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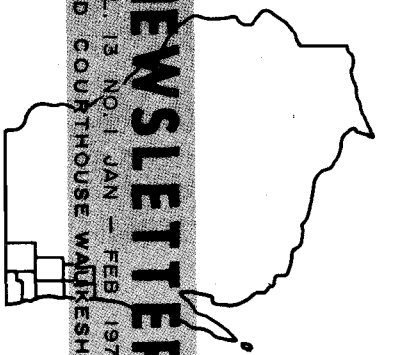


SANDSTONE AQUIFER SIMULATION MODEL TO BE PREPARED FOR THE REGION

The development of a digital computer model which will simulate the performance of the deep sandstone aquifer underlying the Region under varying use and recharge conditions has been undertaken by the U. S. Geological Survey, with cooperative efforts by the Wisconsin Geological and Natural History Survey and the Regional Planning Commission. The program is expected to be completed within the next two years at a cost not to exceed $70,000.

In June 1972 the Wisconsin and U. S. Geological Surveys indicated to the Commission and to certain local government agencies a willingness to develop for the Region a computer model of the deep sandstone aquifer. Subsequently, the Commission invited the major public water utilities within the Region which use groundwater as a source of supply to attend a meeting to discuss the matter. It was agreed by representatives of seven of the utilities, the Wisconsin and U. S. Geological Surveys, the University of Wisconsin-Milwaukee, and the Commission who attended the meeting that it would be highly desirable to proceed with development of the model, and that the Commission should approach the major public water utilities which use, or expect to use, the deep sandstone aquifer as their source of supply, to obtain the local funding necessary to receive matching state and federal grants-in-aid. Of the total program cost, $35,000 over the two-year period will be paid by the U. S. Geological Survey, $17,500 by the Wisconsin Geological and Natural History Survey, and the remaining $17,500 by the major

water utilities. To simplify the administration of the program, it was recommended that only those public utilities serving communities having 1970 population levels of 3,000 or more persons contribute to the funding of the program, and these utilities were accordingly defined as "major" public utilities.

As of January 1, 1973, 11 of the 17 major utilities had agreed to participate in the funding of the modeling program. The cost for each utility was prorated based on the relative population served. The 11 utilities include the City of Brookfield Water Utility, the Cedarburg Light and Water Commission, the Village of Germantown Water Utility, the Grafton Sewer and Water Commission, the City of Hartford Utilities Department, the Village of Menomonee Falls Water Utility, the City of Muskego Water Utility, the Oconomowoc Water Utility, the Village of Pewaukee Water Utility Commission, the Waukesha Water Utility, and the Whitewater Municipal Water Department.

The aquifer simulation modeling program does not constitute a water supply planning program for the Region. Rather, the model will provide an invaluable planning tool which can be used in the formulation of such a plan for the Region. Data collection and program development will be the primary responsibility of the U. S. Geological Survey. The Commission will coordinate the work with the utilities involved, will make the model available to local water utilities for application in the Region, and will create a technical advisory committee to make available the knowledge and experience of local utility officials in the model formulation. The primary work efforts of the U. S. Geological Survey will include analysis of groundwater conditions in the deep sandstone aquifer, determination and mapping of aquifer transmissivity, determination of the recharge potential of the aquifer, and determining the saturated thickness of the aquifer.

The work efforts will culminate in the preparation of a mathematical model in the form of a computer program and attendant data inputs, and an open file report to the cooperators documenting the findings of the

study and discussing desirable future well locations and spacings and well pumpages for various centers of pumpage for 1990 as identified by the Commission and the local utilities. The study area will encompass about 3,500 square miles, and in addition to the Region will include all or parts of Dodge, Jefferson, and Rock Counties and parts of northern Illinois. The actual boundary of the study area will be determined by the location of regional groundwater and surface water divides and the Lake Michigan shoreline.

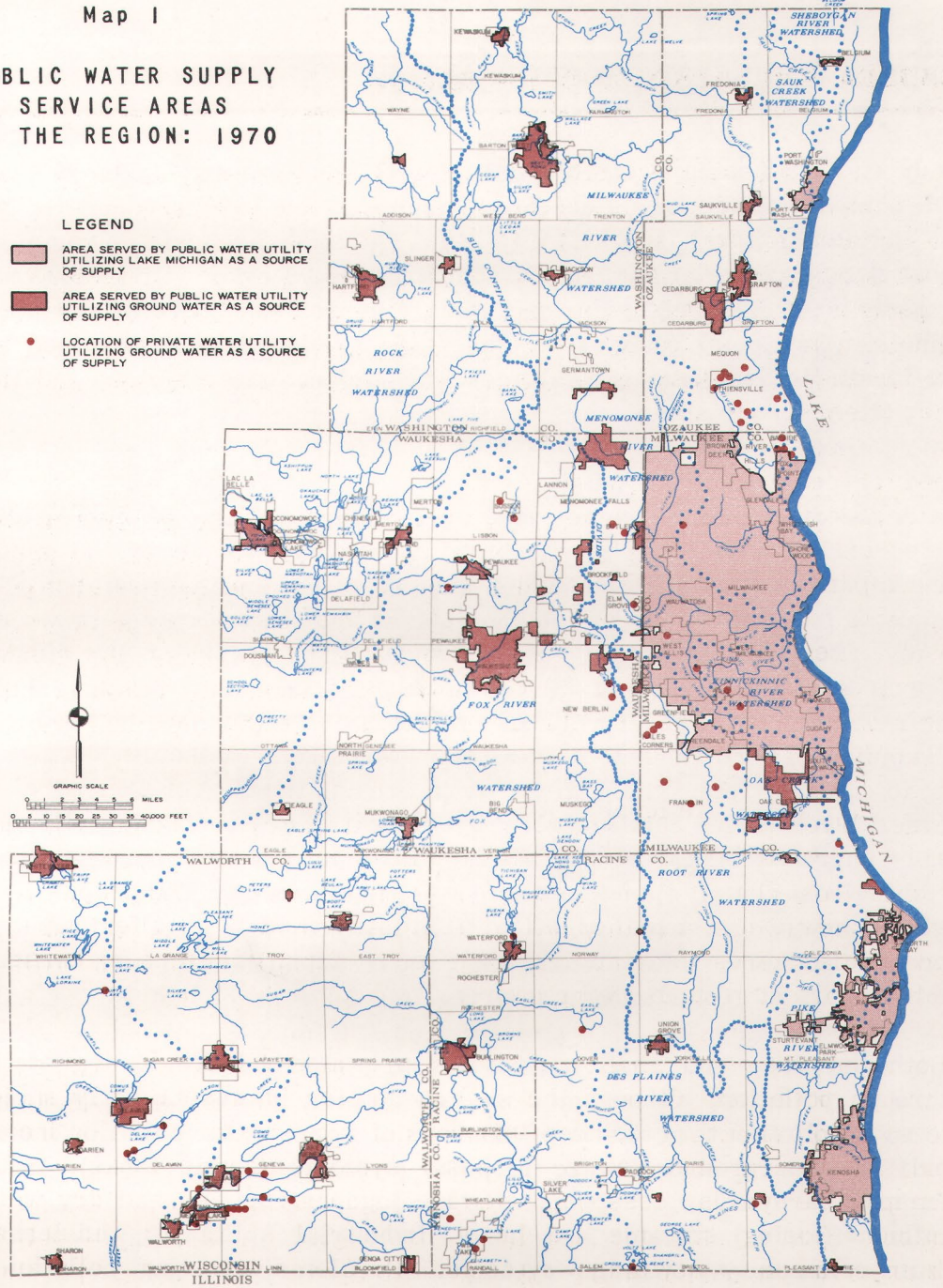
Need for the Simulation Model

Water use by industry, commerce, agriculture, and the general public is increasing rapidly in southeastern Wisconsin. Some of the urban concentrations in the Region which lie east of the subcontinental divide and close to Lake Michigan use the lake as the major source of water supply. But rapidly growing urban concentrations west of the divide, as well as several east of it, are beyond the economic reach of lake water and therefore must rely on groundwater as the principal source of supply (see Map 1).

From 1960 to 1970, the amount of groundwater which was used in the Region increased 67 percent, while the population of the Region increased by only 12 percent. During those 10 years, the groundwater pumpage within the Region increased from 9 billion to 15 billion gallons per year, while the population increased from 1.57 million to 1.76 million persons. Of the total pumpage during this 10-year period, about half was estimated to have been pumped from the deep sandstone aquifer. As a result, declines of as much as eight feet per year are occurring in the water levels of this aquifer, which may in the future make it necessary to deepen wells and thereby increase the cost of the water produced. The total decline in the water levels since this reservoir was first tapped in the mid-1800s has exceeded 300 feet in some areas of the Region. Even greater declines in the water levels in this same aquifer are occurring in northeastern Illinois, with the rate of decline reaching 22 feet per year in some areas.

Map 1

PUBLIC WATER SUPPLY SERVICE AREAS IN THE REGION: 1970



Source: SEWRPC.

Groundwater pumpage within the Region is estimated to reach 36 billion gallons per year by 1990, two and one-half times the 1970 pumpage. It is also estimated that about half of this pumpage will have to come from the deep sandstone aquifer. Because of the relatively high quality and ready availability of the water in the deep aquifer, it may be expected to remain the only practical large-scale water supply source in much of the Region.

Studies conducted by the U. S. Geological Survey, in cooperation with the Wisconsin Geological Survey and the Commission, have indicated that large quantities of groundwater are available to meet future water demands in the Region if the aquifers underlying the Region are soundly managed. Groundwater information thus far acquired indicates that, in the development of the groundwater supply within the Region, municipalities and industries are dealing with a highly complex geologic-hydrologic-chemical system in which natural discharge and recharge rates are highly variable and difficult to determine; in which groundwater withdrawals can greatly alter the rate and direction of groundwater movement, the location and extent of recharge areas, and streamflows and lake levels; and in which water quality conditions are complicated by aquifer pumpage, by waste disposal practices, and by natural sources of pollution.

The development of a mathematical simulation model, therefore, would be an invaluable aid in understanding and dealing with such a complex system. If the deep sandstone aquifer underlying the Region is to be used effectively and to full advantage in the future, adequate planning is necessary so that water levels in this aquifer do not decline so far as to make economic use of the aquifer impractical, if not impossible, for many users. Proper planning for use of the deep aquifer should include consideration of coordinated use of both the shallower dolomite and interconnected sand and gravel aquifers and the deeper sandstone aquifer, proper spacing of wells, possible withdrawal rates to prevent excessive interference between wells and to minimize declines in water levels, and protection of the aquifer recharge areas.

The model itself will consist of a series of mathematical expressions which describe the movement of water into and through the aquifer under varying conditions of withdrawal, programmed for solution on a digital computer to simulate the dynamic performance or behavior of the deep aquifer. Upon completion, the model will be applied immediately to simulate the addition and effects of new wells that might be proposed to be added to the system, and can be used to plan the location and spacing of future wells and to determine the effects of unplanned wells. The model will be flexible and readily updated as more detailed hydrologic data become available over time.

SEWRPC NOTES

THREE NEW COMMISSIONERS APPOINTED, THREE OTHERS REAPPOINTED

Three new commissioners have been named to the Southeastern Wisconsin Regional Planning Commission from Ozaukee, Racine, and Walworth Counties and three others have been reappointed from Milwaukee, Ozaukee, and Washington Counties. Each will serve a six-year term which ends September 15, 1978.

The three new commissioners include John P. Dries, who was elected by the Ozaukee County Board on November 20, 1972; John Margis, Jr., elected by the Racine County Board on October 24, 1972; and John B. Christians, appointed by Governor Lucey from a Walworth County Board approved list of candidates on November 24, 1972.

The commissioners who were reappointed include Richard W. Cutler from Milwaukee County and James F. Egan from Ozaukee County. Both were reappointed by Governor Lucey, Mr. Cutler on the Governor's own motion and Mr. Egan from an Ozaukee County Board approved list of candidates. Joseph A. Schmitz was reelected to the Commission by the Washington County Board on August 8, 1972. Mr. Cutler, Mr. Egan, and Mr. Schmitz have served on the Commission since its creation in 1960.

Mr. Dries, who succeeds Ralph J. Huiras on the Commission, is a former Ozaukee County Civil Defense Director who lives in the Town of Grafton. He has been a member of the Ozaukee County Board for eight years, serving on numerous committees such as the County Finance Committee, Highway Committee, Welfare Committee, and Zoning Committee.

Mr. Margis, who operates a 113-acre dairy farm in the Town of Caledonia, has been a member of the Racine County Board since 1955. He has been a member of the board's Highway and Parks Committee the past 10 years and has been chairman for the past eight years. From 1955 to 1967 he also served as town chairman of the Town of Caledonia. He is a member of the Commission's Root River Watershed Committee and the Racine Urban Planning District Citizens Advisory Committee. Mr. Margis played a leading role in the development of the Commission's Root River watershed plan and has since been a strong advocate on the Racine County Board for its implementation, particularly with respect to acquisition of floodlands along the Root River and the development of a Root River Parkway. Mr. Margis replaces Garth R. Seehawer.

Mr. Christians, who is city attorney for the City of Lake Geneva in Walworth County and a native of Lake Geneva, replaces John D. Voss on the Commission. Mr. Christians is also secretary and co-founder of the Lake Geneva Industrial Development Corporation, and was a founding member and member for two years of the Lake Geneva Plan Commission.

COMMISSION OFFICERS ELECTED, COMMITTEE ASSIGNMENTS ANNOUNCED

George C. Berteau, of Racine County, was reelected to his 12th term as chairman of the Commission at the Commission quarterly meeting December 7, 1972 in the Milwaukee County Courthouse. Other officers elected to one-year terms include James F. Egan, Ozaukee County, reelected to his fourth term as vice-chairman; Richard W. Cutler, Milwaukee County, reelected to his ninth term as secretary; and Joseph A. Schmitz, Washington County, reelected to his fifth term as treasurer.

Members of the Executive Committee were also elected at the quarterly meeting, and include, in addition to the four Commission officers, Eugene A. Hollister, Walworth County; Donald L. Klapper, Kenosha County; John Margis, Jr., Racine County; Theodore F. Matt, Waukesha County; and Norman C. Storck, Milwaukee County.

Mr. Berteau recently announced appointments to the three standing committees of the Commission for 1973, which include:

Administrative Committee

Donald L. Klapper, Chairman
Leonard C. Rauen, Vice-Chairman
John B. Christians
Lyle L. Link
Joseph A. Schmitz

Intergovernmental and Public Relations Committee

Theodore F. Matt, Chairman
Emil M. Stanislawski, Vice-Chairman
George C. Berteau
John P. Dries

Eugene A. Hollister
John Margis, Jr.
Francis J. Pitts
Joseph A. Schmitz

Planning and Research Committee

Norman C. Storck, Chairman
Lawrence W. Hillman, Vice-Chairman
Anthony F. Balestrieri
George C. Berteau
Thomas H. Buestrin
Charles J. Davis
James F. Egan
Eugene A. Hollister
Lyle L. Link
John Margis, Jr.
Theodore F. Matt
Donald E. Mayew
Paul F. Quick
Emil M. Stanislawski

COMMITTEE COMPLETES PROSPECTUS FOR PARK, OUTDOOR RECREATION STUDY

The increasing demand for outdoor recreation, the changing character of outdoor recreation facilities, and the massive conversion of land from rural to urban use within the Region and the concomitant loss of sites having potential for public and private recreational development are among the factors which make the need for a regional park, outdoor recreation, and related open space planning program urgent at this time, as outlined in a prospectus prepared by the 26-member Technical and Citizen Advisory Committee on Regional Park, Outdoor Recreation, and Related Open Space Planning.

The committee, which recently completed the Regional Park, Outdoor Recreation, and Related Open Space Planning Program Prospectus, noted that until the end of World War II, outdoor recreation activities of the majority of people were generally confined to the use of public parks located within a relatively short travel distance of individual places of

residence. But since that time, important social and economic changes have occurred which have had far-reaching impacts on urban development patterns and the use of all types of community facilities, including public park facilities. In addition to documenting the need for such a planning program, the prospectus outlines the scope, content, organization, timing, and budget of the program for the seven-county Region.

Seven factors were identified which make the need for, and conduct of, such a program necessary at this time. In addition to the three previously mentioned, they include the areawide nature of the use of outdoor recreation facilities; the changing approach to the planning, design, acquisition, development, and management of park, outdoor recreation, and related open space facilities; the limited local funding available for park and related open space acquisition and development; and the absence of adequately coordinated planning for public and private park, outdoor recreation, and related open space facility acquisition and development on an areawide basis which will meet the planning prerequisites of state and federal grant-in-aid programs for public park and related open space facility acquisition and development.

The program is expected to be completed within the next three years at a cost of approximately $180,000. The advisory committee was formed subsequent to requests from the City of Racine Common Council, the Milwaukee County Planning Commission, and the U. S. Department of Housing and Urban Development that the Commission undertake such a study. The committee includes the following members:

Richard W. Cutler . . . . . Chairman	Attorney, Brady, Tyrrell, Cotter, and Cutler, Milwaukee; Member, Village of Fox Point Plan Commission; Commissioner, SEWRPC
Kurt W. Bauer . . . . . Secretary	Executive Director, SEWRPC

Loren R. Anderson	President, Geneva Lake Development Corporation, Williams Bay
Anthony S. Bareta	County Planning Director, Milwaukee County Planning Commission
Donald B. Brick	Walworth County Recreation Agent
William H. Claflin	Deputy Commissioner, Department of City Development, City of Milwaukee
Delbert J. Cook	Chairman, Cedar Creek Restoration Council, Cedarburg
Norbert Dettmann	Chairman, Town of Farmington; Washington County Board Supervisor
Arthur D. Doll	Director, Bureau of Planning, Wisconsin Department of Natural Resources
Robert A. Gibson, Jr.	Comptroller, The Abbey Hotel, Fontana
Howard W. Gregg	General Manager, Milwaukee County Park Commission
Booker Hamilton	Member, Board of Directors, Neighborhood House of Milwaukee, Inc.
Karl B. Holzwarth	Park Director, Racine County Highway and Park Commission
Charles Q. Kamps	Attorney, Quarles, Herriott, Clemons, Teschner, & Noelke, Milwaukee
Philip H. Lewis, Jr.	Professor, Department of Landscape Architecture, University of Wisconsin-Madison; Director, Environmental Awareness Center, Madison
Richard J. Lindl	Director of Parks, Kenosha County Park Commission
John Margis, Jr.	Racine County Board Supervisor; Commissioner, SEWRPC
Clinton E. Rose	Milwaukee County Board Supervisor
Robert D. Ross	General Manager, The Journal-Times, Racine

Phil Sander . . . . . Executive Secretary, Southeastern Wisconsin Sportsmen's Federation
George L. Schlitz . . . . . Chairman, Kenosha County Park Commission
Frederick G. Schmidt. . . . . Member, Sierra Club
Mrs. John D. Squier . . Member, Riveredge Nature Center, Inc.
Walter J. Tarmann . . . Executive Director, Waukesha County Park and Planning Commission
Joseph Waters. . . . . Proprietor, Lazy Days Campground, Town of Farmington
Dr. Harry J. Wilkins . . . . . Outdoor Sportsman, Wauwatosa
George T. Wilson . . . . . Assistant Superintendent of Schools, Division of Municipal Recreation and Adult Education, City of Milwaukee Public Schools
Thomas N. Wright . . . . . Director of Planning, City of Racine

Copies of the Prospectus may be obtained by contacting the Commission offices. The price is $1.50 within the Region and $3.00 outside the Region.

MILWAUKEE RIVER WATERSHED COMMITTEE RECONSTITUTED

Although the Comprehensive Plan for the Milwaukee River Watershed was completed in 1971, the Milwaukee River Watershed Committee has been reconstituted in order to promote plan adoption, to monitor development in the watershed, and to review plan implementation progress. The new 29-member committee, which includes several members of the original committee, includes the following:

Richard W. Cutler . . . . . Attorney, Brady, Tyrrell, Cotter, and Cutler, Milwaukee; Member, Village of Fox Point Plan Commission; Commissioner, SEWRPC
Chairman
Kurt W. Bauer. . . . . Executive Director, SEWRPC
Secretary

Vaughn H. Brown . . . . . Vice-President, Tri-County Civic Association
Frederick H. Chlupp . . . . . Land Use and Park Administrator, Washington County
Delbert J. Cook . . . . . Chairman, Cedar Creek Restoration Council, Cedarburg
Arthur G. Degnitz . . . . . Washington County Board Supervisor
Nick R. Didier . . . . . Realtor, Port Washington
Arthur Doll . . . . . Director, Bureau of Planning, Wisconsin Department of Natural Resources
Edward Frauenheim . . . . Sheboygan County Board Supervisor
Herbert A. Goetsch . . . . . Commissioner of Public Works, City of Milwaukee
Howard W. Gregg . . . . . General Manager, Milwaukee County Park Commission
Lawrence W. Hillman . Vice-President, Facilities and Specialty Operations, The West Bend Company, West Bend; Commissioner, SEWRPC
Mrs. Robert Jaskulski . . . . . Treasurer, Milwaukee River Restoration Council, Inc.
Ben E. Johnson . . . . . Alderman, City of Milwaukee
John J. Juntunen. . . . . County Planner, Sheboygan County
John T. Justen. . . . . President, Pfister & Vogel Tanning Company, Milwaukee
Dorothy Klein . . . . . President, Village of Saukville
Robert L. Konik . . . . . County Planner, Fond du Lac County
Adolph Laubenstein . . . . . President, Laubenstein Roofing Company, Saukville
Ray D. Leary . . . . . Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions
Thomas P. Leisle . . . . . Mayor of the City of Mequon; Ozaukee County Board Supervisor

Dr. Darrell M. Martin	Resident Manager, St. Regis Paper Company, Milwaukee
Rudolph Mikulich	Business Administrator, Clerk-Treasurer, City of Glendale
David W. Opitz	Director, Ozaukee County Department of Environmental Health
Albert Schroeder	Former Chairman, Town of Trenton, Washington County
Emil M. Stanislawski	Milwaukee County Board Supervisor; Commissioner, SEWRPC
George Watts	President, Geo. Watts & Son, Inc., Milwaukee
Donald W. Webster	Consulting Civil Engineer, Milwaukee
Richard E. Zarling	Director of Elementary Education, Kewaskum Community Schools

The plan has been adopted to date by four of the five counties in the watershed, including Sheboygan, Washington, Ozaukee, and Milwaukee Counties, and by the Common Council of the City of Milwaukee and the Village Board of the Village of River Hills. The Milwaukee Common Council in its adoption also provided for formation of a technical committee to assist in the implementation of plan recommendations dealing with water pollution abatement.

The plan has been approved by the Wisconsin Natural Resources Board, the City of Milwaukee Board of Harbor Commissioners, and the Milwaukee County Park Commission. It has been endorsed by the Wisconsin Board of Soil and Water Conservation Districts; the Wisconsin Board of Health and Social Services; the Wisconsin State Highway Commission; the U. S. Department of Agriculture, Farmers Home Administration and Soil Conservation Service; the U. S. Department of Housing and Urban Development; and the U. S. Department of the Interior, Geological Survey and Bureau of Outdoor Recreation.

In addition to the plan adoptions and endorsements, which are an important first step toward plan implementation, action has been taken in recent months toward implementation of land use, flood control, pollution abatement, and water supply portions of the plan.

Land Use Plan Implementation

The Town of Polk has adopted a new ordinance with conservancy and exclusive agricultural districts designed to implement the watershed plan, and the Village of Kewaskum has adopted a new comprehensive zoning ordinance, the first in its history, designed to implement particularly the environmental corridor preservation and floodland zoning recommendations of the plan.

Three communities have taken land acquisition actions with regard to environmental corridor preservation recommendations. The Village of Saukville purchased a 13-acre floodplain peninsula; the City of West Bend purchased six floodplain acres along the Silver Brook Parkway; and the City of Mequon has asked that SEWRPC prepare a list of parcels affected by plan recommendations in the riverine areas as a first step in its implementation program. In the area of park development, the City of West Bend and the Village of Grafton have begun initial development of two new parks, Riverside Park in West Bend and Lime Kiln Park in Grafton. The Washington County Board has adopted a new land subdivision ordinance which requires park land dedication or reservation at the time of subdivision plat approval.

Flood Control Plan Implementation

Virtually all of the communities in the Milwaukee River watershed having floodplains within their municipal boundaries have prepared or are preparing floodplain zoning ordinances to protect remaining undeveloped floodlands. The City of Glendale has completed an urban floodway delineation, and a citizens committee has prepared an initial draft of a floodland zoning ordinance for review. The Commission staff has

prepared a preliminary draft of a floodland zoning ordinance for the Village of River Hills, and has been requested to prepare a floodland zoning ordinance by the City of Cedarburg. A detailed urban floodway delineation has been completed by the Village of Saukville, which has also adopted a resolution requiring special review and permits for all proposed structures in floodland areas pending adoption of a formal floodland zoning ordinance. Floodland zoning ordinances have been adopted by the City of Mequon and the City of West Bend and the Village of Kewaskum. The Village of Jackson has asked the SEWRPC staff to prepare floodland regulations for newly annexed areas along Cedar Creek.

Ozaukee County has agreed to finance the cost of continuous stream gaging stations at Waubeka and Cedarburg. Washington County has been asked to finance gages at Filmore and Kewaskum, and Fond du Lac County has been requested to finance a gage at New Fane. Both requests are pending before the respective county boards.

Water Pollution Abatement Plan Implementation

On the lower Milwaukee River watershed, the Milwaukee-Metropolitan Sewerage Commissions are maintaining scheduled progress toward completion of the relief sanitary trunk sewer construction program, with the Lincoln Creek overflow pollution problem expected to be abated in the next few months.

On the upper watershed, the Village of Campbellsport has installed advanced waste treatment and effluent disinfection facilities which provide for at least 85 percent phosphorus removal. Engineering work has been completed on a proposed new municipal waste treatment plant for the Village of Jackson which will provide advanced waste treatment and disinfection and which will receive wastes from the Libby, McNeill, and Libby plant in the village. The Villages of Grafton and Kewaskum have completed new advanced waste treatment facilities to provide for phos-

phorus removal, and the City of Cedarburg has such a facility under construction. The Village of Saukville is preparing a preliminary engineering report for the provision of advanced waste treatment. The City of West Bend has agreed to provide, in principle, sewer service to the Tri-Lakes area. The Village of Thiensville has agreed to ultimately connect to the Milwaukee-Metropolitan sewerage system, with the Department of Natural Resources having issued amended orders to the village to this effect.

Water Supply Plan Implementation

The Villages of Bayside, River Hills, and Thiensville and the City of Mequon are participating with other communities such as the Villages of Germantown and Menomonee Falls and the City of Brookfield in a preliminary engineering study to prepare a water supply engineering report.

AROUND THE REGION

PARK COMMISSION PUBLISHES REPORT

A 113-page report entitled Guide for Growth, A Program for Park Land Acquisition, has been published by the Milwaukee County Park Commission. The report represents an updating of the Park Commission's master plan for park land acquisition which was published in 1966. In its report, the Park Commission utilized SEWRPC population data, as well as data contained in SEWRPC Technical Report No. 1, Potential Parks and Related Open Spaces in the Southeastern Wisconsin Region . The spatial standards used by the Park Commission as a guideline for park and recreation land acquisition are based upon the recommendations of the Regional Planning Commission as well as those of the National Recreation and Park Association and the State Department of Natural Resources.

WHAT IS THE SOURCE OF GROUNDWATER SUPPLY IN THE REGION?

Of all the various elements which comprise the underlying and sustaining natural resource base of the Region, the general public probably knows least about the groundwater resource. That this important element of the resource base is very poorly understood is indicated by the fact that serious misconceptions about groundwater still exist in the minds of many people, including the two rather startling misconceptions that the groundwater reservoir underlying the Region has its source in Lake Superior and that the supply of groundwater is virtually unlimited.

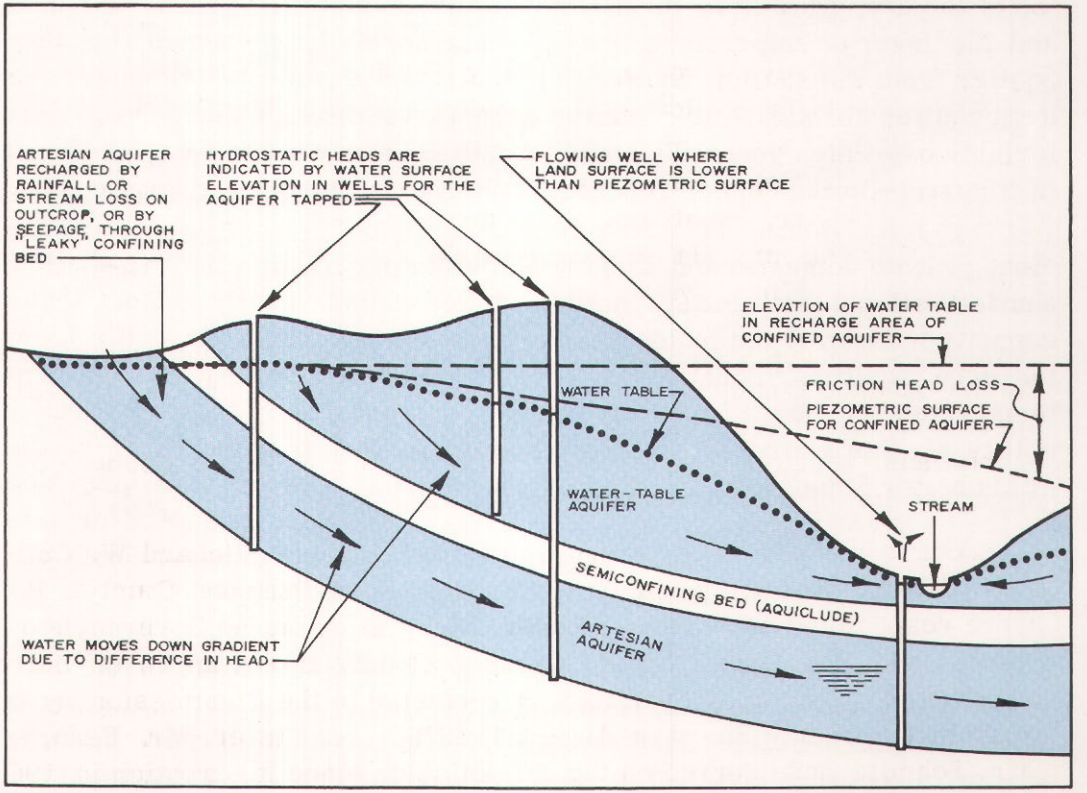
Rainfall and surface water that escape the runoff and the evaporation and transpiration processes move downward from the land surface through the soil and underlying rocks until they reach the zone of saturation. The water levels in shallow wells generally mark the position of the upper limits of this zone of saturation—or water table—and the groundwater in such shallow wells is said to occur under water table conditions. In places, however, relatively impermeable layers of soil or rock—called aquicludes—prevent further vertical seepage of higher groundwater and may confine lower groundwater under pressure. If the water level in wells drilled through these confining layers rises above the base of the confining bed, the wells are termed artesian wells. Under such pressure conditions, a true water table does not exist in an aquifer; however, the level to which water will rise in such a well marks the artesian pressure surface—or pieziometric surface—of the aquifer. These basic concepts of groundwater hydrology are illustrated in Figure 1.

Both water table and artesian aquifer conditions exist within the seven-county Southeastern Wisconsin Region, which is richly endowed with groundwater resources. Three major aquifers—that is, rock units that yield water in usable amounts to pumping wells and in important amounts to lakes and streams—underlie the Region. These are in order from the land surface downward: 1) the sand and gravel deposits of the glacial

drift which covers the Region; 2) the shallow dolomite strata of the underlying bedrock; and 3) the deeper sandstone formations of the underlying bedrock. Because of their relative nearness to the land surface and because of their hydrologic interconnection, the first two aquifers are commonly referred to collectively as the "shallow aquifer," while the third aquifer is commonly referred to as the "deep aquifer." The shallow aquifer is separated from the deep aquifer by a layer of relatively impervious shale, which acts as a barrier to the movement of

Figure 1

DIAGRAM ILLUSTRATING THE OCCURRENCE OF GROUNDWATER



Source: SEWRPC.

water between the shallow and deep aquifers, and which may confine the water in the deep aquifer under pressure. These aquifers, together with the shale barrier, are shown in Figure 2.

The aquifers are supplied—or recharged—with water from zones known as recharge areas. The shallow aquifer is recharged locally by direct infiltration of rainfall and by infiltration from streams or lakes through areas of porous soil. The deep aquifer, however, is recharged by rainfall and stream or lake water which enters the ground through areas of porous soils located only within a recharge area which lies along the westerly boundary of the Region. Throughout this recharge area, the top of the deep aquifer is located relatively close to the ground surface; and the layer of impervious shale, which normally separates the deep aquifer from the shallow aquifer, is absent. The water which enters the deep aquifer through this recharge area flows through the porous rock formations—which generally slope downward from west to east, as shown in Figure 1—to the deeper reaches of the aquifer underlying the Region.

Most private domestic and farm wells within the Region tap the shallow aquifer, which, as already noted, is recharged locally. Most high-capacity industrial and municipal wells, however, take their water from the deep aquifer. Because of the relatively high quality and uniform temperature of the water in this aquifer, and because of the ready availability of this source of supply, it is estimated that over half of the groundwater pumpage in the Region will continue to have to be provided by the deep sandstone aquifer. Protection of the recharge area for this aquifer is, therefore, particularly important in order to assure both the quantity and quality of the water in the deep aquifer.

If wells tapping an aquifer are pumped at a rate which exceeds the rate at which the aquifer is recharged by infiltrating surface water, the water table, or pieziometric surface, will decline; and it is said that the aquifer is "being mined." The pieziometric surface of the deep aquifer

underlying the Region is affected by deep well pumpage throughout all of southeastern Wisconsin and northeastern Illinois. The changes in artesian pressure produced by this areawide pumpage are pronounced and widespread. Since the first well was drilled in this aquifer approximately 100 years ago, water levels have declined nearly 700 feet at Chicago, more than 300 feet at Milwaukee, and more than 200 feet in parts of Waukesha County. Present areawide pumpage is causing the pieziometric surface in the sandstone aquifer to decline at the rate of about three to four feet per year in Racine and Kenosha Counties, one to four feet per year in Waukesha County, and one to three feet per year in Walworth County. These rates of decline in groundwater levels are expected to increase as groundwater withdrawals increase in the future in response to growing demand.

These areawide effects of well development and pumpage on the water levels in the aquifer may be compounded by the local effects of well development and pumpage. The combination of local and regional well development and pumpage is causing water levels to decline at rates of up to eight feet per year in some wells serving the City of Waukesha. As water levels in the aquifer decline, well yields are reduced, wells have to be operated for longer periods of time under greater pumping heads, and the cost of well operation increases significantly. The proper location of new wells, together with the protection of the aquifer recharge areas, can serve to minimize the effects of pumpage and to conserve this important groundwater resource.

Both the deep and shallow aquifers are also subject to degradation through pollution, although the shallow aquifer is more readily subject to such pollution than the deep. Sources of groundwater pollution include private underground sewage disposal systems (septic tanks), refuse dumps, barnyards, cesspools, sewage lagoons, privies and dry wells, influent (losing) streams and lakes, industrial spillages, and leakage from community sewerage systems. Problems involving pollution of

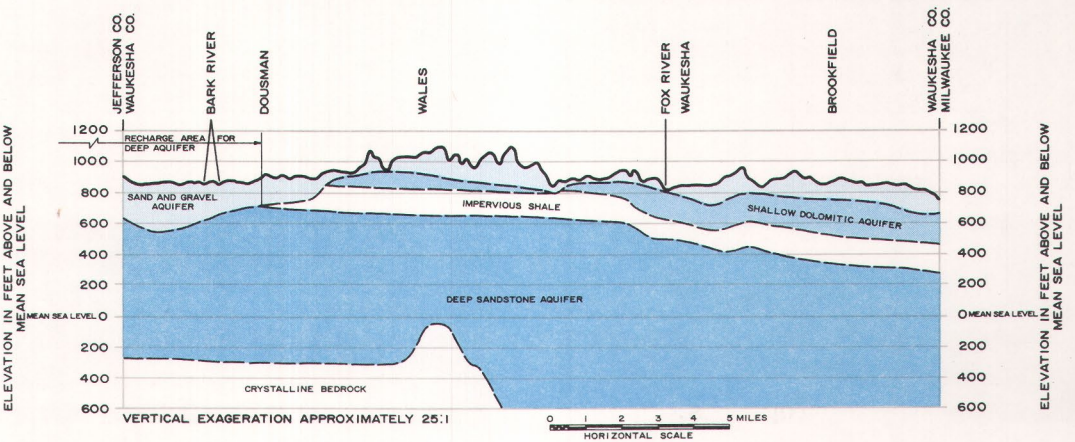
groundwater generally are much more difficult to solve than problems involving surface water because the hidden paths of groundwater contamination cannot be readily traced. Other potential forms of groundwater pollution of both the shallow and deep aquifer include the long-term effects of detergents, insecticides, and herbicides on groundwater quality. The pollutants enter the aquifers by continual seepage through highly pervious material or through intermittent seepage during groundwater recharge, a process which is generally slow. Pollutants can, however, reach the groundwater reservoir relatively rapidly if they enter through unsealed wells or creviced limestone exposed in quarries or at natural outcroppings.

Once a contaminant enters an aquifer it becomes part of the local groundwater movement, and its velocity and direction of travel can be determined by groundwater hydraulics. The movement of groundwater is most commonly shown by means of pieziometric maps, which indicate the horizontal components of flow. Map 2 shows a portion of a pieziometric map for the deep aquifer underlying the Region. Generally, water in the aquifer moves at right angles to the pieziometric contours shown on this map. Thus, a contaminant starting at point A in the recharge area, for example, will follow the path indicated on the map to point B, in this case the location of the City of Waukesha's well fields. It could enter a pumping well anywhere along the way.

Groundwater usually moves slowly, and years may elapse before a contaminant moves any significant distance. The other extreme, however, may be illustrated by a test conducted near Sussex in 1965 by the Waukesha County Health Department in which contaminants moved more than 500 feet per day through creviced bedrock. A condition such as this can pose a severe public health problem if the contaminated aquifer is used as a source of drinking water. Because of the high velocity of the movement in such creviced rock, harmful bacteria or virus may not remain in the water flow long enough to die before ingestion by human beings.

Figure 2

STRATIGRAPHIC SECTION THROUGH A PORTION OF THE REGION SHOWING THE GENERAL AVAILABILITY OF GROUNDWATER FROM BEDROCK UNITS



Source: SEWRPC.

Map 2

PORTION OF PIEZIOMETRIC SURFACE AND SANDSTONE AQUIFER RECHARGE AREA UNDERLYING THE REGION 1966

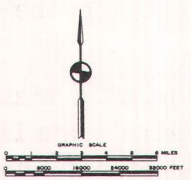
LEGEND

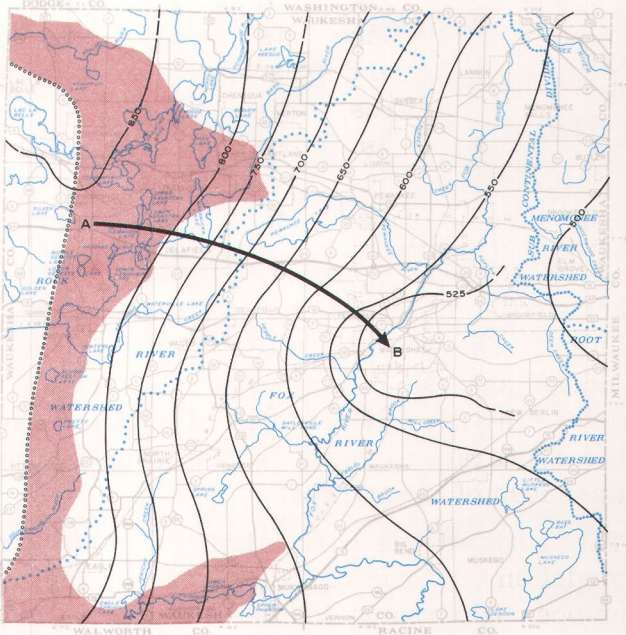
750 — DENOTES ELEVATION OF PIEZOMETRIC SURFACE OF THE SANDSTONE AQUIFER IN FEET ABOVE MEAN SEA LEVEL.

DENOTES GROUND WATER RECHARGE AREA FOR SANDSTONE AQUIFER

DENOTES GROUND WATER DIVIDE

NOTE: GROUND WATER MEASUREMENTS TAKEN SEPTEMBER 1966.





Source: SEWRPC.

QUOTABLE QUOTE.....

"For that which is common to the greatest number has the least care bestowed upon it."

Aristotle

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