science for a changing world

Water Resources Update

Illinois District Newsletter

U.S. Department of Interior
U.S. Geological Survey
District Web Site: http://il.water.usgs.gov/

May 2001

Compiled by D.M. Ayers

MESSAGE FROM ROBERT R. HOLMES, JR., ILLINOIS DISTRICT CHIEF

Mega-livestock farms, urban sprawl, arsenic in ground water, nonpoint source pollution, total maximum daily loads (TMDL's), Gulf Coast Hypoxia, diversion of Lake Michigan waters, peaker power plants, brownfields redevelopment, droughts, flooding—most of these terms are familiar to many of you. Each involves a water-resources issue of some kind and most are hotly debated. Legislation and in some cases, regulation and legal challenges surround many of these issues. Although political by the fact that they all involve public policy, these issues require the assistance of the scientific community to address and resolve.

The U.S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program is an example of the science community providing information and analysis for relevant public policy issues. In the 1980's, the United States Congress asked then USGS Chief Hydrologist Philip Cohen whether the quality of the Nation's waters were improving or degrading. This question was (and is) indeed a hot topic. For the past 20+ years, in addition to other efforts, billions of tax-payer dollars have been spent on building and upgrading wastewater treatment plants to improve the quality of effluent discharged into receiving waters. Congress also anticipated spending billions more dollars in the future on other issues surrounding the Clean Water Act and wanted answers to whether these expenditures were truly improving the Nation's streams, rivers, and lakes. The question from Congress was posed to the Chief Hydrologist because, through the years, the USGS had (and has) maintained a reputation of objective, sound science regarding the Nation's resources; a reputation that USGS works very hard to maintain by rigorous peer technical review of the information—basic data and the interpretation of that data—we provide to the public and policy makers.

At the time of Congress's question, the Chief Hydrologist could not provide an answer for much of the Nation. The USGS had done studies of various drainages but nothing of the regional and national scope for which Congress was asking. From this and subsequent exchanges grew the seed for the NAWQA program, with the primary objective of answering how the quality of the Nation's waters are faring through time. In Illinois, we are fortunate to be involved with two NAWQA studies: the lower Illinois River Basin, which encompasses the drainage area from Ottawa to Valley City; and the upper Illinois River Basin, which encompasses the entire Illinois River basin upstream from Ottawa, including the Chicago metropolitan area.

This issue of our newsletter includes an overview article of the results of the recently completed lower Illinois River Basin NAWQA study. I encourage you to read the article and to order the summary report. NAWQA is the type of endeavor that provides scientific information to those who have the difficult task of making public policy.

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NEWSLETTERS ON THE WEB

The Illinois District Newsletters are now available for downloading from the District's public Web site at http://ilwater.usgs.gov/. Click on "Hot Issues" or "Publications" to download the previous issues. They are large PDF files, so it will take time. You also may obtain additional paper copies by calling Donna Ayers at (217) 344-0037, extension 3053 or by email at dmayers@usgs.gov.

Lower Illinois River Basin NAWQA Summary
by
George Groschen

Stream and river highlights

During the past century, agricultural runoff, channel and drainage modifications, urbanization, and other activities have altered water quality, aquatic biological communities, and aquatic habitat in the Lower Illinois River Basin. During 1995–98, the water quality of large rivers, such as the Illinois and Sangamon Rivers, was more likely to meet drinking-water standards than water quality of small streams. In spring, concentrations of nitrate—especially in small streams—exceeded the Maximum Contaminant Level (MCL) of 10 mg/L (milligrams per liter) for drinking water. Some streams replenish drinking-water reservoirs. In samples collected during runoff from spring and early summer storms, concentrations of herbicides and a few insecticides exceeded drinking-water standards or guidelines, or guidelines to protect aquatic life. In a few samples from small streams, concentrations of commonly used agricultural pesticides were among the highest nationally. Although most concentrations were low with respect to existing drinking-water standards or guidelines, criteria for the protection of human health or wildlife have not been established for more than one-half of the chemicals detected.

- Nitrogen and phosphorus concentrations were among the highest in the Nation. The highest concentrations in the basin were found in small streams in agricultural areas. The MCL for nitrate was exceeded in 15 percent of samples from all streams and rivers. The concentration of total phosphorus in most samples (79 percent) from all streams and rivers exceeded the 0.1 mg/L guideline recommended by the U.S. Environmental Protection Agency (USEPA) to prevent excess algal growth in streams.
- Nitrate concentrations in the Illinois River at the inflow to the basin (Ottawa) and outflow from the basin (Valley City) were similar; however, approximately twice the amount of nitrogen was transported out of the basin (124,000 tons per year) as was transported into the basin (66,000 tons per year) (fig.1).
- During August 1997, concentrations of nitrate in streams were lower in the basin than in other NAWQA study-area streams of the upper Midwest. Algal communities may have incorporated much of the instream nitrogen, resulting in lower nitrate concentrations in the water during late summer.
- Three herbicides commonly used by farmers to protect corn and soybean crops—atrazine, metolachlor, and cyanazine—were detected in every sample collected during 1995–98. During periods of spring runoff, these herbicides exceeded drinking-water standards or guidelines, or aquatic-life guidelines. Another herbicide, acetochlor, was detected in most samples (81 percent).
- Pesticide breakdown products were detected much more frequently than the parent compound and, generally, at higher concentrations and for a longer period of time after application.
- Organochlorine compounds (including insecticides no longer used) were detected in fish tissue and sediment, and polycyclic aromatic hydrocarbons were detected in sediments at levels of concern.
- The biological communities of streams in the basin comprised many organisms that are tolerant of poor water quality; however, some high-velocity streams had fairly diverse invertebrate communities.

Trends in stream-water quality

For decades, fertilizers and many pesticides have been applied to crops and land. The persistence of pesticides and breakdown products in the soil, water, and sediment within a watershed is not well understood. In the Illinois River, concentrations of the herbicides alachlor and cyanazine, however, decreased from the 1991–92 period to the 1996–98 period because of reduced application rates since the early 1990s (fig. 2).

Ground-water highlights

In contrast to the water quality of streams and rivers in the basin and the quality of ground water in other areas across the Nation, agricultural chemicals in ground-water samples from shallow monitoring wells (generally less than 100 feet deep) and drinking-water wells only rarely exceeded the nitrate MCL. Except for radon and nitrate, shallow ground-water quality in the lower Illinois River Basin generally met drinking-water standards or guidelines. Except for radon and arsenic, the water quality in the Mahomet aquifer (greater than 200 feet deep) meets all drinking-water standards or guidelines.

- Major corn and soybean herbicides were not as frequently detected in ground-water samples as in stream-water samples. No ground-water sample exceeded drinking-water standards or guidelines for pesticides.
- Concentrations naturally occurring arsenic exceeded the current MCL of 50 mg/L in 2 of 30 wells sampled in the Mahomet aquifer, a major drinking-water source. If the MCL is lowered to 10 mg/L, as proposed by the USEPA, samples from 43 percent (13 of 30) of the domestic (private household) and public-supply (publicly owned wells generally serving a community) wells sampled exceeded the lower standard.
- Geologic materials underlying the basin indicate that it is an area of potentially high radon concentrations in ground water. In about one-half of the samples of shallow ground water concentrations, radon exceeded the proposed MCL of 300 pCi/L (picocuries per liter). Only 2 of the 30 samples from the Mahomet aquifer exceeded the proposed radon MCL.
- Volatile organic compounds (VOCs) were detected in samples from 83 percent of shallow domestic and public-supply wells, but no samples exceeded drinking-water standards or guidelines. VOCs were detected in 80 percent of samples from the Mahomet aquifer but at concentrations near the method detection limit and well below drinking-water standards and guidelines.

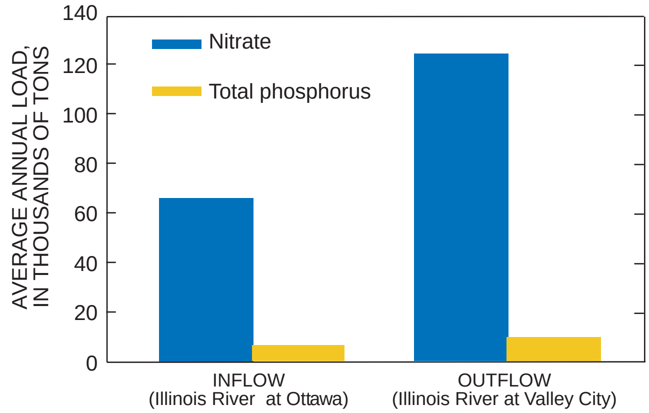

Figure 1. About twice as much nitrate and total phosphorus leaves the lower Illinois River Basin as enters it. The loads for the upper Illinois River Basin—the basin upstream from Ottawa—are about one-half of the respective loads for the lower Illinois River Basin.

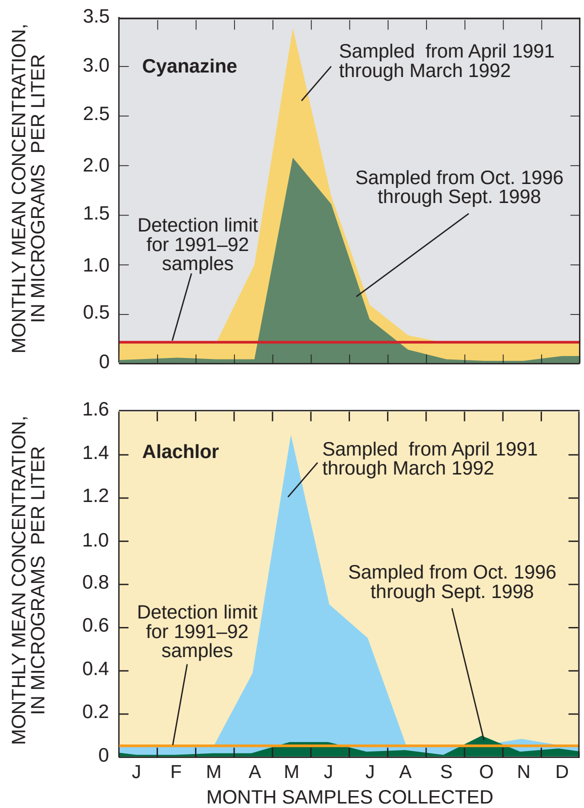

Figure 2. Cyanazine and alachlor—commonly used to protect crops from weeds—were detected in most surface-water samples in the basin. However, the mean concentrations of these two herbicides declined substantially from the levels found in water samples collected from the Illinois River at Valley City in the early 1990s. Use of alachlor in the basin has declined to almost zero in recent years, and the use of cyanazine is decreasing in anticipation of its registration ending in 2003.

Frequency Analysis for Peak Streamflows of Rural Watersheds in Illinois

by

David Soong

Peak streamflows of selected frequencies are needed in designing the capacity of hydraulic structures, such as culverts at stream crossings, floodways for drainage and/or flood control, and spillways for dams and reservoirs, or for planning the safety and economic use of water-resources projects. Also, peak streamflows are useful in designing and maintaining stable and sustainable habitats for ecosystem management.

Peak streamflows are of random nature, and the objective frequency analysis is to relate the magnitude of peak flow to the frequency of occurrence. Therefore, both the techniques used and data availability will affect the results, especially the estimates at low and high recurrence intervals—the values often sought in engineering practices. Improving these estimates using improved techniques and longer data records is needed for Illinois considering the broad range of applications.

The USGS, Water Resources Division, Illinois District and the Illinois Department of Natural Resources, Office of Water Resources (IDNR, OWR) are collaborating on a project to analyze the frequencies of peak streamflows. This project is focusing on watersheds unaffected by urbanization and stream regulation. The project began in July 2000 and is scheduled for completion in September 2002.

The last frequency analysis for streamflows in Illinois was performed by Curtis (1987) on the basis of data available to 1985. More than 14 years of additional data (up to 1999) are available, including flood flows for 1993 and 1996. The affect of the new data on flood estimates will be examined through the analysis of the updated annual maximum series (AMS), which is the conventional data series for analyzing peak streamflows. A primary project task is to analyze the peak streamflow frequencies using the partial duration series (PDS). In the field of channel maintenance and habitat management, the more frequent floods (floods that occur on the order of 1.4 to 1.8 years return intervals) are of interest. The AMS, however, tends to give lower estimates on more frequent floods because the maximum discharge in a year or consecutive years may be much smaller than the second, third, fourth, ... floods occurring in the next year. Flood peaks above a base value are used in the PDS. Therefore, the PDS is expected to give more appropriate estimates of flood peaks in these ranges of floods. After the two types of analyses (AMS and PDS) are completed, the third task is to incorporate the two results and to derive the regional equations. The AMS and PDS are performed at gages with a minimum of 10 years of record. Regionalization is the method to extend the results to ungaged sites so that proper estimates can be obtained. Two improvements are proposed in the approach: (1) use updated basin characteristics from geographic information system analysis, and other new information, such as the U.S. Department of Agriculture

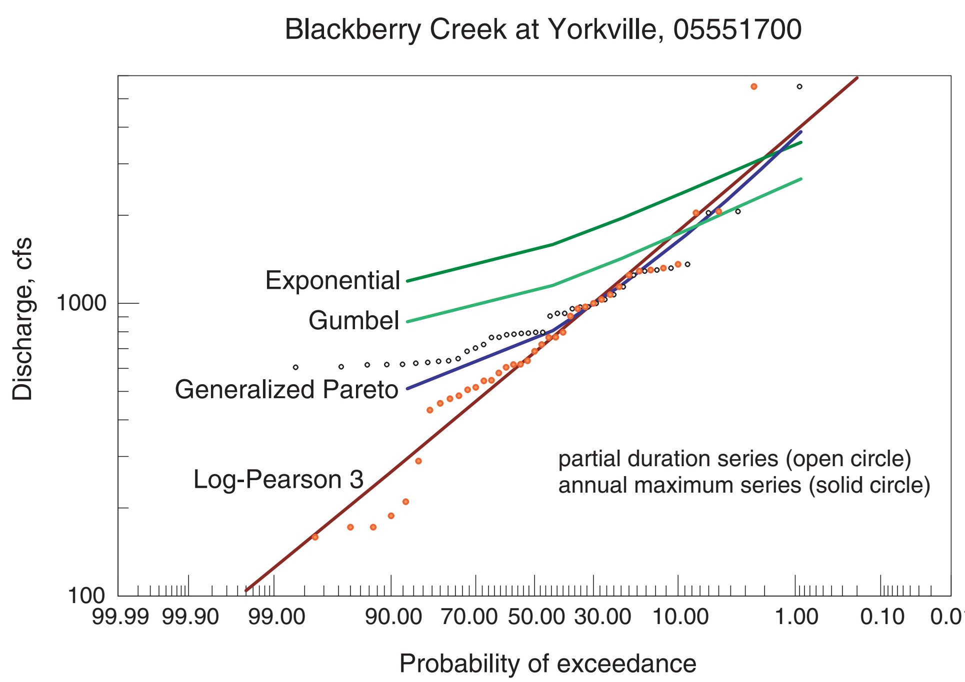

Figure 1. The annual maximum series is fitted with Log-Pearson Type III distribution and the partial duration series is fitted by the Exponential, Gumbel, and Generalized Pareto distributions. The number of data points for PDS has been truncated for plotting purposes. Currently, sample moments are used to estimate the statistical parameters in the PDS analysis, and testing on base values is underway. CFS, cubic feet per second.

State Soil Geographic Data Base (SCS, 1993) for hydraulic characteristics of soils information, the 1996 multiresolution land-use data base (IDNR), and updated rainfall frequency estimates for Illinois (Huff and Angel, 1989); and (2) use hydrologic and physiographic features to define regions with similar hydrologic characteristics and regional equations.

Technical procedures for analyzing AMS follow the standard method described in Bulletin 17–B (Interagency Advisory Committee on Water Data, 1982). Project activities include incorporating high outliers/historical events in the analysis and assessing the criteria for a best fit and how to improve the estimates for gaging stations with a short period of record. Because the underlying Log-Pearson Type III distribution is a three-parameter function that includes skew coefficients, examining the effects of sample and regional skews are undertaken. Standard technique for analyzing PDS for flow frequencies has not been defined. The Gumbel and Exponential, as well as Generalized Pareto distributions, are possible choices (fig.1).

Additional project activities involve providing project results on the World Wide Web. This study is considered as a pilot in examining the needed techniques used for frequency analysis. The USGS and IDNR, OWR are confident that the results of this study will be of great benefit to a wide range of users throughout the State.

EMPLOYEE SPOTLIGHT

JON (JAY) ANGEL
HYDROLOGIC TECHNICIAN
DE KALB SUBDISTRICT OFFICE

Jon (Jay) Angel began his career as a volunteer for science at the De Kalb Subdistrict Office in February 1995. He was hired as a student employee shortly afterwards. As a student, his duties involved assisting the hydrologists with various projects, such as the Lake County rainfall runoff project and assisting in collecting sediment, and total and dissolved phosphorus samples. He finished his Master of Science Degree in Physical Geography at Northern Illinois University in August 1997. His thesis focused on regional differences in sediment transport trends in the Illinois River Basin. Immediately after completion of his degree, he became a full-time employee.

As a full-time employee, Jay spends most of his time involved in the stream gaging program. He has a network of 16 gages that range from the extreme north side of Chicago to the Wisconsin State line. “It is quite challenging to ensure that the entire stream gaging network is collecting accurate data, especially during extreme weather conditions,” Jay stated. His favorite parts of the job are troubleshooting faulty gages and making ice measurements.

Jay also measures water-quality parameters, such as dissolved oxygen and specific conductivity, as well as collecting samples that will be analyzed in the laboratory for bacteria and phosphorus.

In 1997, Jay was invited to serve on a committee with the Northeastern Regional Hydrologist which addressed the retention problem with hydrologic technicians. “This invitation was definitely one of the highlights of my career so far,” stated Jay. As a result of his experience on this committee, Jay was invited to join the U.S. Geological Surveywide Bureau Outreach Recruitment Team. This team was tasked with increasing the diversity of the U.S. Geological Survey by identifying methods of recruiting underrepresented minorities. Being on this team gave Jay a sense of who comprises the U.S. Geological Survey because he had the opportunity to meet people from the different divisions and talk to people from different parts of the country.

Jay spends a great deal of his off-duty time fishing and has been an avid fisherman for his entire life. A couple of years ago, he began writing an outdoor column for his local newspaper and fishing in walleye tournaments.

Jay is the proud father of Laren Elizabeth who is 21 months old and 9-month-old Matthew William. Jay, his wife (Lisa) and their two children reside in De Kalb, Illinois.

Cooperator Spotlight

U.S. Army Corps of Engineers

Four districts of the U.S. Army Corps of Engineers (USACE) (Chicago, Rock Island, St. Louis, and Louisville Districts) work closely with the U.S. Geological Survey (USGS), Illinois District, on a wide variety of hydrologic data-collection and project activities. River stage (elevation) and/or streamflow data collected by the USGS are used by the USACE to assess and implement mitigation efforts during droughts and floods. In addition, the USACE uses the data to make day-to-day operational decisions on water-control structures throughout the State. USACE and USGS also work on cooperative, interpretive hydrologic projects. Examples of this work include calculating the amount of water diverted from Lake Michigan by the State of Illinois, environmental aspects of implementing the McCook Reservoir for stormwater storage in northeastern Illinois, and determining water-mixing patterns in flood-control reservoirs as part of the Chicagoland Urban Flow Plan/Tunnel and Reservoir Plan.

The USACE is made up of approximately 34,600 civilian and 650 military personnel and is the world's largest public engineering, design, and construction management agency. The USACE works in a variety of engineering and environmental matters. The mission of the USACE is to provide quality, responsive engineering services to the Nation, which include:

- Planning, designing, building, and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, and others).
- Designing and managing the condition of military facilities for the Army and Air Force (military construction).
- Providing design and construction management support for other Defense and Federal agencies.

The USACE began in 1775 when the Continental Congress authorized the first chief engineer whose first task was to build fortifications near Boston at Bunker Hill. Currently, the USACE is organized geographically into 8 divisions in the United States and 41 subordinate districts throughout the United States, Asia, and Europe. The districts oversee project offices throughout the world. Divisions and districts are defined by major watershed boundaries and not by States or other political boundaries. The USACE also operates eight unique laboratories throughout the country, supporting research that includes:

- mapping and terrain analysis;
- infrastructure design, construction, operations and maintenance;
- structural engineering;
- cold region and ice engineering;
- coastal and hydraulic engineering;
- environmental quality;
- geotechnical engineering; and
- high performance computing and information technology.

Various other administrative and technical organizations are operated by the USACE in mission support.

Lake Michigan Diversion by Jim Duncker

The city of Chicago owes its location to geographic factors that influenced the first voyageurs and settlers to establish a settlement at the mouth of the Chicago River. Easy access to the Great Lakes and Mississippi River waterways made the mouth of the Chicago River an ideal location. A short portage trail across a low drainage divide connected the two great waterways. In the early part of the 1800's, the city utilized the Chicago River as an open sewer, and human waste flowed into Lake Michigan. During the mid-to-late 1800's, the city's growing population overwhelmed the Chicago River's ability to rid itself of human waste. Contaminated drinking water and outbreaks of waterborne diseases prompted local officials to develop a means of dealing with the waste issue. Engineers again relied upon the same geographic factors that first influenced the siting of the city. In the late 1800's, work began on a project to dig a canal through the drainage divide, along the original path of the early portage. With completion of the canal, the contaminated water that previously flowed out into Lake Michigan was diverted away from the city's drinking-water supply and into the Mississippi River Basin. On January 13, 1900, the Chicago Sanitary and Ship Canal was completed, and the flow of the Chicago River was "reversed". Water that previously flowed into the Great Lakes Basin was now flowing into the Mississippi River Basin and forming the Lake Michigan diversion.

Prior to the completion of the canal system in Chicago, the plans for the diversion were being contested within the legal system. The State of Missouri was the first to object to the diversion, with concerns about the contamination from Chicago's waste reaching the Mississippi River. In the early 1900's, the other Great Lakes States also joined Missouri in voicing their objections to the diversion of Lake Michigan water at Chicago. Thus began decades of legal challenges and rulings concerning the diversion.

Since the completion of the canal system in 1900, the amount of water diverted at Chicago has ranged as high as 30,000 cubin feet per second (cfs). The initial canal system was regulated by a dam at the downstream end of the canal at Lockport, Illinois. In 1908, the Illinois legislature authorized construction of a hydroelectric power plant adjacent to the dam at Lockport. The hydroelectric plant generated more money with increased flows through the turbines, so it was in the city's interest from a waste removal and economic standpoint to divert as much flow as possible. In 1920, the Calumet-Sag (Cal-Sag) Channel, an additional tributary of the canal system that prevents flows in the Calumet River watershed from going into Lake Michigan, was completed (fig. 1). Growing concern from the other Great Lakes States and Canada regarding the diversion and lowered lake levels resulted in the courts setting a much reduced annual diversion at Chicago. Since 1930, there have been a number of modifications to the court ruling on diversion, the last of which being a 1981 United States Supreme Court decree. At present, the decree states that Illinois is limited to an annual diversion of 3,200 cfs. Details of the decree allow for fluctuations above and below the 3,200 cfs to account for the variability of climate and other factors.

In early 1984, the USGS was asked by the State of Illinois for technical assistance in the measurement of diversion flows. Prior to 1984, diversion flows were measured using theoretical ratings developed at the hydroelectric power plant at Lockport. Flow measurement in the canal system represents several technical challenges. The highly unsteady flow and variable backwater conditions in the canal precludes use of standard stream-gaging methods and technology. Accurate measurement of the low velocities found in the canal system also represented a unique challenge. Acoustic methods are the only reliable means of accurately measuring the diversion flows in the hydraulic conditions typical of the canal system. Acoustics utilize underwater transducers to send sound waves back and forth across the channel. Acoustic velocity meters (AVMs) then compute water velocity from the difference in the upstream travel time versus the downstream travel time of the sound waves (fig. 2). Additional sensors measure water levels and determine the wetted cross-sectional area. Discharge is then a function of the cross-sectional area and the mean velocity. Later in 1984, the USGS installed the first AVM gaging station on the Chicago Sanitary and Ship Canal at Romeoville to measure the diversion flows.

Since 1984, a number of additional gaging stations have been installed on the Chicago River system to better define the flow in the canal system and more accurately measure the diversion. New AVM gages have been installed near the lakefront at three locations within the Chicago River at O'Brien Lock and Dam. These gages give a more detailed distribution of diversion flows within the canal system. Advances in acoustic instrumentation have been incorporated for more accurate flow measurements in the canals. Acoustic Doppler current profilers (ADCPs) provide additional detail on the distribution of velocity and enable a better calibration of the AVM gaging stations. While it has been 101 years since the Chicago Sanitary and Ship Canal "reversed" the flow of the Chicago River, more detailed data collection and analysis on the distribution of flows within the system should provide for a more efficient use of the Lake Michigan diversion.

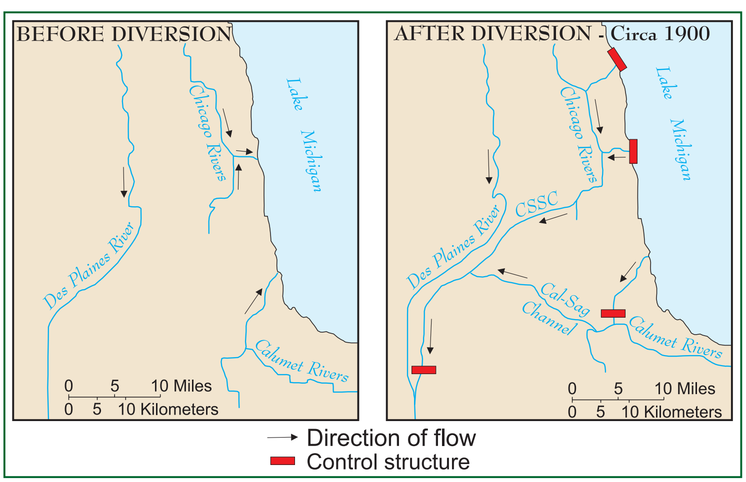

Figure 1. The Chicago River drainage system before and after diversion. CSSC, Chicago Sanitary and Ship Canal

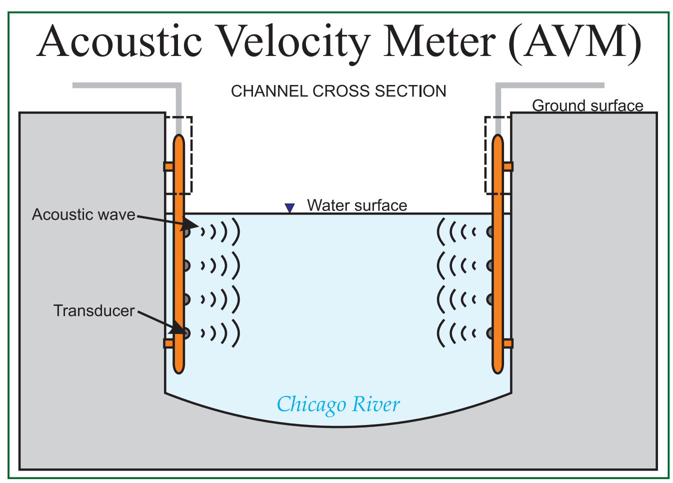

Figure 2. Channel cross section showing acoustic velocity meter transducers.

From the Mailbag

If you have comments about our newsletter or our Web site, please use the form on the back page. Comments also can be sent to dc_il@usgs.gov.

"I was routed the November 2000 issue of the USGS Illinois newsletter and just wanted to tell you that I found it to be an informative and attractive publication..."

"Good going! I'm glad to see one of our Districts using some creative design and thinking in building a District home page..."

"It's a good newsletter..."

"The 1999 CD is fantastic."

ILLINOIS DISTRICT PUBLICATIONS

Listed below are publications that were recently published. District policy is to provide copies of our publications to requestors at no cost as long as the publication is in stock in the District office. To obtain copies of the following, or any other Illinois District publication, you may contact Donna Ayers at (217) 344-0037, extension 3053 or by email at dmayers@usgs.gov.

FY 2000

WRIR 99-4229, Volatile Organic Compounds in Ground Water of the Lower Illinois River Basin, by W.S. Morrow, Jr.

OFR 99-69, Water, Sediment, and Nutrient Budgets, and Bathymetric Survey of Old and New Gillespie Lakes, Macoupin County, Illinois, May 1996-April 1997, by G.P. Johnson

WRIR 97-4054-C, Altitude, Depth, and Thickness of the Galena-Platteville Bedrock Unit in the Subcrop Area of Illinois and Wisconsin, by T.A. Brown, C.P. Dunning, and J.B. Sharpe

WRIR 99-4138, Geology, Hydrology, and Ground-Water Quality of the Upper Part of the Galena-Platteville Aquifer at the Parson's Casket Hardware Superfund Site in Belvidere, Illinois, by R.T. Kay, D.J. Yeskis, J.W. Lane, Jr., P.C. Mills, P.K. Joesten, G.L. Cygan, and J.R. Ursic

WRIR 99-4152, Analysis of Nutrients, Selected Inorganic Constituents, and Trace Elements in Water from Illinois Community-Supply Wells, 1984-91, by K.L. Warner

WRIR 00-4027, Recharge Potential of Surficial and Shallow Bedrock Aquifers in the Upper Illinois River Basin, by T.L. Arnold and M.J. Friedel

WRIR 00-4088, Hydrology, Water Quality, and Nutrient Loads to Lake Catherine and Channel Lake, near Antioch, Lake County, Illinois, by R.T. Kay and others

WRIR 00-4101, Methodology, Data Collection, and Data Analysis for Determination of Water-Mixing Patterns Induced by Aerators and Mixers, by G.P. Johnson and others

WRIR 00-4115, Suspended Budget, Flow Distribution, and Lake Circulation for the Fox Chain of Lakes in Lake and McHenry Counties, Illinois, 1997-99, by D.L. Schrader and R.R. Holmes

WRIR 00-4184, Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois, by T.D. Straub, C.S. Melching, and K.E. Kocher

FY 2001

OFR 00-400, Geology, Hydrology, and Water Quality in the Vicinity of a Brownfield Redevelopment Site in East Moline, Illinois, by R.T. Kay

WRIR 00-4152, Geology, Hydrology, and Ground-Water Quality of the Galena-Platteville Aquifer in the Vicinity of the Parson's Casket Hardware Superfund Site, Belvidere, Illinois, by R.T. Kay

Circular 1209, Water Quality in the Lower Illinois River Basin, Illinois, 1995-98, by G.E. Groschen, M.A. Harris, R.B. King, P.J. Terrio, and K.L. Warner

COMMENTS

We would like your feedback on our newsletter. What would you like to see included in future issues? Tell us what you liked or did not like in this issue. To return: fold in half, and return to address on reverse; postage required. Thank you.

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Name and Mailing Address

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