L)	20	14	14	13	14
Iron (µg/L)	1,000	767	1,468	2,009	1,314
Lead (µg/L)	100	51	46	41	40
Manganese (µg/L)	1,000	88	93	126	108
Nickel (µg/L)	1,000	9	4	6	11
Silver (µg/L)	5	3	2	3	3
Zinc (µg/L)	1,000	96	71	61	71

*IEPA, 1986.

Table 24. Instream Suspended Load Data for Monitoring Stations near the Proposed SSC Site

Water	*Annual load*		*Seasonal loads (tons)*							
year	*Tons*	*Tons/ sq mi*	*Oct-Dec*		*Jan-Mar*		*Apr-Jun*		*Jul-Sep*	
Ferson Creek near St. Charles										
1981	**6,010**	**116**	**1,231**	**(20.5)**	**859**	**(14.3)**	**3,004**	**(50.0)**	**916**	**(15.2)**
1982	**4,706**	**91**	**640**	**(13.6)**	**1,901**	**(40.4)**	**1,481**	**(31.5)**	**684**	**(14.5)**
(Mean)	**5,358**	**104**	**936**	**(17.5)**	**1,380**	**(25.8)**	**2,242**	**(41.7)**	**800**	**(14.9)**
South Branch Kishwaukee River at DeKalb										
1980	**9,248**	**119**	**339**	**(3.7)**	**330**	**(3.6)**	**3,886**	**(42.0)**	**4,693**	**(50.7)**
1981	**13,222**	**170**	**791**	**(6.0)**	**505**	**(3.8)**	**11,292**	**(85.4)**	**643**	**(4.8)**
(Mean)	**11,235**	**144**	**565**	**(5.0)**	**418**	**(3.7)**	**7,589**	**(67.6)**	**2,663**	**(23.7)**
South Branch Kishwaukee River near Fairdale										
1981	**45,651**	**118**	**10,971**	**(24.0)**	**5,969**	**(13.1)**	**24,466**	**(53.6)**	**4,245**	**(9.3)**
1982	**55,169**	**143**	**5,247**	**(9.5)**	**18,929**	**(34.3)**	**15,276**	**(27.7)**	**15,717**	**(28.5)**
(Mean)	**50,410**	**130**	**8,109**	**(16.1)**	**12,449**	**(24.7)**	**19,871**	**(39.4)**	**9,981**	**(19.8)**
Kishwaukee River at Belvidere										
1981	**33,136**	**62**	**9,373**	**(28.3)**	**7,324**	**(22.1)**	**9,560**	**(28.8)**	**6,879**	**(20.8)**
1982	**54,160**	**101**	**9,909**	**(18.3)**	**15,920**	**(29.4)**	**16,494**	**(30.4)**	**11,837**	**(21.9)**
(Mean)	**43,648**	**82**	**9,641**	**(22.1)**	**11,622**	**(26.6)**	**13,027**	**(29.9)**	**9,358**	**(21.4)**
DuPage River at Shorewood										
1981	**79,079**	**244**	**6,586**	**(8.3)**	**4,899**	**(6.2)**	**62,092**	**(78.5)**	**5,502**	**(7.0)**

Source: Adams et al., 1984.

Note: Numbers in parenthesis indicate percentage of total load.

Suspended sediment data were collected for the Fox River at Montgomery, with a drainage area of 1,732 square miles for the years 1981-1983 (Bhowmik et al., 1986). The regional sediment yield gives an annual sediment load of 67.6 tsm or 0.105 tons per acre. This area of the state has low instream sediment loads.

Given the present water quality of the Fox River, it would have served as a good source for the SSC potable water supply. The city of Elgin has been using river water since 1983. Generally, the river water quality has been adequate except during extreme low flows, when problems with odor and taste have been encountered. Fermilab has a pumping station in the Fox River near Batavia and uses untreated water from the Fox River for cooling purposes.

EXISTING WATER SUPPLY SYSTEMS

Public **and** Industrial

Eighteen public water supply systems serve the incorporated municipalities within the 16-township study area. Each of these public water systems supplied 0.1 mgd or more in 1986. Many small subdivisions operate their own public water supply systems or purchase their water from privately owned water companies. These systems typically have one or two wells and each supplied less than about 0.1 mgd in 1986. In 1988 all public water supplies in the study area were taken from ground-water sources. Many industries in the 16-township area secured their own water, and in 1986 all self-supplied industrial water was obtained from ground-water sources. The only surface water withdrawals were made by Fermilab from the Fox River.

Within the study area, water withdrawals in 1986 for public water supplies totaled 34.9 mgd. Of this, 25.2 mgd or 72% was obtained from the Cambrian-Ordovician aquifer system, 6.5 mgd (19%) was withdrawn from the Silurian dolomite aquifer, and 3.1 mgd (9%) was supplied from sand and gravel aquifers. Public water system and industrial water withdrawals in each township for 1986 are tabulated by sources in Table 25.

Total ground-water use in the study area has been projected for the years 1990, 2000, 2010, and 2020. These values, including rural usage, are listed in Table 26. Ground-water withdrawals in the area are projected to decline considerably by 1990 and to increase slowly, reaching 1985 levels in about 2020. Ground-water use is expected to decline as communities switch to other sources of supply. Communities in DuPage County are gaining access to Lake Michigan water. Communities along the Fox River are planning to withdraw water from this source. Elgin, located north of the study area (T41N R8E), began withdrawing water from the Fox River in 1983 for public water supply. Prior to 1983 nearly all of Elgin's water supply was obtained from the deep aquifer system, but by 1986 Fox River water met a major portion of Elgin's demand. Aurora has obtained a permit from the Illinois Department of Transportation to construct an intake on the east bank of the Fox River. The city's permit request indicates plans to withdraw approximately 15 mgd. Batavia, Geneva, and St Charles have also expressed interest in using the Fox River.

Public water systems that supplied between 0.11 and 10.59 mgd in 1986 are listed in Table 27. Public water supply systems serving small communities with 1986 average annual withdrawals of less than 0.1 mgd are not listed in the table because the smallest water demand at any SSC site would have been 0.18 mgd (125 gpm at each major service area). The location of each system is given by township and range; most of the wells for the systems are located in

Table 25. Ground-Water and Surface Water Use by Public Water Supply Systems and Self-Supplied Industries in the SSC 16-Township Area, 1986

	***Public water supply** systems (mgd)*						*Self-supplied industry systems (mgd)*						
Township and range	***Surface water***	***Sand and gravel***	***Mississippian-Pennsylvanian***	***Silurian-Devonian***	***Cambrian-Ordovician***	***Total ground water***	*Surface water*	*Sand and gravel*	*Mississippian-Pennsylvanian*	*Silurian-Devonian*	*Cambrian-Ordovician*	*Total ground-water*	*TOTAL*
DuPage County													
38N 9E	0	0	0	4.627	2.590	7.217	0	0	0	0.103	0	0.103	7.320
39N 9E	0	0	0	1.365	1.732	3.096	0	0	0	0.076	<.001	0.076	3.172
40N 9E	0	0.347	0	0.352	0.926	1.624	0	0	0	0.154	0	0.154	1.778
Kane County													
38N 6E	0	0	0	0	0	0	0	0	0	0	0	0	0
38N 7E	0	0.220	0	0	2.276	2.496	0	0	0	0	0	0	2.496
38N 8E	0	0	0	0.115	9.734	9.848	0	0	0	1.326	0.217	1.543	11.391
39N 6E	0	0	0	0	0	0	0	0	0	0	0	0	0
39N 7E	0	0	0	0	0.035	0.035	0	0	0	0	0.044	0.044	0.079
39N 8E	0	0	0	0	4.060	4.060	1.160	0	0	0.069	0.018	0.086	5.306
40N 6E	0	0	0	0	0.051	0.051	0	0	0	0	0	0	0.051
40N 7E	0	0.056	0	0	0.096	0.152	0	0	0	0	0	0	0.152
40N 8E	0	1.795	0	0.004	2.102	3.902	0	0	0	0	<.001	<.001	3.902
Will County													
37N 9E	0	0	0	0.004	0.877	0.881	0	0	0	0	0	0	0.881
Kendall County													
37N 6E	0	0.717	0	0	0.008	0.725	0	0	0	0	0	0	.725
37N 7E	0	0	0	0	0.375	0.375	0	0	0	0	0.008	0.008	.383
37N 8E	0	0	0	.076	0.360	0.437	0	0	0	0.002	0.674	0.677	1.114
		3.135		**6.543**	**25.222**	**34.899**	**1.160**			**1.730**	**0.961**	**2.691**	**38.750**

Table 26. Current and Projected Ground-Water Use in the 16-Township SSC Area

Township and range	*1985 (mgd)*	*1990 (mgd)*	*2000 (mgd)*	*2010 (mgd)*	*2020 (mgd)*
DuPage County					
38N 9E	6.72	0.63	0.72	0.78	0.86
39N 9E	3.80	0.87	1.00	1.08	1.18
40N 9E	3.26	0.90	0.94	1.01	1.09
Kane County					
38N 6E	0.16	0.17	0.18	0.21	0.22
39N 6E	0.11	0.11	0.12	0.14	0.14
40N 6E	0.21	0.22	0.24	0.27	0.28
38N 7E	2.66	2.83	3.00	3.39	3.54
39N 7E	0.33	0.35	0.37	0.42	0.44
40N 7E	0.64	0.68	0.72	0.82	0.85
38N 8E	11.05	11.74	12.45	14.08	14.69
39N 8E	4.41	4.69	4.97	5.62	5.86
40N 8E	3.69	3.92	4.16	4.70	4.90
Will County					
37N 9E	0.28	0.30	0.36	0.41	0.45
Kendall County					
37N 6E	1.55	1.80	2.18	2.63	2.86
37N 7E	0.80	0.96	1.13	1.32	1.46
37N 8E	2.58	2.50	2.86	3.28	3.52
TOTAL	42.25	32.67	35.40	40.16	42.34

Table 27. Selected Public Water Supply Systems

System name	*Location (township and range)*	*1986 withdrawals*	
		Millions of gallons	*Millions of gallons per day*
DuPage County			
Bartlett	**40N 09E**	**355.165**	**0.97**
Carol Stream	**40N 10E**	**932.553**	**2.55**
Naperville	**38N 09E**	**3,510.764**	**9.62**
Warrenville	**39N 09E**	**267.300**	**0.73**
West Chicago	**39N 09E**	**817.552**	**2.24**
Winfield	**39N 09E**	**224.029**	**0.61**
Kane County			
Aurora	**38N 08E**	**3,867.088**	**10.59**
Batavia	**39N 08E**	**751.27**	**2.06**
Elburn	**39N 07E**	**38.676**	**0.11**
Geneva	**39N 08E**	**656.395**	**1.80**
Maple Park	**40N 06E**	**18.550**	**0.05**
Montgomery	**38N 08E**	**648.020**	**1.78**
North Aurora	**38N 08E**	**367.882**	**1.01**
St. Charles	**40N 08E**	**1,341.154**	**3.67**
Sugar Grove	**38N 07E**	**48.356**	**0.13**
Kendall County			
Oswego	**37N 08E**	**111.055**	**0.30**
Piano	**37N 08E**	**261.689**	**0.72**
Yorkville	**37N 08E**	**131.220**	**0.36**

the respective townships. The 1986 water withdrawals are listed for each system in terms of total millions of gallons and the annual average daily use in millions of gallons per day.

Three of the systems listed in Table 27 are in the proximity of three major SSC service areas and would be more than able to meet the 0.18 mgd demand. Major service area F1 would have been located on the outskirts of Aurora, major service area F2 in the environs of Oswego, and major service area F9 near St. Charles. Each of these major service areas would have been less than 0.5 miles from an existing water main. The capacity of the current water treatment plant at Aurora is rated at 19.7 mgd, and the average maximum daily demand in 1986 was 17.8 mgd. The excess plant capacity of 1.9 mgd is ten times greater than the proposed SSC requirement. Oswego, in Kendall County, has a water treatment plant capacity estimated at 2.9 mgd. Comparing the plant capacity to the average maximum daily demand of 1.3 mgd (1985 value), the existing facility could have met both Oswego and SSC F2 site demands. The water treatment plant at St. Charles has an estimated capacity of 12.2 mgd, which is nearly double the maximum daily 1986 demand of 6.42 mgd. In each case the excess capacities of the existing plants far exceed the SSC sites' proposed demands, leaving ample margin for the growth of the communities.

Fermilab and Weston Village

The current industrial cooling water system at Fermilab is supplied primarily by local surface drainage. This water is supplemented by a pumping system that withdraws water from the Fox River. The average daily withdrawal in 1986 was 1.16 mgd. The pumping capacity of this system is 1,100 gpm. Storage for the industrial cooling water and for fire protection is supplied by Casey's Pond, which has a storage capacity of 18 million gallons. Water from each of these sources receives no special treatment for use in industrial cooling, but it would require substantial treatment for potable use.

The Silurian dolomite aquifer currently supplies all of the potable water needs at Fermilab. A system of 11 wells at Fermilab (3 of which are in use) pump water from the dolomite at depths from 65 to 220 feet below the ground surface. Current water use at Fermilab is 0.09 mgd averaged over the year (with a maximum of about 0.15 mgd). Water is pumped at a rate of approximately 250 gpm from the Silurian dolomite. Virtually the entire amount is supplied by one well, which has a tested capacity of over 500 gpm. Other existing wells are rated at about 200 gpm. The total yield from three wells is estimated to be 900 gpm, or 1.30 mgd. In addition to the numerous wells drilled into the Silurian aquifer, Fermilab also has a deep well that can withdraw large quantities of water from the Ironton-Galesville sandstone.

Visiting scientists are housed at Weston Village near the Fermilab complex. The potable water needs of the village are supplied by the city water system of Warrenville, which is located in DuPage County. Current water demand at the village is 30,000 gallons per day (gpd) or 0.03 mgd. With planned expansions, village demand may reach 80,000 gpd (0.08 mgd). Warrenville's well capacity is estimated at 2.35 mgd and the storage capacity at 1.023 million gallons. Average maximum daily demand in 1986 was 1.89 mgd. The excess capacity far exceeds the anticipated increase in demand that would be generated by expanding the village.

DEVELOPMENT OF POTENTIAL WATER SUPPLY SOURCES

Ground Water

Ground water is readily available at all of the proposed SSC sites. The deep sandstone aquifer system underlies the entire study area, and wells drilled to this aquifer have a consistent record of yielding large quantities of water. Depending on the aquifer unit selected, one to three wells would have sufficient yield to supply any of the SSC sites' needs. The shallow bedrock (Silurian dolomite) aquifer is a reliable and adequate source along the eastern side of the area as demonstrated by the capacities of Fermilab wells. Shallow sand and gravel aquifers are abundant in the region, but unless they have been previously identified, they must be located through exploration. Current studies of the area document the location of some water-bearing sand and gravel deposits, particularly the Newark Valley site near the far experimental areas, which has an estimated yield far beyond the demand of 542 gpm at that site.

Surface Water

The regional relationships for average flows, low flows, and droughts were used to identify area streams with flows sufficient to supply proposed SSC water needs. The drainage areas of streams that intersect the projection of the SSC ring were determined from USGS information (Healy, 1979) and delineation of watershed boundaries on USGS topographic maps. Figure 9 shows the points at which the SSC ring would intersect area streams, each marked with an alphabetic label. The drainage areas at these points are listed in Table 28. Flow parameter values are listed for average flow durations of 90, 50, and 10; four flood flows were also computed and are listed in the table.

Only a few streams in the study area have a sustained flow rate that would be adequate to meet the demand of 125 gpm (0.28 cfs) at the major SSC service areas. The Fox River, located along the east side of the ring, is the only surface water source in the study area with a sustained flow high enough to meet the proposed demand of the main campus or the lesser demand of the major service areas. In addition to the Fox River, Welch Creek (point M), Blackberry Creek (point N), **and** Ferson Creek (point W) could each have potentially supplied a major service area.

Water withdrawals in Illinois are not directly regulated. However, the Illinois Department of Transportation recommends a minimum protected flow of not less than the 7-day 10-year low flow. The purpose of the protected flow is to preserve adequate instream flow to assimilate waste and avoid extreme degradation of the stream environment. The 7-day 10-year low flow for a stream with a drainage area of 50 square miles in region 2 is estimated at

Table 28. Estimated Flow-Parameter Values at Selected Locations for Streams Intersecting the Planned SSC Ring

ID	*Stream*	*Location*	*Drainage area (sq mi)*	*Channel length (mi)*	*Estimated flow-parametervalues in cfs*							
					Q	*Q(90)*	*Q(50)*	*0(10)*	*Q_2*	*Q_{25}*	*Q_{50}*	*Q100*
A	**Trib to Ferson Ck.**	**T40N R7E S12**	**0.41**	**0.86**	**0.4**	**0.0**	**0.1**	**0.9**	**23.1**	**54.1**	**61.1**	**68.5**
B	**Trib to Ferson Ck.**	**T40N R7E S11**	**1.33**	**2.19**	**1.2**	**0.0**	**0.3**	**2.8**	**46.2**	**99.0**	**110.7**	**122.4**
C	**Trib to Ferson Ck.**	**T40N R7E S10**	**0.82**	**0.78**	**0.7**	**0.0**	**0.2**	**1.8**	**52.1**	**146.8**	**170.9**	**195.7**
D	**Trib to Ferson Ck.**	**T40N R7E S17**	**1.08**	**1.05**	**1.0**	**0.0**	**0.3**	**2.3**	**58.4**	**156.5**	**180.9**	**205.8**
E	**Trib to Ferson Ck.**	**T40N R7E S19**	**0.18**	**0.57**	**0.2**	**0.0**	**0.0**	**0.4**	**12.2**	**27.8**	**31.3**	**35.0**
F	**Virgil Ditch #1**	**T40N R6E S36**	**2.90**	**2.51**	**2.3**	**0.0**	**0.5**	**6.3**	**99.0**	**238.5**	**271.8**	**304.7**
G	**Welch Creek**	**T39N R6E S23**	**9.91**	**3.98**	**8.1**	**0.3**	**3.0**	**18.4**	**282.0**	**747.8**	**866.3**	**980.8**
H	**Welch Creek**	**T39N R6E S27**	**12.07**	**4.92**	**9.8**	**0.4**	**3.7**	**22.3**	**306.0**	**783.3**	**903.0**	**1,017.6**
I	**Welch Creek**	**T39N R6E S34**	**13.59**	**6.57**	**11.0**	**0.5**	**4.2**	**25.0**	**290.4**	**686.1**	**781.6**	**872.0**
J	**Trib to Welch Ck.**	**T38N R6E S11**	**1.33**	**2.57**	**1.2**	**0.0**	**0.3**	**2.8**	**41.8**	**84.4**	**93.6**	**102.8**
K	**Welch Creek**	**T38N R6E S14**	**19.92**	**12.11**	**15.8**	**0.9**	**6.3**	**35.8**	**300.1**	**615.4**	**686.7**	**752.5**
L	**Welch Creek**	**T38N R6E S23**	**22.12**	**13.08**	**17.5**	**1.0**	**7.1**	**39.5**	**320.5**	**653.5**	**728.7**	**797.8**
M	**Welch Creek**	**T38N R6E S25**	**37.37**	**14.76**	**29.0**	**2.2**	**12.5**	**64.6**	**525.4**	**1,147.3**	**1,293.8**	**1,427.4**
N	**Blackberry Creek**	**T37N R7E S10**	**64.51**	**26.97**	**49.0**	**5.0**	**22.5**	**107.9**	**652.2**	**1,284.4**	**1,427.3**	**1,553.7**
0	**Fox River***	**T37N R8E S8**	**1,737.88**	**138.29**	**1,080.0**	**223.0**	**687.0**	**2,490.0**	**5,460.0**	**12,200.0**	**13,800.0**	**15,300.0**
P	**Waubansee Creek**	**T37N R8E S10**	**20.28**	**9.46**	**16.1**	**0.9**	**6.4**	**36.4**	**357.2**	**804.8**	**910.9**	**1,009.8**
Q	**Waubansee Creek**	**T37N R8E S2**	**18.44**	**7.80**	**14.7**	**0.8**	**5.8**	**33.3**	**363.5**	**861.1**	**981.8**	**1,095.3**
R	**Waubansee Creek**	**T38N R8E S36**	**9.39**	**6.39**	**7.7**	**0.3**	**2.8**	**17.6**	**197.7**	**435.9**	**491.0**	**543.5**
S	**Trib to Kress Ck.**	**T38N R9E S17**	**3.57**	**3.08**	**2.9**	**0.0**	**0.6**	**7.7**	**109.1**	**255.2**	**289.6**	**323.4**
T	**Kress Creek**	**T39N R9E S17**	**12.55**	**5.08**	**9.5**	**0.1**	**2.5**	**25.0**	**312.9**	**798.4**	**919.9**	**1,036.2**
U	**Kress Creek**	**T39N R9E S8**	**10.09**	**3.78**	**7.7**	**0.0**	**2.0**	**20.4**	**297.0**	**805.7**	**936.6**	**1,063.3**
V	**Fox River***	**T40N R8E S15**	**1,592.21**	**119.60**	**980.0**	**202.0**	**625.0**	**2,260.0**	**4,450.0**	**9,560.0**	**10,700.0**	**11,800.0**
W	**Ferson Creek**	**T40N R8E S8**	**45.33**	**8.40**	**34.9**	**2.9**	**15.4**	**77.5**	**922.4**	**2,580.6**	**3,021.4**	**3,435.7**
X	**Norton Creek**	**T40N R8E S15**	**11.50**	**4.80**	**9.3**	**0.4**	**3.5**	**21.3**	**294.8**	**753.7**	**868.6**	**978.8**

*Flow parameter values were not estimated from regression equations since they are not applicable to the main Fox River. The values given are estimated from the historical flow records for the Fox River at Algonquin and at Dayton.

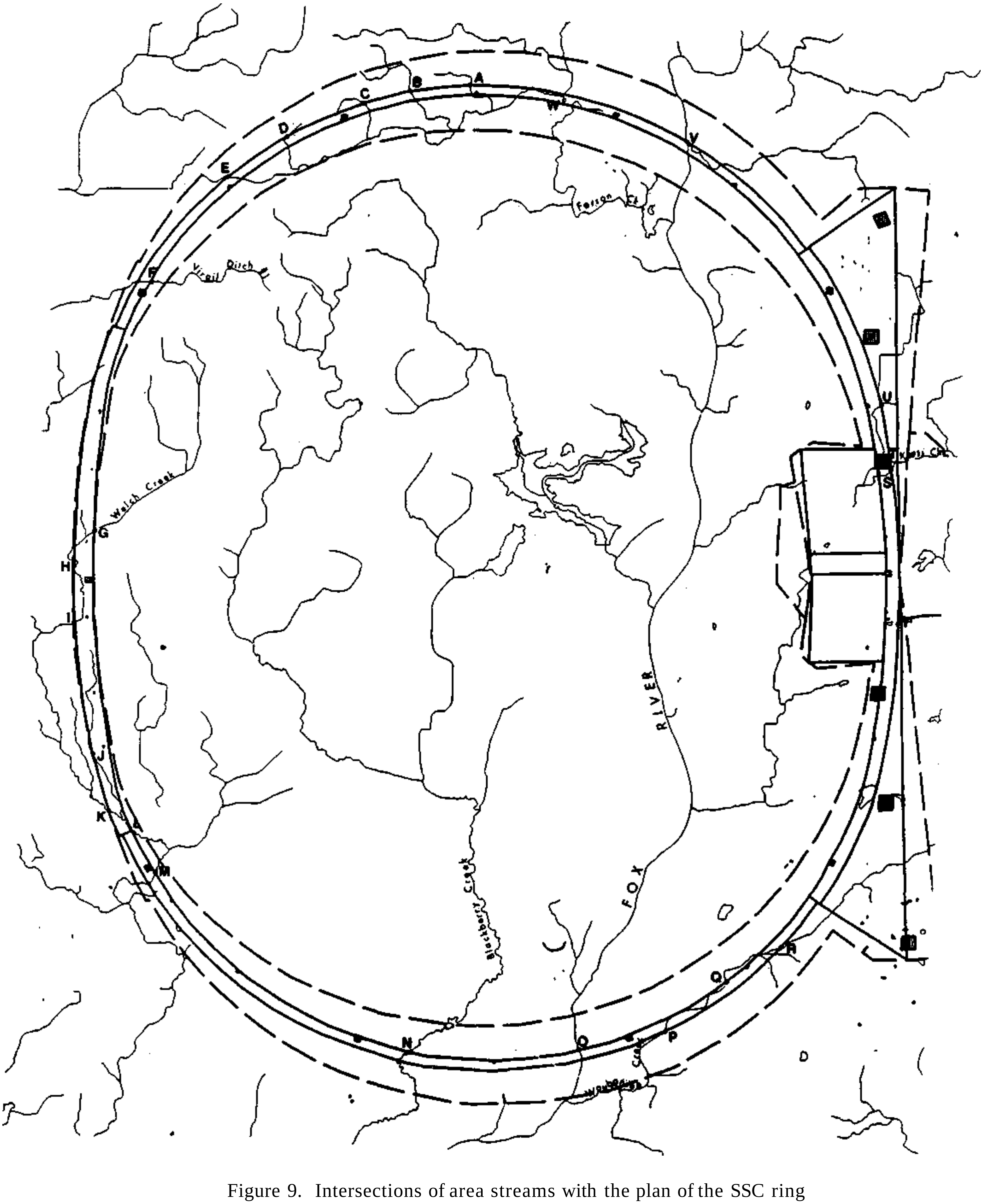


Figure 9. Intersections of area streams with the plan of the SSC ring

0.60 cfs (see Table 11). The drainage areas at points M, N, and W in figure 9 range from 37.37 to 64.51 square miles. Thus withdrawals during very dry periods would likely conflict with instream flow needs.

Limiting withdrawals to flows greater than the 7-day 10-year low flow requires some form of storage or an alternate ground-water source to guarantee a reliable water supply during low flows. Developing both a ground-water and a surface water supply for a single location is not economically sound. Two options for surface water storage include impounding reservoirs or off-channel storage.

Impounding Reservoirs

No lakes or reservoirs capable of supporting a reliable water supply currently exist in the study area. The Illinois Natural History Survey (INHS) compiled an inventory of lakes and impoundments with areas greater than one acre within the study area. The surface area, use, and location of each body of water are listed in Table 29. It shows that the surface areas of existing water bodies are all 50 acres or less. Potential reservoir sites have been identified for northern Illinois (Dawes and Terstriep, 1967), but because of the relatively flat topography of the region, few sites have the potential to serve as water supplies. The permeability of the sand and gravel in the glacial deposits of the area may create significant leakage problems as well.

One potential reservoir site on Big Rock Creek, just south of the Kane-Kendall county line, is within two miles of the western experimental area. The estimated net yield of a reservoir at this site is greater than 1.0 mgd. Thus, it could have supplied the water needs of the western experimental area. Because its potential yield exceeds the needs at the far experimental area, it would also have the capacity to support further development. Sites identified by Dawes and Terstriep are either too far from the SSC site or have inadequate safe yields. Further, the quantity of water that would have been required at the major service areas does not justify the cost of constructing an impounding reservoir at other potential locations.

Off-Channel Storage

Off-channel storage would have been another option for ensuring an adequate surface water supply during low-flow periods. The amount of storage required would vary with the average stream flow and thus the drainage area of the source stream. Storage required to serve the western experimental area proposed peak demand of 542 gpm was determined for four selected drainage areas (Table 30). The storage was estimated following the procedure described in Knapp (1982). Table 30 shows that with the addition of off-channel storage, any stream with a drainage area of ten square miles or more could have supplied SSC needs up to 542 gpm. However, experience has shown that the volume of water required by the SSC would

Table 29. Lakes and Impoundments with Areas Greater than One Acre Located within the SSC 16-Township Area in Northeastern Illinois

Name	*Surface area (acres)*	*Use*	*Location*	*Occurrence in corridor*
DuPage County				
Roy C. Blackwell Lake	33.0	Unknown	T39N, R9E, Sec 26	No
Elmhurst Chicago Stone Company Lake No. 3	10.4	Sport fishing	T38N, R9E, Sec 2	No
Elmhurst Chicago Stone Company Lake No. 4	9.6	Sport fishing	T38N, R9E, Sec 2	No
McDowell Borrow Pit Lake	23.6	Sport fishing	T38N, R9E, Sec 2	No
PossLake	7.5	Sport fishing	T38N, R9E, Sec 6	No
Pratt's Wayne Woods Lake No. 1	16.2	Sport fishing, recreation	T40N, R9E, Sec 7	No
Pratt's Wayne Woods Lake No. 2	5.8	Sport fishing	T40N, R9E, Sec 7	No
Spring Lake	6.0	Nature study	T39N, R9E, Sec 2	No
West DuPage Park Forest Preserve Lake	13.5	Protected	T39N, R9E, Sec 11	No
Kane County				
Aurora Country Club Pond	1.9	Sport fishing	T38N, R8E, Sec 29	Yes
Aurora Hunting & Fishing Club Lakes	5.8	Sport fishing, duck hunting	T38N, R8E, Sec 32	No
Baker Lake	9.7	Sport fishing	T40N, R7E, Sec 12	Yes
Booth Pond	4.2	Unknown	T38N, R8E, Sec 29	No
Boy's Lake	5.6	Sport fishing	T40N, R7E, Sec 36	No
Camp Dean Pond	1.3	Recreation	T38N, R6E, Sec 26	No
Campton Lake Slough	14.5	Sport fishing	T40N, R7E, Sec 15	Yes
Campton Lake	30.6	Swimming, boating, sport fishing	T40N, R7E, Sec 15	Yes
Charlotte Lake	2.3	Sport fishing, swimming	T40N, R8E, Sec 30	No
Crescent Lake	15.8	Unknown	T38N, R8E, Sec 32	No
Lookout Park Ponds (8)	5.2	Sport fishing	T39N, R7E, Sec 20	No
Lucky 50 Club Lake	50.0	Sport fishing, swimming, boating	T38N, R8E, Sec 29	No

Table 29. (Concluded)

Name	*Surface area (acres)*	*Usage*	*Location*	*Occurrence in corridor*
Mastodon Lake	22.3	Boating, swimming, sport fishing	T38N, R8E, Sec 26,35	No
Mighell Park Lake	25	Unknown	T38N, R7E, Sec 25	No
Mooseheart Lake	19	Sport fishing, boating	T39N, R8E, Sec 28	No
McCormack Lake	6.5	Unknown	T40N, R8E, Sec 19	No
Nelson Lake	25.3	Duck hunting	T39N, R7E, Sec 25	No
Peck Lake	16.0	Duck hunting	T39N, R8E, Sec 18	No
Prestbury Lake	18.1	Sport fishing, recreation	T38N, R7E, Sec 15	No
Quarry Park Pool	1.5	Swimming	T39N, R8E, Sec 22	No
St. Charles Country Club Pond	1.4	Unknown	T40N, R8E, Sec 22	
Willow Lake	1.6	Boating	T40N, R8E, Sec 12	No
Kendall County				
Barber Greene Club Lakes	56	Sport fishing	T37N,R7E,Sec 27	No
Knollwood Gun Club	7.0	Waterfowl hunting	T37N,R7E,Sec 26	No
Leisure Oaks Resort Lake	4.0	Fishing, swimming	T37N,R6E,Sec 24	No
Piano Lake	5.0	Fishing, swimming	T37N,R6E,Sec 27	No
Will County				
Minus 300 Club	116	Fishing	T37N,R9E,Sec 35	No

Table 30. Off-Channel Storage Required for the Far Experimental Areas

Drainage area of source stream (sq mi)	*Mean streamflow (cfs)*	*Demand (0.78 mgd) as percentage of mean flow*	*Total storage required (acre-feet)*	*Approximate surface area (acres)*
10	**7.0**	**17.0**	**1758**	**118**
20	**14.0**	**9.0**	**1300**	**92**
50	**35.0**	**3.5**	**915**	**68**
100	**70.0**	**1.7**	**758**	**58**

Source: Knapp, 1982.

Note: Cooling water demand = 0.78 mgd; design drought = 40 years.

make construction of surface storage facilities far more expensive than well drilling and other means of accessing ground-water sources when available.

Impoundment of Local Surface Drainage

For most periods during the year, the water storage accumulated from the drainage of a small local watershed (with a minimum area of 0.5 square miles) is sufficient to provide for the maximum cooling water needs of 125 gpm. However, during the dry season of the year, in late summer and early autumn, this would have to be supplemented with water obtained from a back-up source.

The amount of storage needed would depend on the supply from the supplementary source. If the supplementary system could be depended on to supply half of the required 125 gpm, then the estimated storage would be approximately 40 acre-feet, or 13 million gallons. This type of system is similar to the one that currently serves the Fermilab, in which the storage in Casey's Pond is supplemented by pumping from the Fox River. Because of the cost of developing dual water supply systems, it would have been more expensive to use the surface runoff than to develop ground-water sources.

EVALUATION OF WATER SUPPLY SOURCE OPTIONS

Local availability, distance to the sources, and quantity and quality requirements affect the suitability of a particular water source for each proposed SSC location. Possible sources of water supply, their firm flow rates, and distance to the SSC sites are listed in Table 31. Economics becomes the deciding factor because multiple sources are available and adequate at several sites.

Cost Considerations

The cost of supplying water to each of the sites would involve an initial capital outlay for design and construction as well as the annual operation and maintenance cost. To compare the economy of each potential water supply source for each site, an initial estimate of the annual cost per 1,000 gallons of water for each potential water supply source was computed. The factors addressed in estimating the cost of cooling water for each system were:

- the cost of wells, pumps, and housing structure for all ground-water systems
- the cost of reservoir construction for all surface storage needs
- the cost of conveyance from the source to the SSC area, including pipeline and additional pumps (this cost would be negligible for the ground-water systems)
- the operation, maintenance, and repair (OM&R) cost
- the annual energy costs associated with each system

Once water was delivered to the SSC area, essentially the same local distribution system would be required regardless of the water source. The conveyance cost computed in the initial cost estimate relates only to the pipeline, pumps, and other appurtenances needed between the source and a single distribution point at each site. It is assumed that ground-water supply systems would require little if any conveyance beyond well costs. Most surface water sources would be located some distance from the point of use, and conveyance over a distance much more than one mile could be a major expense.

The costs of the water supply components described above were computed from equations given by Singh and Adams (1980). They were updated to fourth-quarter 1985 values through the use of cost indexes given in the *Engineering News Record* (1985). Area contractors supplied current costs for well drilling, pumps, and water main installation. Cost estimates from the updated equations were compared to available cost estimates and modified as needed. Several design components were specified to determine the cost for each system. The length of pipe required between the source and each SSC site was estimated. Head losses and energy costs were considered in determining the most economical pump size and, when not specified, the

Table 31. Sources of Cooling Water and Firm Flow Rates Available for the SSC

Source	*Distance from site (miles)*	*Dependable yield (mgd)*	*Flow rate (gpm)*
Main campus			
Fox River	**2.5**	**1.58**	**1,100**
Ironton-Galesville sandstone (per well)	**0.0**	**0.86**	**597**
Silurian dolomite (per well)	**0.0**	**1.30**	**900**
Far experimental areas			
Ironton-Galesville sandstone (per well)	**0.0**	**0.86**	**597**
Newark Valley sand and gravel	**1.7**	**1.78**	**1,200**
Off-channel storage	**0.5-2.0**	**0.78 or more (as sized)**	**542**
Potential reservoir on Big Rock Creek	**2.0.**	**10.0**	**6,944**
Major service areas			
Shallow sands and gravel (per well)	**0.0**	**>0.18 in most locations**	**>125**
Silurian dolomite (per well)	**0.0**	**>0.00(west of Fox River)**	**>0.00**
		>0.18(east of Fox River)	**>125**
St. Peter sandstone per well	**0.0**	**0.29**	**200**
Local public water supplies	**0.2-0.5**	**>0.18(east side of ring)**	**>125**

Note: Flow rate data represent an average for the areas identified.

pipe size for each system. The unit cost of energy was assumed to be $0.04 per kilowatt-hour, which was a special rate negotiated for the SSC project.

Water Treatment Cost

In addition to the cost of the components previously noted, the cost of treatment had to be added to the system development cost for the main campus and the far experimental areas. The quality of the water provided by each source varies and with it the treatment required. In particular, the cost of water treatment for potable uses varies greatly between ground-water and surface water sources. Costs would also vary significantly depending on the type of treatment required, and the cost for treating 1,000 gallons of water could vary depending on the total volume treated. Potable water must meet the applicable federal and state standards listed in Table 15.

Surface water, whether from streams or reservoirs, must be treated for turbidity and bacteria. The treatment processes generally required are: 1) coagulation and sedimentation, 2) filtration, and 3) disinfection (usually chlorination). Coagulation and sedimentation in combination with filtration can almost totally remove the colloidal material that causes turbidity, and removal efficiencies exceed 96%. Chlorination is expected to destroy approximately 99% of bacteria, including fecal coliform. The unit cost of this treatment for the main campus and the west experimental area was estimated at $1.36 and $1.51 per 1,000 gallons, respectively (Volkert, 1974; *Engineering News Record*, 1985).

Ground water is generally free of the turbidity and bacteria that require the most expensive treatment, but water from shallow sources may have an excessive concentration of iron. Routine treatment with phosphate and aeration will reduce iron and other mineral concentrations to acceptable levels. The aeration process is expected to cost no more than $0.05 per 1,000 gallons. Phosphate treatments cost approximately $0.05 per 1,000 gallons. Odor and taste problems in ground water are uncommon, but if present they may be treated by chlorination. The treatment cost for this process ranges from $0.03 to $0.07 per 1,000 gallons. Some reduction in iron content can also be achieved through chlorination.

High levels of radium and barium expected to be found in the deep sandstone and Galena-Platteville dolomites are usually treated through ion exchange treatment The estimated cost of this treatment varies from $1.12 per 1,000 gallons at the main campus to $1.50 per 1,000 gallons at the west experimental area. The increased cost is due to the lower volume of water to be treated.

As described previously, the cooling water supplied to the SSC at the major service areas would not have required any treatment. This assumption is made on the basis of the quality of water currently used at Fermilab. The cooling water extracted from the Fox River is lower in

quality than other sources identified, and it contains more commonly treated constituents than any other available source. But it does not require treatment, so it was unnecessary to add treatment costs to the water supply cost at the eight sites that would have supplied only the major service areas.

Annual Cost of Water

The cost of water supplied from any of the sources consists of two components: the initial, one-time capital cost of developing the source; and the ongoing operation, maintenance, and repair cost. In the preceding list of cost considerations, the first three items constitute the initial capital cost of development, while the remaining two items identify annual costs. The capital costs are converted to annual costs by means of the capital recovery factor (CRF) given by:

$$CRF = i / [1 - (1 + i)^{-n}] \qquad (13)$$

in which i is the interest rate, taken as 0.08 (8%), and n is the amortization period in years. The amortization period and capital recovery factor for the various system costs are given in Table 32.

Water Supply Costs

Estimated water supply costs for each of the K and F sites and campuses are presented in Table 33. The water supply costs were calculated for those sources that would have been sufficiently reliable and economically reasonable. A contingency factor of 25% was incorporated in each cost estimate. Costs were not calculated for sources that would not have been adequate to supply the entire demand at a site (listed in Table 31).

Main Campus

Three water supply sources would have been adequate, reliable, and near the SSC main campus: the Ironton-Galesville unit of the deep sandstone aquifer system; the Silurian dolomite aquifer; and the Fox River. Fermilab currently uses the Fox River (and surface drainage) for cooling water, and the Silurian dolomite supplies the potable water needs. The unit cost summary information in Table 33 clearly demonstrates that the Silurian dolomite would have been the most economical source of water supply. Development costs for the Silurian dolomite are negligible because with only minor modifications, the existing well system would be adequate to supply the SSC needs. The energy cost to pump water from the source of supply is linearly related to the vertical distance that the water must be lifted. Silurian dolomite is about one-fifth as deep as the sandstone, and the cost of energy to operate the pumps is about 20% of the cost to pump from the deep sandstone aquifer system. Installation of a back-up

Table 32. Capital Recovery Factors for Water Supply Components

System component	*Amoritization period (years)*	*CRF*
Wells		
Sand and gravel	**25**	**.0937**
Dolomite	**50**	**.0817**
Well pumps	**10**	**.1490**
Reservoirs and streams		
Land and construction	**50**	**.0817**
Intake stations	**50**	**.0817**
Conveyance systems		
Pipelines	**50**	**.0817**
Pumps	**30**	**.0888**
Water treatment plants	**30**	**.0888**

Note: 8% interest rate

Table 33. Water Supply Costs for the SSC

SSC use area	*Source*	*Unit cost (cents per 1,000 gallons)*
Main campus (K1,K2, and F10)	**Silurian dolomite**	**$0.16**
	Ironton-Galesville sandstone	**$1.58**
	Fox River	**$1.49**
Far experimental areas (K3-K6 and F5)	**Surface water supply from off-channel storage**	
	20 sq mi drainage area	**$2.41**
	100 sq mi drainage area	**$2.31**
	Little Rock Creek Reservoir	**$4.87**
	Ironton-Galesville sandstone	**$2.07**
	Sand and gravel aquifer, Newark Valley	**$0.69**
Major service areas (All areas)	**St Peter sandstone**	**$0.66**
	Sand and gravel	**$0.49**
East side of ring only (P1, F2, and F9)	**Silurian dolomite**	**$0.27**
	Public water supplies	**$0.08**

pumping and conveyance pipe system and higher operation and maintenance costs contribute to a higher unit cost for the Fox River water; nevertheless the unit cost to treat the river water to meet potable water standards is the major factor creating the cost difference. Because of its superior quality, water from the Silurian dolomite requires the least expensive treatment, $0.05 per 1,000 gallons for chlorination, compared to $1.36 and $1.12 per 1,000 gallons for the water from the Fox River and Ironton-Galesville aquifer, respectively. The Silurian dolomite aquifer was recommended as the supply source for both industrial cooling water and potable water at the main campus.

Weston Village. **The water needed to support proposed village expansion to accommodate visiting scientists could readily have been provided by the city of Warrenville water system, which currently serves the village. The capacity of Warrenville system could have handled the increase in demand, and the conveyance system is in place.**

Fire Protection. **The SSC main campus would need up to 500 gpm of water for fire protection. To meet this requirement, on-site storage for 300,000 gallons ought to be available. The specified flow rate can be maintained for ten hours with this volume of storage. This water does not have to be treated. Casey's Pond has a storage capacity of 18 million gallons, which is more than adequate, and the required storage capacity for the SSC could have been readily maintained through surface drainage and Fox River water.**

Infrastructure Improvements. **Some minor changes to the Fermilab water supply system would have been necessary to meet the SSC requirements. Two wells located near the Fermi central laboratory and experimental laboratories currently supply the potable water needs of Fermilab. During periods of high demand several other wells can be activated, and connection from these additional wells to the central distribution system is required. Chlorine feeders would have had to be installed at other wells that would have been activated for SSC water supply needs. Additions to the distribution system would connect it to the two experimental areas, K1 and K2, and the major service area, F10.**

Far Experimental Areas

Three surface water sources and two ground-water sources were identified as adequate to meet the needs of the far experimental areas. Sites K4 and K5 and major service area F5 would have been served initially. Sites K3 and K6 would be added in the future. Given that the total demand would be met with treated water, the cost of treatment is the leading factor contributing to the cost differences among various sources. Surface water must be treated for

turbidity and bacteria. The cost of treatment at this site was estimated at $1.51 per 1,000 gallons. The two ground-water sources identified in Table 31 are the Ironton-Galesville aquifer and local sand and gravel aquifers. The high concentrations of radium and barium in the water from Ironton-Galesville requires treatment that costs about $1.50 per 1,000 gallons at this site. The sand and gravel aquifer offers superior-quality water requiring minimal treatment. Treatment costs are expected to be only about $0.17 per 1,000 gallons. This cost includes aeration, chlorination, and phosphate treatment.

The water supply recommended for the SSC was a shallow sand and gravel aquifer located along a localized buried bedrock valley known as the Newark Valley. The average depth of the valley is 150 feet. Several test wells within four miles of the far experimental sites have produced yields in excess of 1,200 gpm. The nearest test well is 1.5 miles due east of the village of Kaneville. Experimental areas K3-K6 and major service area F5 are located in the vicinity of the village of Kaneville.

Infrastructure Improvements. A test well was proposed near the village of Kaneville with a 12-inch pipeline leading to the SSC facility. The recommended route for the pipeline was along Main Street through Kaneville. The proposed water main would have been approximately 9,000 feet long. From this supply source, additional water mains would have served the K4 and K5 experimental areas and the F5 major service area. Service would have been extended to sites K3 and K6 when they were established.

Major Service Areas

Eight major service areas would not have been served by the same water supply systems as the main campus and the far experimental areas. These major service areas are designated as F1, F2, F3, F4, F6, F7, F8, and F9. Their proposed locations are shown on the map in Figure 2.

As previously noted, three of these major service areas, F1, F2 and F9 would have been within one-half mile of public water distribution systems: Aurora, Oswego, and St Charles, respectively. Units of local government had committed to providing the water distribution network to the SSC at no cost. This zero-cost option made them the most desirable sources of water supply for the three service areas. The extension of a 6-inch water main was the only development cost needed to use the public water supplies. It was the basis of the unit cost listed in Table 33 for the public water supplies. Other possible sources of supply would have been wells tapping the Silurian dolomite aquifer, shallow sand and gravel deposits, or the deep sandstone aquifer system.

The five remaining service areas, F3, F4, F6, F7, and F8, could have been served from ground-water sources. A ground-water source was the best option for these sites because surface water sources are either not sufficient to meet demand year-round or the cost of development was excessive. The Silurian dolomite aquifer is not available in the western portion of the study area where these five service areas would have been located. Thus the remaining options were sand and gravel deposits or the deep sandstone aquifer system. The unit cost for water presented in Table 33 shows that sand and gravel deposits would have been a slightly more economical source, although no wells were previously located in the immediate areas of the various proposed sites. The unit cost for the sand and gravel aquifers was calculated assuming that two wells would be drilled to ensure a dependable supply. A well open to the deep sandstone aquifer would almost surely produce the required industrial water at each site. Only one well would be needed to tap the deep sandstone aquifer. The recommended guaranteed source of water is the St. Peter sandstone unit of the deep aquifer system. The anticipated yield of the St. Peter sandstone, although less than the Ironton-Galesville, would have been adequate to supply a major service area, and the cost of treatment would typically have been less.

Infrastructure Improvements. Each of the three sites obtaining water from public water supplies would have needed an extension from the communities' present water distribution systems to reach the service area. All proposed extensions would have consisted of water mains with 6-inch diameters. The F1 site would have required an extension from the Aurora Public Water Supply water main, which runs along Illinois State Route 65 (New York Street) near the Aurora Mall. The extension would have been approximately 2,500 feet long. The F2 site would have required an 800-foot extension from a water main within the Boulder Hill subdivision in Oswego. The F9 site was to be located approximately 1,000 feet south of an existing industrial water main for the city of St. Charles. The extension would have run south from this water main directly along Kautz Road.

One well would be drilled at each of the five remaining sites. Each well would be 6 inches in diameter with an expected depth of about 750 feet. Only a short connection from the well to the service area facilities would have been required. Water from these wells would not have required treatment

Summary of Recommendations and Costs

The recommended sources of water supply for each of the ten SSC locations are summarized in Table 34, along with a breakdown of the water demand. The state of Illinois offered to develop the various recommended water supply systems at no cost to the U.S.

Table 34. Industrial Cooling and Potable Water Demand and Costs for the SSC

	Estimated demand distribution		*Initial developmental costs*		
SSC use area	*Industrial cooling (gallons per minute)*	*Potable[1] (gallons per minute)*	*To the SSC project (dollars)*	*To state or local government (dollars)*	*Unit cost of water (dollars per million gallons)*
SSC main campus and K1, K2, and F10	**700**	**208**	**Minimal due to existing Fermilab wells**	**0**	**160[2]**
Far experimental areas (K5, K3-K6)	**500**	**42**	**0**	**600,000[3]**	**350[2,4]**
Major service areas (8)					
a. St. Peter sandstone wells on site (5) (F3, F4, F6-F8)	**625**	**Minimal**	**0**	**800,000[3]**	**110[2]**
b. Local public water supplies (3) (P1, F2, and F9)	**375**	**Minimal**	**0**	**120,000**	**0**
Total	**2,200**	**250**	**0**	**$1,520,000**	**$165**

[1] **Based on a distribution of 2,500 versus 500 people at the two principal usage points.**

[2] **Assumes that annual unit cost of energy to power pump is at a special SSC rate of $0.04 per kilowatt-hour.**

[3] **State cost.**

[4] **Based on recovery of operating and maintenance expenses.**

Note: Local costs estimated based on $40,000 minimum per location.
Available from Aurora (F1), Oswego (F2), and St. Charles (F9).
Weighted average based on estimated demand distribution and associated unit cost.

Department of Energy as an added incentive for siting the SSC in Illinois. The ongoing cost of water supply operation, maintenance and repair (OM&R), energy, and treatment would have been the only cost borne by the SSC project. The capital cost for each supply to be paid by the state of Illinois and the SSC unit cost for water delivery are listed in Table 34. Unit costs of water delivery are based on OM&R, energy, and treatment. The proposed infrastructure improvements for the water supply systems are shown in Figure 10.

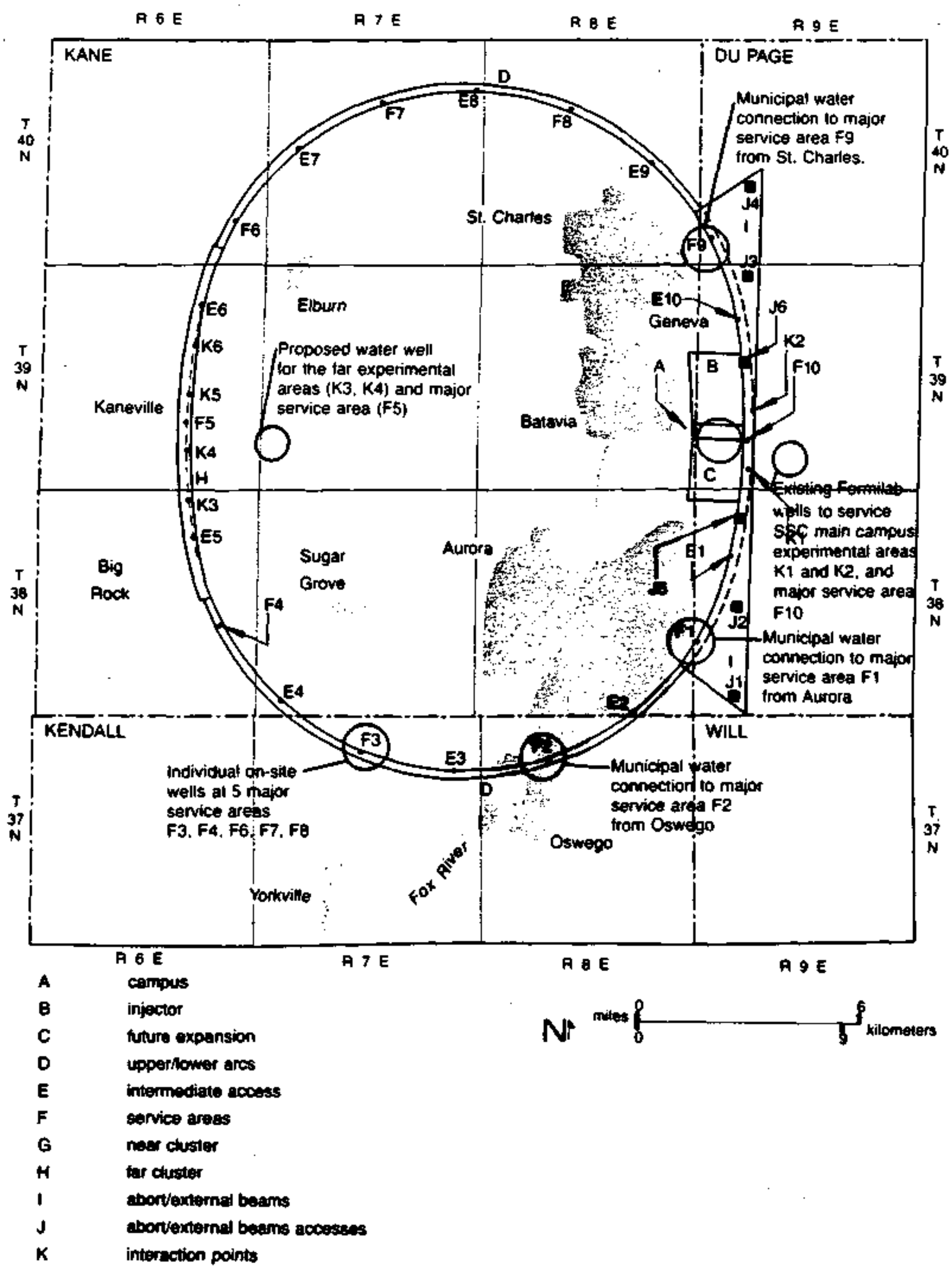


Figure 10. Proposed water supply infrastructure for the SSC

WASTEWATER DISPOSAL OPTIONS

Domestic wastewater would have been generated at the main campus, at the far experimental areas, and at Weston village. This wastewater would have required conventional treatment and disposal. A conservative estimate of the volume of sewage expected from the main campus is 0.150 mgd. The far experimental areas could have produced a total of 0.03 mgd. These estimates are made on the basis of one person generating an average of 60 gpd of wastewater. Laboratory staff and visitors were expected to number 2,500 at the main campus and 500 at the west experimental area. Weston village currently consists of 200 housing units located near the laboratory facilities. Up to 500 additional housing units may be added to accommodate visiting scientists. Wastewater loads from Weston village expansion are projected to be 0.05 mgd, which will vary with the number of visitors. Peak wastewater loads will typically be 40% greater than the annual average load.

Two options would have been available for the disposal of effluents generated at the SSC sites: either to use existing wastewater treatment facilities in the vicinity or build a new sewage treatment plant. Several factors had to be assessed to determine the best alternative for each site. In order to use an existing facility, excess capacity must be sufficient to handle the SSC discharges. The cost to extend service to the SSC site, if necessary, must be compared to the cost of constructing a new treatment plant. Common practice in the area is to perform secondary treatment of wastewater and then discharge the treated wastewater to area streams whose low flows are adequate for dilution purposes. If the wastewater is obtained from a source hydrologically independent of the receiving stream, such as ground water, the impact of the effluent load on high and low flows in the stream had to be evaluated. Discharges during high flows should not increase flooding. The low flows of the receiving stream must be adequate to assimilate the increased SSC loading. These factors were investigated to assess the best method for disposal of domestic wastewater that would have been produced at the SSC sites.

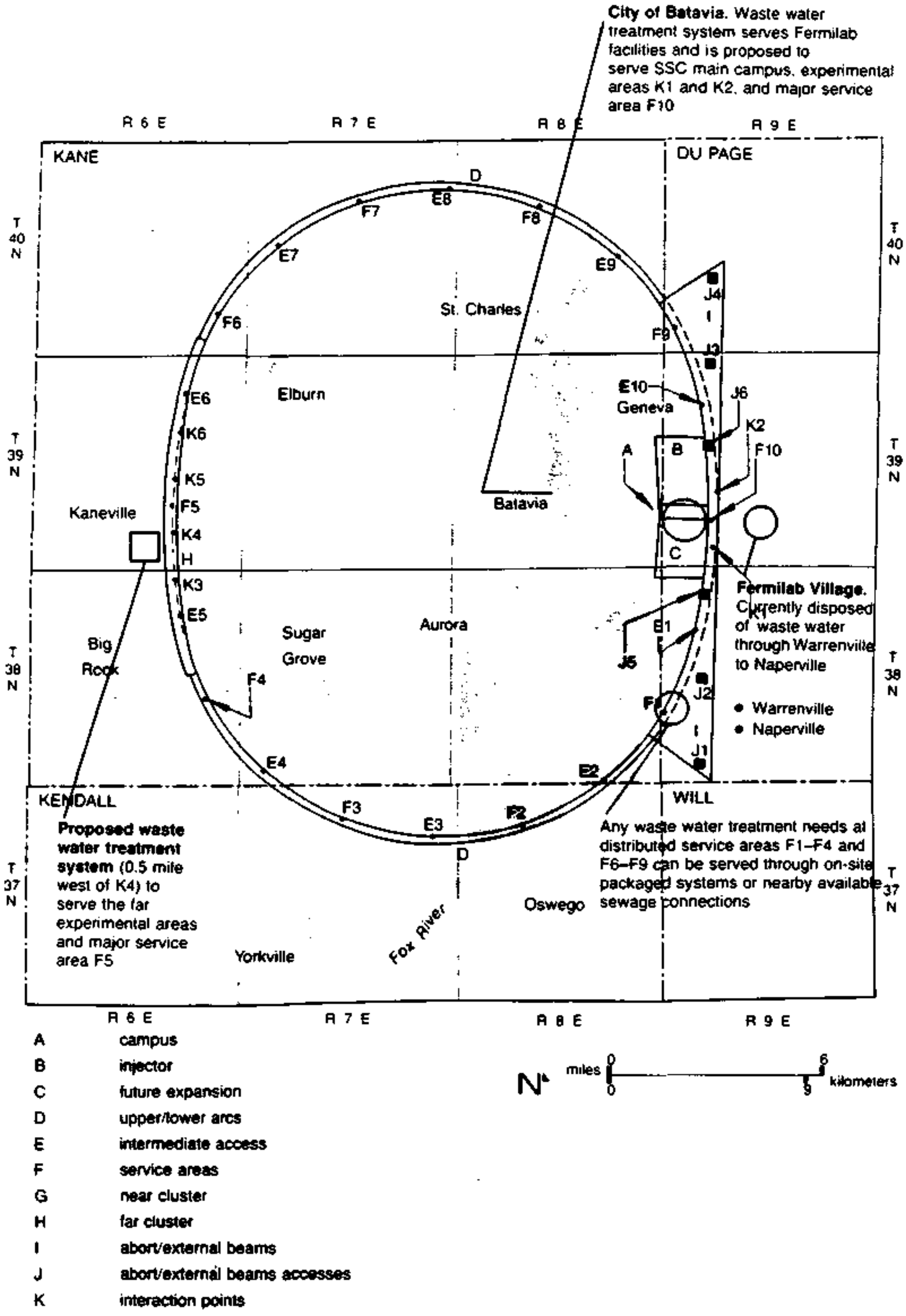
Existing Facilities

The main sewer system serving the laboratory complex at Fermilab has been connected to the city of Batavia wastewater system since 1979 (Baker, 1985). Only minor connection costs associated with the proposed SSC facilities (experimental areas K1 and K2) would have been incurred. Potential increases in the amount of sewage due to the SSC could have been accommodated by the Batavia treatment plant, which has a remaining capacity of 1.4 mgd. The Batavia wastewater treatment plant discharges treated wastewater to the Fox River. The 1984 7-day 10-year low flow of the Fox River at this site was 123.1 cfs. The comparable 1984 effluent discharged by the Batavia treatment plant was 1.56 cfs, less than 2% of the 7-day 10-year low flow (see Figure 5). The 7-day 10-year low flows projected for 1990 and 2000 at this location are greater than the 1984 value, as can be seen in Table 12. The volume of the effluent loads are insignificant in comparison to high flows along the Fox River. Construction of a new treatment plant would far exceed the cost of conveying the sewage through the existing network to Batavia. The present system of conveying wastewater to Batavia was recommended for the proposed SSC facilities at the main campus.

The city of Batavia charges Fermilab $0.0075 per cubic foot of treated wastewater or the equivalent of $1 per 1,000 gallons. At an expected wastewater disposal rate of 0.150 mgd, the monthly cost of treatment would have been $4,500 for the SSC main campus.

Weston village has a sewer system independent of the Fermilab complex. Presently, the village sewer system is connected to the Naperville-Springbrook treatment plant via the city of Warrenville system. Prior to December 1986, the wastewater was discharged to an oxidation pond that provided secondary treatment and polishing. The pond is still in existence (Baker, 1985). The Naperville-Springbrook treatment plant has a remaining capacity of more than 1.5 mgd, and the city of Naperville is planning to expand its facility. The increase in wastewater load anticipated for Weston village could have been handled readily by the Naperville-Springbrook plant.

The Batavia treatment plant and the Naperville-Springbrook plant were recommended as the facilities to receive wastewater generated at the main campus and Weston village, respectively. The proposed disposal options are illustrated in Figure 11, which shows the location of the municipalities involved and the SSC sites. If for some reason these treatment plants could not serve the SSC in the future, there are alternative treatment facilities. Several municipal wastewater treatment plants are near the main campus and Weston village. Most of these treatment plants have excess capacity and could have readily handled the wastewater loads from the SSC sites. The following list shows the various communities whose excess unused capacities could potentially have served the SSC. The municipal treatment systems around Fermilab have excess capacities sufficient to handle the proposed additional SSC load. As an alternative to the Batavia plant, the treatment plant serving West Chicago is the next nearest to the SSC main campus area, about three miles distance. At a capital cost of $25 per linear foot of sewer line, connection would cost $370,000. This alternative is less expensive than the cost of a new system. If Batavia could not handle the SSC wastewater load in the future, connection to another existing system was recommended. Similarly, for Weston village the Aurora treatment plant is close enough that the capital cost to extend service would not have been prohibitive. The plant has an excess capacity of 11.8 mgd.



City of Batavia. Waste water treatment system serves Fermilab facilities and is proposed to serve SSC main campus, experimental areas K1 and K2, and major service area F10

Fermilab Village. Currently disposed of waste water through Warrenville to Naperville

Proposed waste water treatment system (0.5 mile west of K4) to serve the far experimental areas and major service area F5

Any waste water treatment needs at distributed service areas F1–F4 and F6–F9 can be served through on-site packaged systems or nearby available sewage connections

Figure 11. Proposed wastewater infrastructure for the SSC

Municipality	*Remaining capacity (mgd)*
Aurora	11.8
St. Charles	4.5
Wheaton Sanitary District	2.4
West Chicago	1.8
Bartlett	1.4
Batavia	1.4
Geneva	2.0

The municipal treatment plants listed above are all in the vicinity of the main campus; no treatment plants are near the far experimental areas. The closest wastewater treatment facility to the proposed far experimental areas is at the village of Elburn, a distance of about five miles northeast. The next closest plant serves the village of Sugar Grove located south of the area. Each plant has a remaining capacity of more than 0.1 mgd and could have received sewage from the far experimental areas. However, as the distance is five or more miles, the cost of conveying treated sewage to these locations could be expected to be at least $1.50 per 1,000 gallons. The unit charge for treatment at either of these facilities is assumed to be at least $2 per 1,000 gallons, creating a cumulative unit cost of more than $3.50 per 1,000 gallons. The expenses related to connection to either of these plants exceeds the total cost of a new system.

Sewage Treatment Facility for the Far Experimental Areas

Because of the distances between the proposed far experimental areas and existing municipal treatment plants, conveying sewage water to an existing facility is not considered a primary option. Construction of a new wastewater treatment plant would be the more economical plan for managing the effluent expected from the far experimental areas. The plant design must meet the applicable federal and state standards, and an IEPA permit would be required. The type of treatment required would depend on the means of disposal of the treated wastewater.

An additional factor to consider in evaluating the various design alternatives for a new plant would be the possibility of providing service to potential secondary users. The village of Kaneville is located in the vicinity of the proposed far experimental areas and does not presently have a public wastewater treatment facility. Kaneville's current water use is estimated at 100 gpd per capita, or a total of 0.03 mgd. Wastewater volume will be somewhat less than water use. The SSC staff would most likely have contributed to the community's growth and subsequently expanded wastewater treatment needs. Community growth of 1,000 people was projected after construction of the SSC. The combined needs of the SSC and Kaneville could have been served by a treatment plant designed for a flow rate of 0.150 mgd. Economy of scale could have been achieved by a combined service addressing local needs and SSC needs.

Treatment and Disposal Alternatives

Federal standards require that all wastewater receive at least secondary treatment, which is the biological treatment that removes most of the biological oxygen demand (BOD) and suspended solids from the wastewater. After secondary treatment, several alternatives exist for disposing of the SSC wastewater: 1) discharge into a receiving stream with sufficient low flow, so that treated wastewater discharge is less than one-fifth (20%) of the 7-day 10-year low flow of the stream; 2) application of wastewater to land; and 3) advanced treatment and subsequent discharge of the wastewater to a nearby stream. A fourth alternative, injecting wastewater into deep wells, was not recommended because of potential pollution of aquifer systems.

Secondary treatment is typically achieved by transferring filtered wastewater to oxidation lagoons where most of the solids and BOD removal occur. For the SSC maximum load of 0.042 mgd (140% of the average volume), the lagoon system would have required an oxidation pond of 2 to 4 acres in size. An average unit cost for oxidation lagoon treatment for this capacity would be about $3 per 1,000 gallons. Having undergone secondary treatment, wastewater may be discharged into a receiving stream only if the stream's low flow provides an adequate dilution ratio. For the far experimental areas alone, the minimum low-flow value required in the receiving streams would have been 0.48 cfs. However, no streams in the vicinity of the far experimental areas have sufficient low flows to meet the standard. The nearest stream with a sufficiently high 7-day 10-year low flow is Big Rock Creek downstream of the village of Big Rock. The cost to convey wastewater to this point would have been prohibitive. The combined volume from the SSC and Kaneville would have had to be conveyed even further to reach a point in the stream with a greater 7-day 10-year low flow.

Other than being discharged to an appropriate stream, effluent having received secondary treatment through the oxidation lagoons could also have been applied to a plot of land. The three major types of land application for wastewater are irrigation, overland flow, and infiltration. Irrigation treatment is the most common, and it can be accomplished either by ridge-and-furrow application or by spray irrigation. The capital costs associated with spray irrigation are usually higher, and it may produce a greater odor problem than ridge-and-furrow applications. Ridge-and-furrow irrigation must be restricted to slopes of less than 1.5%, but this restriction does not affect most of the study area. For either case, a minimum irrigated area of 2 acres is suggested for every 10,000 gallons of effluent per day. This sparse application rate ensures that the effluent will infiltrate even in most winter conditions.

The capital costs for irrigation vary greatly, but they may range from less than $1,000 per acre for certain ridge-and-furrow projects to more than $4,000 for some spray irrigation systems. Adding in operating costs, the total unit cost for ridge-and-furrow application systems is expected to range from $0.20 to $0.35 per 1,000 gallons. The cost range for spray irrigation treatment is an additional $0.10 to $0.15 per 1,000 gallons. Including treatment costs, the total unit cost of this alternative for the far experimental areas was estimated at less than $3.20 to $3.50 per 1,000 gallons. This cost is comparable to the cost to convey the wastewater to an existing plant.

Wastewater receiving tertiary treatment can be discharged to area streams without the stipulation of a minimum low flow for dilution. Advanced tertiary treatment may be accomplished through the use of a polishing pond, where additional aeration and settling takes place. For the far experimental areas, construction of a plant with tertiary treatment facilities would have eliminated excessive conveyance cost and the cost associated with land treatments. Service to the SSC site and the village of Kaneville could have been economically achieved through this design.

Proposed Facility

The proposed site for the wastewater treatment plant was located immediately south of the floodplain of Welch Creek, approximately 0.5 miles west of the K4 experimental area and one mile south of Kaneville on Dauberman Road. The site is more than 0.5 mile from any habitation, leaving considerable room for expansion. Local governments reviewed this proposed system and its location and considered it compatible with their land use and development plans. Typical slopes in the area are sufficient to deliver the wastewater under gravity flow, precluding the need and cost for intermediate pumping stations. The drainage area of Welch Creek at this location is approximately 15.6 square miles. The discharge, calculated from the regression relations (Table 8) for the 50% flow duration, is about 5.0 cfs for a drainage area of 15.6 square miles. The mean annual discharge is about 12.0 cfs. The mean annual flood peak, the approximate flow at which a stream will begin to overtop its banks, is about 255 cfs, and the 100-year discharge is estimated at 644 cfs. Operating at a design capacity of 0.150 mgd, the average discharge to this stream from the wastewater treatment plant would be 0.23 cfs. This flow is less than 2% of the mean flow of 12.0 cfs, which is negligible compared to the flood peaks. The additional flow added by the wastewater treatment facility would have had a negligible effect on stream flooding.

The treatment method recommended for the combined needs of the SSC site and Kaneville was a multicell aerated lagoon system. Rock filtering would be required for the aerated lagoons in order to ensure sufficient algae removal and an associated reduction in BOD and suspended solids. The proposed system included a polishing lagoon to substitute for tertiary treatment in relatively small plants such as this. An estimated area of 18 acres would have accommodated the multicell lagoon system. A typical layout is shown in Figure 12. A 10-inch sewer main would have connected the treatment plant to experimental areas K4 and K5. Figure 11 shows the location of the site relative to the SSC study area.

The estimated total cost of a lagoon system of this size is $700,000, which includes peripheral costs such as land acquisition and engineering fees. Actual costs may vary depending on site conditions and specific design attributes. Operation and maintenance could run $1,000 per month.

Cooling Water Disposal

Any discharge from cooling towers along the SSC into streams or ponds would have required an NPDES permit from the Illinois Environmental Protection Agency, in accordance with Subtitle C of the *State of Illinois Rules and Regulations.* On the whole, discharges of noncontact cooling water to the public waters throughout the state are of acceptable quality, and the IEPA does not require additional treatment. This could have been expected to be true of cooling water discharged from the SSC sites as well. However, each case must be evaluated on an individual basis and depending on its evaluation, the state could require occasional monitoring of the discharge.

The major aspects to be evaluated affecting water quality include 1) the chemicals added as dispersants to the cooling water; 2) the build-up of dissolved solids, which is a function of the time the water spends in the cooling system; and 3) the temperature of the discharge. Based on the chemical practices used at Fermilab and the ample amount of water available for recirculation and dilution at the proposed SSC service areas, there should have been no problem with the quality of discharges from the SSC sites.

Cooling Water Use and Treatment at Fermilab

Casey's Pond, a storage reservoir with a capacity of 18 million gallons, acts as the water supply source for the cooling water used at Fermilab. Water entering the heat exchangers/cooling towers at Fermilab is treated with either bromine or chlorine and biodegradable dispersants (e.g., polyglycol). These chemicals are added for 30-minute periods, four times a day. The concentration of the treatments is controlled to ensure that an acceptable quality of water is returned to Casey's Pond. Water is returned to Casey's Pond after one pass

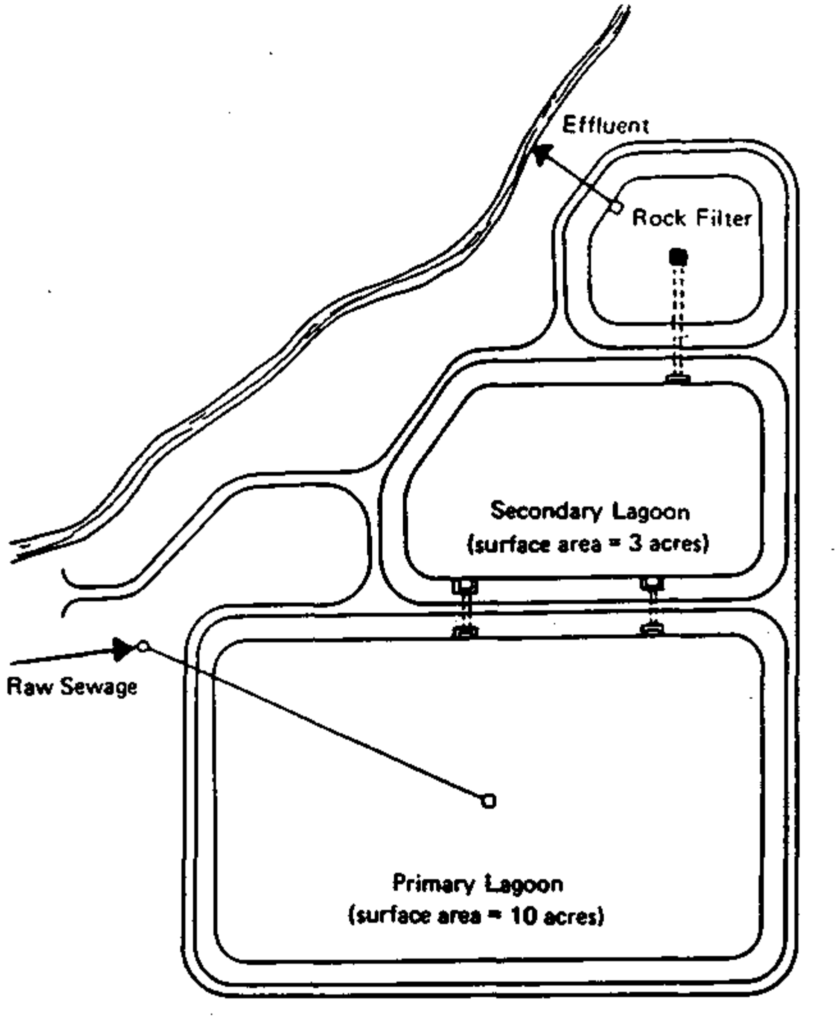


Figure 12. Representative layout of a multicell lagoon system

through the cooling system. The total annual water used for cooling is approximately one mgd, or less than 6% of the total water stored in the pond. Water enters the cooling towers after it has passed through the heat exchangers, and for this reason the temperature of the release (blow-down) is lower than the ambient temperature of the pond.

Discharges of cooling water at Fermilab are not currently subject to permit by the IEPA for several reasons: 1) Fermilab's system represents an almost-closed recirculation system, in which the discharge to area streams is very small; 2) overflow from Casey's Pond into the local stream (Kress Creek) occurs only during periods of storm runoff and is therefore highly diluted; 3) the storage of water used by the cooling system is much greater than the daily use of cooling water-so there is no significant build-up of dissolved solids; 4) the temperature of the blow-down into Casey's Pond is lower than the ambient temperature of the pond (during summer); and 5) the chemicals added in the cooling process are biodegradable and do not seem to harm the waters of the state.

Cooling Water Use and Treatment at the SSC Sites

An ample amount of raw water for use in cooling seems to be available at each of the proposed SSC service areas. Each site would have been served by either a well or hookup to a public water supply. At each site these sources were to be designed to provide a minimum of 125 gpm with the capability to provide twice this amount. In addition, the service areas were to be collection sites for the small amounts of water that would seep into the tunnel. The average discharge of seepage water, collected over a 5-mile stretch of tunnel, is estimated to be 50 to 250 gpm. Together the two sources of water at each service area would have been sufficient to ensure that 1) the average period of residency for water within the cooling system would be short enough to prevent significant accumulation of dissolved solids and 2) a high potential for dilution (both chemically and for temperature control) would be available for all water released from the cooling towers (blow-down).

Assessment of Potential Discharges to Area Streams

The potential discharge of cooling waters from the SSC sites would generally have been small compared to the average flows of the streams that would receive them. The maximum combined quantity of cooling water, whether derived from ground water or public supply systems, plus the tunnel seepage water is 500 gpm or 1.11 cfs. Figure 9 shows the proposed ring, the service area sites, and the area streams. The points at which the ring would intersect a stream are labeled A through X. The drainage areas at each of these locations and the values of various flow parameters are listed in Table 28. The discharge of 1.11 cfs of water to area streams would increase the low flows in the streams. However, the ground water is generally of superior quality, so discharges would not have an adverse impact and could be beneficial for aquatic habitats and recreation. The discharge of 1.11 cfs of water to the area streams during flood conditions (e.g., 100-year flood) would increase the flood by 0.1 to 1.0% and would have negligible impact as far as additional flooding is concerned.

Character of Major Stream Channels Crossing the Ring

Figure 9 shows the plan of the proposed SSC ring area and the streams intersecting it. These streams are listed in Table 28, which includes the intersection point with the SSC ring; name of the stream; location of the intersecting point in terms of township, range, and section; drainage area of the stream at the intersection point in square miles; and length in miles of channel from the intersection point to the watershed divide. Drainage area and channel length were determined from the USGS 7.5-minute topographic maps and USGS publications on river mileages and drainage areas (Healy, 1979). The various values at intersection points A through X are also given in Table 28.

Data on channel cross section, the bed and bank materials, and amount and type of vegetation are available from Illinois Department of Conservation (IDOC) reports (1968) on surface water resources published for Kane and DuPage Counties. A brief description of the channel characteristics, excerpted from the IDOC publications, is given below for the major streams in the SSC area.

> *Fox River,* about 35 miles long in Kane County, drains nearly 75% or 390 square miles of predominantly rich agricultural land. Almost all of the shoreline remains tree lined and much of it is heavily forested. The river bottom is mostly gravel with some bedrock in the upper and middle sections of the pools that becomes silt- or mud-laden in the lower lake-type portions of the pools. The river north of Batavia can be considered as a series of reservoirs. The southward flow of the river varies with each pool. From Batavia southward, the river becomes more characteristic of a stream or lotic environment.
>
> *Norton Creek* is a short, permanent valley-type creek with a moderate gradient. It begins as ditches draining the agricultural area just south of Wayne in DuPage County and flows westerly through a hilly, well forested, estate-type area. The creek empties into the Fox River two miles north of St. Charles, is well meandered, and has heavily wooded banks for the most part. The stream has a predominantly gravel-type bottom, but the upper portion has more silt deposition.
>
> *Kress Creek,* located in west-central DuPage County, flows southerly as a drainage ditch for about 4 miles, then turns eastward to continue as an open ditch to Kaelin Road. From here it continues as a meandering riffle-flat-type stream except where impounded. The creek drains approximately 18.5 square miles of gently rolling watershed devoted primarily to agriculture. The middle portion of the creek drains part of the 6,800-acre Fermi Laboratory property. The ditched portion of the creek flows as silt-laden gravel flats with well grassed banks. The natural meandering riffle-flat sections have gravel-rubble bottoms.

Waubansee Creek originates in the southwest corner of DuPage County and flows in a southwesterly direction to join the Fox River at Oswego. The creek drains approximately 10 square miles of gently rolling agricultural land in DuPage County. It flows as a drainage ditch for about 1.75 miles with open, well grassed, often steep-sided banks. The ditched portion mainly comprises extensive flats, generally silt-laden, with sandy gravel areas exposed as riffles. The unditched meandering portion has primarily wooded banks and shorter flats with more gravel on the bottom and a higher incidence of riffle areas.

Blackberry Creek, a mostly natural valley-type creek in south-central Kane County, begins in a terminal moraine and flows south in its upper portion as two open ditches, some portions of which are heavily wooded. The creek meanders through open meadows to the Sugar Grove Forest Preserve, then through rich agricultural lands. The base of the creek is primarily gravel with numerous riffle areas.

Welch Creek begins at Elburn in central Kane County as an open drainage ditch with grassed banks and flows in a southwest direction to Kaneville, where it becomes a meandering stream flowing south through partially wooded meadows. The bottom materials are basically gravel with considerable silt deposition in the upper sections of the creek.

Fer8on Creek is a picturesque, permanent, low-gradient stream that begins in central Kane County and flows easterly into the Fox River about one mile north of St. Charles. It originates in a small marshy area and its upper portion meanders through a narrow valley with many well turfed open meadows. It also flows through a partially wooded section and then becomes a well vegetated open ditch with a few wooded meanders before it receives Otter Creek. The stream bottom is mostly gravel to rubble.

Virgil Ditch is a series of three main ditches originating in west-central Kane County draining an extensive outwash plain area of rich agricultural land. The ditches are mainly steep-sided and the banks are grassey and heavily wooded or shrubbed. Riffle areas are generally of exposed gravel, while pools have predominantly silt bottoms; sand and gravel become more pronounced in the lower portion of the system.

LOCATION OF SSC FACILITIES RELATIVE TO 100-YEAR FLOODPLAINS

The location of surface facility sites and 100-year floodplain information were plotted on the GIS at a scale of 1 inch = 200 feet. Thirty-two sites were checked for their locations relative to 100-year floodplains of area streams. These sites include: the intermediate access areas E1-E10 (200 x 200 feet); major service areas F1- F10 (500 x 500 feet); abort/external accesses J1-J6 (1,320 x 1,320 feet); and interaction experimental areas K1-K6 (120 x 160 feet).

The portions of the block areas delineating these surface facilities within the floodplain were determined. Four facility service areas would have been close to the 100-year floodplain but only one of them (J6) would have covered actual floodplain.

Facility service area F5 was proposed for a location east of Dauberman Road and just to the east of the floodplain boundary of Welch Creek. Facility service area K4 would have been entirely out of the Welch Creek floodplain, and thus would not encroach on a floodplain at this site. Facility service area J3 was proposed for the southwest corner some distance away from Hawthorne Road and Kress Road, which would have entailed no encroachment onto the floodplain. Site J6 would have been wholly in the Fermilab area, which is federally owned. About 54% of the proposed site area would have been in the floodplain of Kress Creek and its tributary. However, only about 13% of the area would have been in the floodway defined by the Illinois standards. The floodway is that portion of the floodplain that must be kept free of encroachment to limit the increase in the 100-year flood stage or surcharge to 0.1 foot. The Illinois limit of 0.1 foot is much stricter than the federal limit of 1.0 foot. Thus a small portion of J6 would have been in the floodway. Its impact on the floodplain could have been mitigated through the arrangement of surface structures in this 40-acre site, by channel diversion, or by movement of the site about 200 feet to the south.

For the purposes of the Flood Insurance Program, the floodway concept was used as a tool to assist local communities in floodplain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe (Figure 13). The floodway consists of the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood can be carried without increasing flood heights by more than 1.0 foot. However, the state of Illinois has established criteria limiting the increase in flood heights or surcharge to 0.1 foot.

Areas in the flood fringe would typically require raising the floodplain level by 2 or 3 feet, in which case, a permit would be needed from the Illinois Department of Transportation. Alternatively, structures may be elevated or otherwise designed to prevent intrusion of overbank flows. Compensatory storage of flood waters upstream of a structure within a floodplain is a common means of negating any effects of flooding.

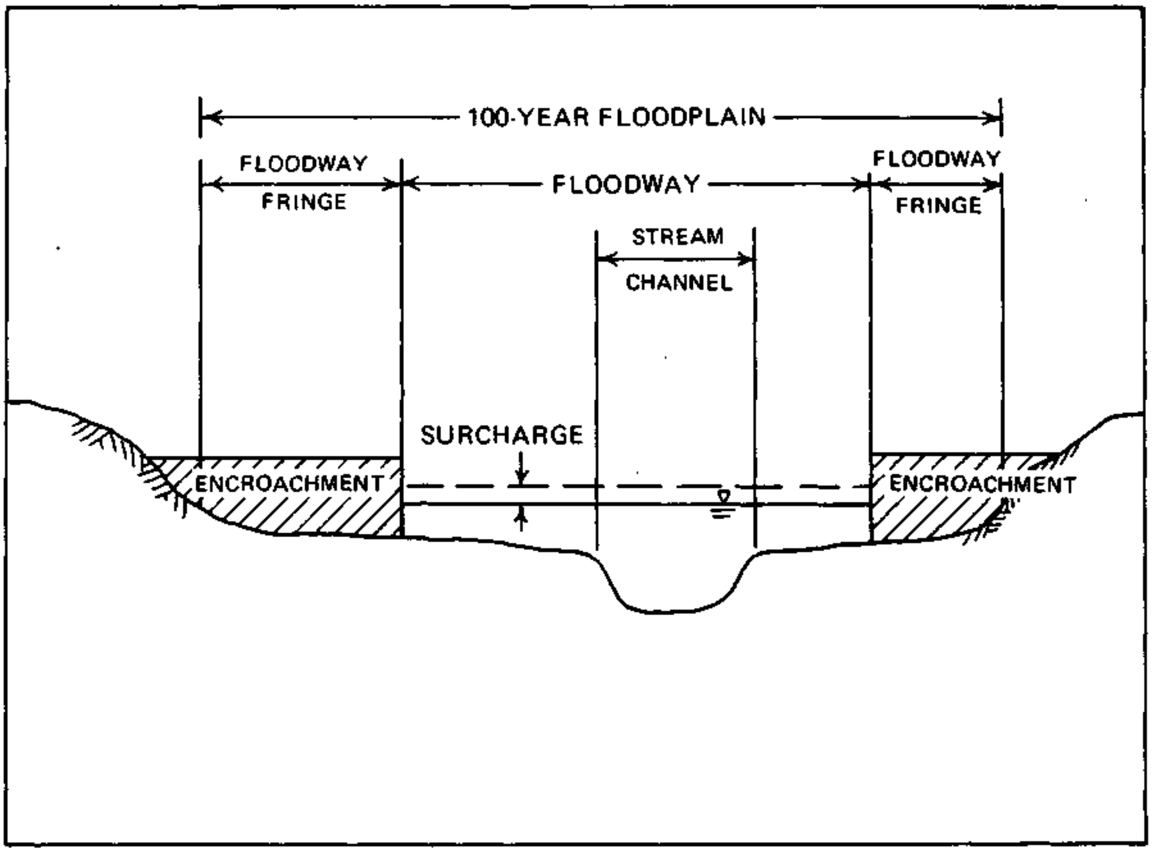


Figure 13. Floodway schematic

Since only a small portion of the northeast corner of site J6 would have been in the floodway, and a small portion in the southwest corner in the wetland, it is feasible to have located structures outside of the floodway and completely avoided any direct impact. The location of a facility below ground would also eliminate any impact on local flooding. The floodway area involved would have been small and given the options for the location and design, the SSC surface facilities could have been constructed with virtually no impact on the 100-year flood. The average velocity during a 100-year flood at proposed site J6 is less than 2 fps. Velocities near the floodway boundaries would be much smaller. Thus there is minimum chance that the raised areas would have suffered erosion.

SUMMARY AND CONCLUSIONS

The location proposed for the SSC in Illinois has ample primary and secondary (back-up) water supplies that would have met the SSC demand for both cooling and potable water. The SSC water needs are small compared to current water use within the area, and allocation of water resources to serve the SSC would not have deprived communities or other conventional users within the area. Disposal of conventional wastewater, cooling water, and tunnel seepage water could have been readily managed through existing or proposed facilities with little or no negative impact on the quality or integrity of area streams and rivers.

The proposed SSC requirements for potable and cooling water are distributed around the ring at ten separate locations. The main campus at the east side of the ring (Fermilab) would have had the greatest demand, followed by the far experimental areas along the west side of the ring. The eight remaining sites, major service areas, would have had relatively small water demands. Water at each of the ten sites could have been supplied through independent water systems. Both cooling and potable water could have been supplied from ground-water sources. The main campus and Weston village would have obtained water from existing Fermilab wells and the Warrenville public water supply, respectively. Three of the major service areas would have received their water through extensions of water mains from public water supply systems. The far experimental area water supply would have been secured by developing an existing test well and drilling a back-up well. Five new wells would be necessary to serve five major service areas located on the north and south arcs of the ring. Each of the proposed sources could reliably have served the SSC needs.

Domestic wastewater generated at the main campus, Weston village, and the far experimental areas would have required treatment and disposal. The present Fermilab system of conveying water to the Batavia treatment plant would also have served the main campus. Similarly, wastewater from Weston village could have continued to be conveyed to the Naperville-Springbrook plant A new wastewater treatment plant would have to be constructed to serve both the far experimental area and the village of Kaneville. Discharges of treated effluents to area streams would comply with the guidelines established by state standards.

Other interactions between the SSC structures and water resources in the area are discharges of cooling and/or seepage water to area streams and construction within the 100-year floodplain. Discharges of water to area streams were expected to be small and should have had no adverse impact on stream integrity. Flooding is not a significant problem in the region. The siting of the SSC facilities was for the most part removed from the 100-year floodplain and no significant effect on flood flows was anticipated.

Because of the abundance of water resources in the region, SSC water needs could have been economically met. The recommended water supply sources and method of wastewater treatment and disposal would have been the most cost-effective options for meeting the long-term needs of the SSC.

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