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A SURVEY OF ILLINOIS WATER SUPPLY PROBLEMS WITH SPECIAL REFERENCE TO CHARLESTON

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It is often difficult for people to realize that Illinois with its many well-developed river systems and ample average precipitation faces water supply problems. Upon consideration of the domestic and industrial state-wide water use, which totals over 370 gallons daily per capita, the necessity for maintaining and increasing available sources becomes evident.

Subsurface Water Supply Problem

The principal subsurface water problem in Illinois is the reduction of quantity from the lowering of water levels. Subsurface water can be procured in various quantities from eighty percent of the areal extent of Illinois (fig. 1).

Contrary to common opinion, the state's subsurface water resources are basically in good condition. That is, approximately 95 percent of the subsurface water area of Illinois is not faced with decreasing water levels. However, at certain locations where large urban concentrations have relied on subsurface water, there are serious water supply problems. Furthermore, fifty percent of the state population lives in these urban areas where water levels are being seriously lowered by concentrated pumpage. It can be easily understood, then, why there is a common suspicion that subsurface water resources throughout Illinois are dwindling.

The problem areas are Chicago and its suburbs and Joliet, Rock Island, and Peoria, especially Chicago and Joliet, where water levels in the bedrock deep wells have dropped as much as 400 feet over a period of sixty years. Figure 2 shows the recession in the Joliet city wells from 1890 through 1950. Some Chicago suburbs, one-time users of subsurface water, are forced to obtain water supplies from Lake Michigan.

As far as can be determined, the East St. Louis area and Peoria area rank first and second, respectively, in the world's per capita use of subsurface water per day. Because the Illinois River's highly silted floor allows little river water to infiltrate and recharge the aquifers beneath Peoria, the Illinois Water Survey has constructed an experimental infiltration pit near the river. During cooler months of the year the pit replenishes underground aquifers directly in quantities up to two million gallons daily, which is ten percent of the daily recharge needed for Peoria.

Subsurface water resources are being seriously depleted in only five percent of Illinois' subsurface water area. However, this small area's supply difficulty is becoming an acute problem for municipal and industrial planners.

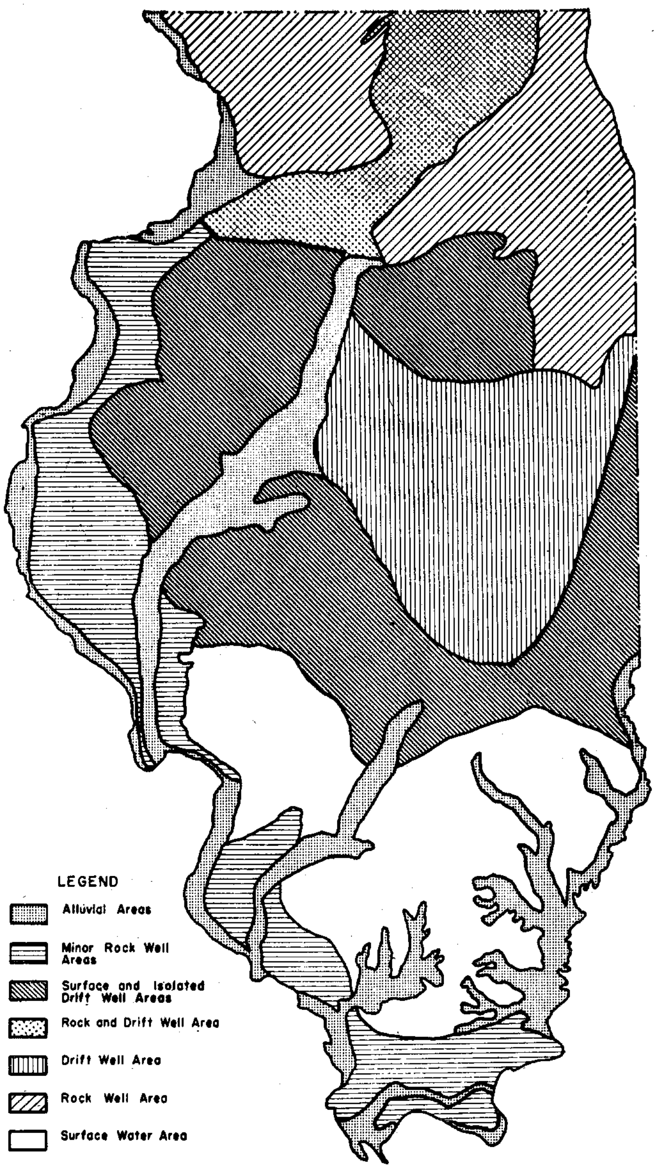

FIG. 1.—Water sources of Illinois. Subsurface water is found in all areas except the unmarked southern region.

SURFACE WATER SUPPLY PROBLEMS

The quantitative decrease of surface supplies in Illinois has been influenced by pollution, but pollution is subordinated to a more important problem. For example, it has been calculated that waste disposal in the Illinois River totals one part per million as compared to 418 parts per million of silt in the river.

Reservoir silting and silt pollution have become the major problems of surface water sources. Unfortunately these problems have become fully recognized only in the past twenty-five years. Twenty-five percent of fourteen sedimentation surveys in the past sixteen years have revealed such damage to the lakes as to necessitate immediate consideration of additional facilities. Of the 600 public supply systems in Illinois, approximately 100 depend on surface water sources other than Lake Michigan. However, concerning quantity used, municipal surface water pumpage is nine times greater than subsurface water pumpage.

Figure 3 compares industrial use of groundwater and surface water in nine major industrial areas. Over 350 industries in Illinois use subsurface water totaling 258 million gallons daily, but the surface water pumpage by 200 industries is six times larger, totaling 1.753 billion gallons daily. There can be no doubt of the necessity and value of maintaining surface water sources in Illinois.

In all reservoirs, which have been constructed to trap and contain the irregular seasonal runoff, the particles of silt settle throughout the lake bottom. Usually the silt also forms deltas or natural levees at the location of stream entrance to the reservoir.

The volume of silt deposited in reservoirs depends upon seven characteristics of the watershed area. These are watershed size, soil permeability, amount of rainfall, degree of

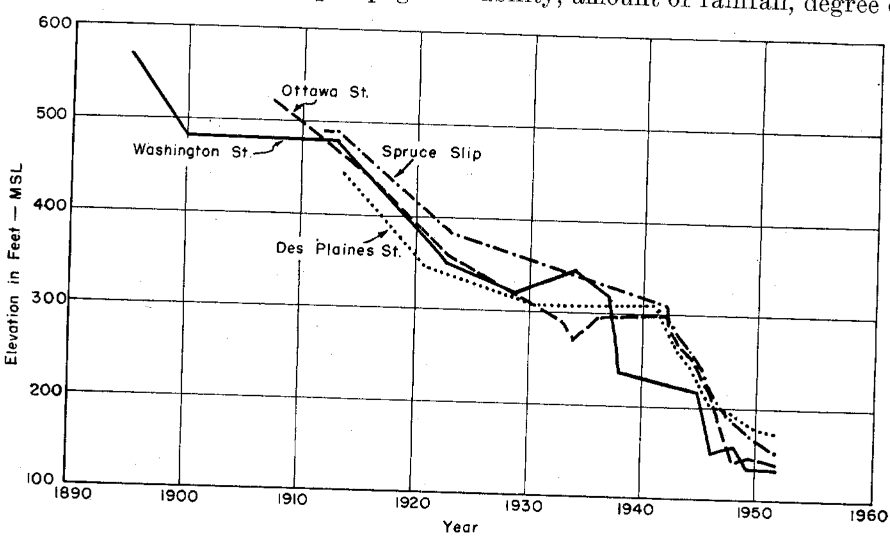

Fig. 2.—Recession in Joliet city wells.

land slope, reservoir capacity, stream gradient, and land use.

Silting and soil pollution as problems of surface water sources are only end results of the real problem, and that is soil erosion. The areal extent of the various degrees of slope and the resulting degree of erosion are factors of the watershed that directly affect silting. Another characteristic is the amount of runoff as determined by the rainfall over the watershed and the permeability of the watershed's soils. A small reservoir receives a larger volume of silt per square mile of watershed than does a larger reservoir. In a very large watershed, it is obvious that the distance to be traveled by the sediment will be greater; and therefore the sediment has many more opportunities to be deposited before it reaches the reservoir.

From experiment and detailed sedimentation surveys, a ratio has been devised that is indicative of future reservoir sedimentation. This ratio is reservoir storage capacity in acre-feet divided by the number of square miles in the watershed area. From examination of the seven causes of sedimentation, it appears that present trends in land use within the watersheds are causing the recent increase of reservoir silting in Illinois.

Several remedial measures are available to solve severe silting and obtain an adequate supply. Selection of such measures is dependent on the problem area's physical and economic situation. Reservoir dredging, dam raising, additional reservoir construction, and controlled land-use conservation throughout the watershed are the primary solutions. When reservoir construction ends, reservoir destruction begins.

Development of New Sources

Illinois has available approximately 600 useful reservoir sites. Furthermore, with careful planning and control, the state's surface water sources can support a population ten times the present population. Further growth of many industrial areas using subsurface water is deterred by insufficient volume. The state's subsurface water distress areas reflect a trend towards dependence on surface water sources, as is the case in many suburban Chicago cities.

The inadequacy of groundwater for municipal supplies was a major factor behind the fifteen percent increase in the number of city surface reservoirs during a seven year period ending in 1944. The increasing attempts to find new water sources also include probing the major buried bedrock valleys. As example, in order to obtain necessary water for the recent industrial development at Tuscola, according to newspaper reports, the possibility of drilling wells in the buried Mahomet-Teays Valley, twenty-two miles from Tuscola, is being considered. The expense and problems encountered in pumping and moving this water indicate the amount of trouble industry is willing to undergo in its quest for a satisfactory water supply. Champaign, to maintain an adequate municipal supply, has had to sink new wells in the same buried valley. Rockford, a city long dependent on bedrock sandstone aquifers is beginning to augment its supply with subsurface water obtained from a preglacial valley. Illinois may be approaching

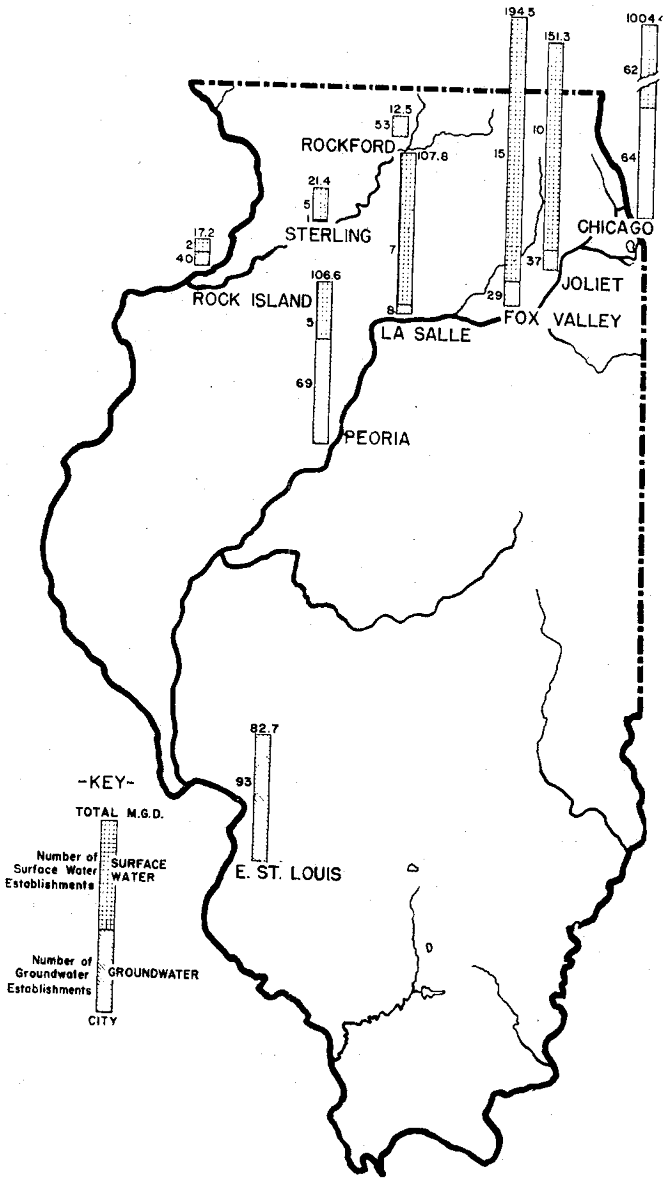

FIG. 3.—Total water use of nine industrial areas of Illinois representing total pumpage, groundwater and surface water proportional use, and the number of industries for each source.

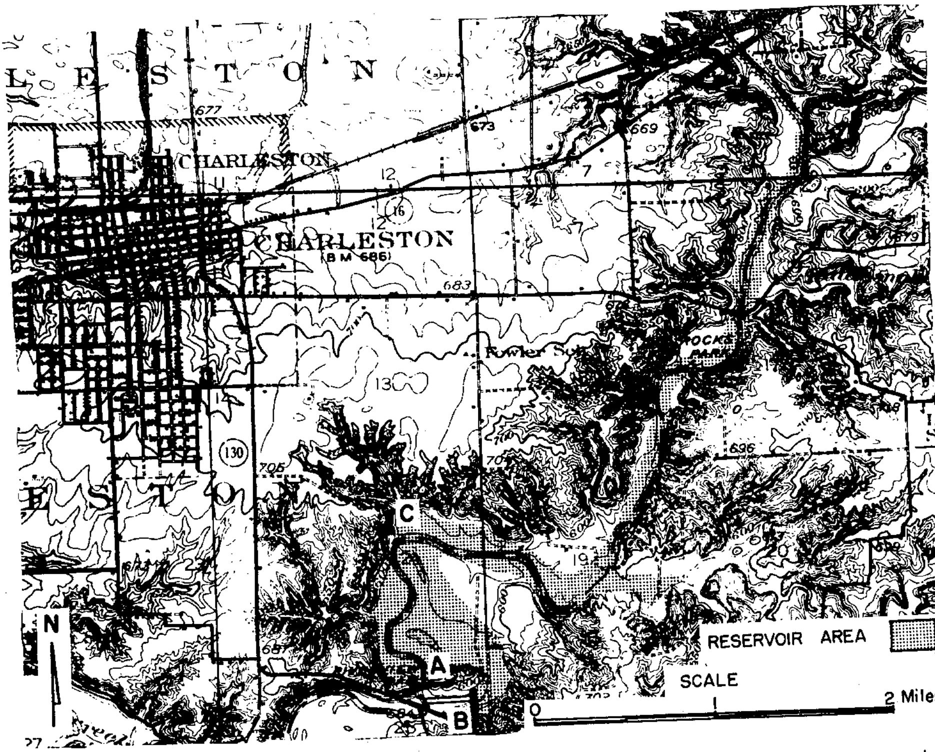

Fig. 4.—Topographic map of Charleston and vicinity showing the arrangement of water supply facilities. New Lake Charleston is approximated by dots.

a period in the water supply situation in which availability of large quantities of subsurface water in buried valleys will be a deciding factor in industrial location.

Water Supply Situation at Charleston

Charleston's water supply situation is typical of past, present, and future problems faced by the majority of surface water supplied cities in Illinois. For 76 years the city has obtained its water from the south-flowing Embarrass River two miles east of the city (fig. 4). The drift and bedrock underlying Charleston and its vicinity have no large water-bearing formations. In the area the drift ranges from 40 to 75 feet of sands and gravels. The few shallow drift wells in the area furnish limited quantities of two to ten gallons per minute, and suffer a rapid "drawdown" after continual pumping. The few wells drilled into bedrock have brought in very small quantities of highly mineralized, corrosive water. With such an unfortunate subsurface water situation, an adequate surface supply has been a necessity for Charleston.

The water has always been obtained at an intake about one mile southeast of the city (point C, fig. 4) where the waterworks are located. Water flowing past the point of intake represents runoff from a drainage area of approximately 800 square miles. The river is incised to a depth of over 100 feet, forming compact clay till, which contains few scattered lenses of water-bearing meanders and steep-sided valley walls.

From 1876 to 1895 the city supply depended entirely on river flow with no damming or reservoir supply. In times of low flow, the river bed was plowed to allow free inflow of the spring water that fed the river. To get a more regular supply in times of low flow, an eight-foot high channel dam was constructed in 1895 on the Embarrass a mile below the intake (point A, fig. 4). Until 1912 all city water was untreated. One former city father said, "We hadn't worried about pollution, as all towns dumping sewage into the river are at least fifteen miles upstream." During 1912 and 1913 a filter plant and settling basin were built, and by 1918 a small elevated tank had been constructed and meter installation begun. In 1925 one of fate's blessings in disguise occurred when the waterworks plant burned. After this disaster modern electric pumps with complete new facilities were installed, which made Charleston's supply facilities temporarily satisfactory.

By 1927, the city consumed 250,000 gallons daily above the capacity of the filters, so that 20 percent of the water used was raw river water. From 1930 through 1939 minor improvements were made at the overtaxed waterworks, but by 1940 the inadequacies of source and facilities were becoming so serious, that the city began long range planning for a new reservoir and complete waterworks improvement. During the following three years several plans were considered for a new reservoir, which mainly concerned use of the various Embarrass tributaries near Charleston. However, in late 1943 a plan for improvement was decided on calling for the construction of two dams (locations A and B, on fig. 4). The bonds were issued, land purchased, and the present reservoir was realized in 1947. The new reservoir impounded 860 million gallons over an area of 400 acres.

Since reservoir completion and general waterworks improvement, other problems have arisen. Several temporary water shutoffs have resulted from breakage of the single water main that connects the waterworks at the reservoir and the city. The major problem at present is the need for an extra connecting main and a large new elevated water tank within the city. Both items were called for in the long range improvement plan, but have not been constructed. For this reason fire insurance companies were forced to raise rates in Charleston last year. However, the people of Charleston have just this February voted to issue the necessary bonds to complete the needed water supply improvements. Therefore, 1952 should complete a very fine water supply system for this city.

Except for periodic repairs and replacement of the waterworks equipment, the future holds possibly one major problem for Charleston to consider, that of loss of reservoir volume through silting. Admittedly, silting is not an immediate problem, but its possible future seriousness will require periodic investigations. Since no accurate sedimentation survey has been made as yet, any prediction of the rate of silting and the date of serious loss of volume is highly empirical. However, to get an estimation I have selected Lake Decatur for comparison, as it has many silting characteristics similar to Lake Charleston.

From this comparison, it appears the watersheds are not markedly different in respect to rainfall and soil types; therefore the proportion of runoff is approximately the same for both. Lake Decatur's watershed totals 906 square miles as compared to Charleston's 800 square mile basin. Degree of slope within the watersheds is also similar with low slopes totaling 93 percent of the Decatur area and 89 percent of the Charleston watershed area. A factor which indicates possible greater Lake Charleston silting, is that a much larger percentage of the Decatur watershed is under the control of drainage districts. Stream gradients are almost identical for both rivers, and the land use in both watersheds indicates only a three percent difference in the amount of land in intertilled crops. Therefore, except for the factor of impounding volume, the lakes are quite similar, and may possibly have approximately equal silting rates. A big factor in silting is the ratio of reservoir capacity to watershed area, which figures out to be 22 acre-feet per square mile for Lake Decatur and 3.25 for Lake Charleston. Sedimentation experts consider any lake with a ratio below 100 to be in danger of serious volume loss from silting, and the lower this ratio the more dangerous are the silting possibilities. Actual studies of silt in Lake Decatur indicate a 1.1 percent loss in reservoir capacity yearly for the past thirty years. Further empirical application in relation to the 3.25 ratio and the trap efficiency of Lake Charleston, indicates that Lake Charleston would be losing 1.75 percent of its original capacity per year. If this be true, the lake has lost approximately nine percent of its capacity since construction ended.

Summary

The frequent water supply problems in Charleston's past are but a reflection of the common lack of planning in respect to the requirements of the ever-present population and industrial growth. Fortunately the city here now appears to have the water supply situation under control. It must not relax its present ambitious policy in the future. The typical trial-and-error water supply development with its resulting inadequacies has been and is being repeated in many cities and towns throughout Illinois.

With the increasing statewide, dependence, development, and use of surface water supplies, the difficulties, as encountered at Charleston, and the general water supply problems should be, can be, and must be avoided to maintain adequate supplies in Illinois.

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