

# **Prioritized Water Quality Research Plan for the Illinois State Water Survey**



**Illinois State Water Survey  
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# Prioritized Water Quality Research Plan for the Illinois State Water Survey

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## Abstract

The Prioritized Water Quality Research Plan for the Illinois State Water Survey (ISWS) establishes a roadmap for the ISWS, outlining priorities for water quality programs consistent with the mission of the ISWS. It is intended to provide a direction for ISWS staff and administration, as well as a greater understanding for other agencies about the priorities for the ISWS in water quality research and services. Major priority areas identified in the plan include:

- Data Archival and Access,
- Emerging Contaminants,
- Nutrients in Illinois Waters,
- Sediments in Illinois Streams and Lakes,
- Groundwater Quality, and
- Water Treatment Issues.

In outlining these major priorities for Illinois' water quality research, it recognizes the roles of other agencies that also have water quality-related responsibilities. The plan will be updated and revised on a regular basis based on the latest research results and the changing environment in the state and the nation.

# Prioritized Water Quality Research Plan for the Illinois State Water Survey

## Introduction

The Illinois State Water Survey (ISWS) has a long history of water quality research, dating back to its inception in 1896 in sanitary surveys of Illinois water supplies where typhoid and cholera were prevalent. Since then, the role of the ISWS in regard to water quality research has expanded greatly to include analyses of rainfall, rivers and lakes, and groundwater. The 1970 Illinois Environmental Protection Act established a statewide program for environmental protection, by creating and assigning authorities for implementing the purpose of the Act to three agencies: the Illinois Pollution Control Board (IPCB); the Illinois Environmental Protection Agency (IEPA); and the Illinois Institute for Environmental Quality (IEQ, the parent agency of the Scientific Surveys at that time).

The IPCB was assigned the responsibility of establishing the basic regulations and standards necessary for the preservation of the environment. The IEPA was responsible for implementation of the environmental programs. The IEQ was responsible for research and education. As the principal water research and data collection agency within IEQ, the ISWS was primarily responsible for these programs, in cooperation with the other Scientific Surveys. The IEQ later became the Illinois Department of Energy and Natural Resources, which then became part of the Illinois Department of Natural Resources (IDNR) during a state governmental reorganization in 1995. Responsibilities for water quality research and educational services still remain with the ISWS, now within IDNR.

This plan establishes a roadmap for the ISWS, outlining priorities for water quality programs. By doing so, it provides a direction for ISWS staff and administration, as well as a greater understanding for other agencies about the important ISWS niche in Illinois water quality research and service. In outlining major priorities for Illinois' water quality research, it recognizes the roles of other agencies that also have primary water quality-related responsibilities. It supports the 2001 ISWS *Plan for Scientific Assessment of Water Supplies in Illinois*, which was designed to outline ISWS investigations “*to continue to provide adequate supplies of clean water at a reasonable cost, to protect the state's precious water resources and ecosystems, to reduce conflicts, and to support economic growth.*” This document also recognizes the realities of personnel and funding resources, and therefore, provides prioritized goals of importance to Illinois, while also presenting areas of research that could be attempted with reasonable additional resources.

The mission of the ISWS is based on several legal mandates and evolving priorities:

*The Illinois State Water Survey is the primary agency in Illinois for research and information on surface water, groundwater, and the atmosphere. Its mission is to characterize and evaluate the quality, quantity, and use of these resources. The mission is achieved through basic and applied research; by collecting, analyzing, archiving, and disseminating objective scientific and engineering data and information; and through service, education, and outreach programs. This information provides a sound technical basis for the citizens and policymakers of Illinois and the nation to make wise social, economic, and environmental decisions.*



## Considerations in Developing the Water Quality Plan

This plan for the ISWS was developed in the context of current conditions and emerging trends. The following findings were important considerations in developing the water quality plan:

- The demand for water is increasing in many parts of the state, primarily as a result of growth in population and the economy. The Northeastern Illinois Planning Commission projects that population in the Chicago metropolitan area will grow by about one million by 2020 (NIPC, 2002). The quality of water will have a tremendous impact on its availability for water supply, be it surface water or groundwater. For example, the Fox River, highly utilized for drinking water, is also the receiving body for treated wastewaters from numerous communities. And groundwater pumped from the deep bedrock aquifers beneath northeastern Illinois contains moderate to high concentrations of dissolved minerals (including radium) that may increase as a result of greater withdrawals. Can these two major sources of water adequately continue to provide good quality water? What kind of treatment may be necessary in the future, and what economic consequences can be expected?
- New and better analytical and monitoring equipment allow detection of water-borne contaminants at lower and lower levels and at greater frequencies. Often, as a result, water quality standards become more stringent. In addition, the development of new compounds is outstripping capabilities to monitor their occurrence and fate in the environment.
- Just as in the ISWS *Plan for Scientific Assessment for Water Supplies in Illinois*, the hydrologic cycle forms the fundamental basis for investigating the scientific issues cited. However, the water quality plan is directed specifically toward the many and varied issues surrounding surface water and groundwater, and numerous issues tangential to those two major components of the hydrologic cycle. The externally funded National Atmospheric Deposition Program (NADP) and other aspects of air quality investigated at the ISWS are not included in this plan. More information about those programs is available (<http://www.sws.uiuc.edu/atmos/> and <http://nadp.sws.uiuc.edu/>).
- This plan is not meant to duplicate ongoing monitoring and sampling efforts of other agencies (e.g., IEPA or U.S. Geological Survey); however, elements of this plan will be complementary. Many of the IEPA monitoring efforts are compliance related in that the sampling is done to meet a drinking water or water pollution regulation (IEPA, 2002; 2004; 2006). The ISWS does not seek to become involved in regulatory monitoring. However, in some cases, the plan addresses issues of importance to the IEPA's regulatory efforts.
- The following plan does not include a list of ongoing ISWS water quality projects and services. Rather, the scientific issues outlined on the following pages build upon ISWS historical research strengths with an awareness of new and evolving water quality issues,

but also with an eye on fiscal reality. Therefore, most of the issues and activities described have some ongoing effort already or could be addressed, to some degree, with existing resources and personnel.

- This plan also recognizes the strengths of numerous other agencies with which collaborations are natural outgrowths of research. For example, the Illinois State Geological Survey (ISGS) maintains an isotope laboratory. Numerous groundwater and sediment research projects use this laboratory in a collaborative manner and will continue to do so. The same can be said for the laboratory facilities and staff at the Illinois Waste Management and Research Center (WMRC) and the numerous laboratories and expertise available at the University of Illinois (UI), as well as at other universities.
- The ISWS Analytical Services group provides chemical analyses in support of the research activities of ISWS staff and university researchers. These laboratory facilities must be kept up-to-date to provide the data necessary to support ongoing and future ISWS water quality research and service.
- One of the goals of this plan is to encourage and strengthen interdisciplinary ISWS research efforts, using the multiple disciplines available within the ISWS and collaborations with colleagues at other agencies and Scientific Surveys. However, as one examines the scientific issues presented, there are clearly topics that favor either surface water or groundwater disciplines (e.g., sediment). Although topics such as these fall into the scientific discipline of one group over another, involvement of multidisciplinary teams is encouraged.
- The rate and order of implementation of the outlined studies will depend upon the level and sources of funds and priorities and upon collaborative efforts with other organizations. Existing resources are addressing many of the described topics, but additional resources are necessary to complete the activities in a timely manner.
- The ISWS has long been a source of hydrologic and environmental data for other agencies and consulting engineers. To facilitate access to these data, the ISWS is developing a point-and-click system with Internet access to ISWS data, including water quality.

## ISWS Water Quality Plan Strategies

### Goal

The goal of this plan is to provide a framework for ISWS water quality programs and to document those activities that the ISWS, working with others, needs to conduct to provide Illinois with water quality data and expertise to address important water quality issues.

### Strategies

- Collaborate with other organizations and professionals to coordinate and integrate water quality activities, set priorities, plan and conduct future activities, and seek additional resources.
- Assemble, archive, digitize, analyze, and synthesize existing data, including appropriate data from neighboring states, into a comprehensive, interdisciplinary water quality database.
- Identify critical gaps in data, information, and knowledge necessary to address important water quality issues.
- Develop integrated modeling tool(s) for water quality studies that can be used at the state, regional, watershed, and political unit scale.
- Disseminate results as they become available.



## Prioritized Activities

The ISWS has prepared the following prioritized activities that will be implemented within two years. These activities will be conducted by existing staff supported by General Revenue Fund (GRF) and Grant and Contract (G&C). Because of the decline in GRF funding over the last few years, especially the loss of the coordinator for the Water Quality Program for the Center for Watershed Science, there will be more reliance on G&C-funded projects. However, GRF-funded staff will continue to conduct water quality programs and use some of their time as leverage to get additional funding from state and federal agencies to conduct research in the priority research areas. As activities are prioritized, it also will be possible to channel more GRF time to the high-priority activities.

Priorities will be revisited regularly. Advances in science and technology continually are made in the water quality field, and issues of public and regulatory concern can change. For example, studies of arsenic in groundwater were not a priority five years ago, but a significant change in the drinking water standard created an important avenue for ISWS research.

### I. Data Archival and Access

#### A. Surface Water

The ISWS has collected significant amounts of water quality data over the 100+ years of its existence. A regular State-supported surface water quality monitoring program, which monitored water quality in Illinois streams and rivers on a five-year cycle, existed from 1945 until 1978. Research projects supported by State funds and other grants and contracts have collected water quality data throughout Illinois. All these water quality datasets are not available in organized and easily accessed databases. Different ISWS committees have made several attempts to gather and organize the datasets, but none of the plans have been implemented fully. The following activities will result in the development of specific databases consistent with ISWS guidelines and protocols.

##### *Illinois River Water Quality Data*

The Illinois River is the most significant river in Illinois and drains about 44 percent of the state, including densely populated northeastern Illinois. Land-use changes and contaminant discharges from municipalities and industries have had significant impact on the river's water quality. Although Illinois River water quality has improved significantly since the 1970s, a large part of the river still was listed as impaired in the IEPA's 303(d) List in 2002. Nutrient loads and yields from the Illinois River are among the highest in the Mississippi River basin and are reported to contribute to the hypoxia problem in the Gulf of Mexico.

State and federal agencies have initiated major restoration efforts to improve water quality and wildlife habitat in the Illinois River basin. The ISWS has been very active in collecting data and preparing research reports in support of these restoration efforts. As part of

these efforts, the Center for Watershed Science (CWS) has been developing a water quality database for the Illinois River over the last few years. This effort was based on a previous ISWS research project to create a historical water quality database for the Illinois Waterway for the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (Larson, 2001). The database contained datasets from different research projects that collected water quality data during 1965–1995. Scientists from CWS spent an extensive amount of time evaluating the database with the assistance of Bob Larson, who created the database. In the final analysis, the scientists concluded that the database is very valuable and should be enhanced and maintained by the CWS. There were, however, numerous errors and inconsistencies in the database that needed to be corrected. In addition, it was recognized that many water quality datasets from that period still needed to be incorporated into the dataset.

That project will be the highest priority CWS water quality project over the next two years. The work will be accelerated to *have a completed water quality database for the Illinois River by December 2008*. A progress report prepared by Shackleford and Lin (2005) summarizes the work accomplished so far. That report includes a detailed work plan with a description of available data not already included in the database, a metadata development plan consistent with the ISWS guidelines, detailed procedures and criteria for accepting and rejecting data, procedures for determining the data quality and associated uncertainties, and a plan for integration with other databases such as the Illinois Rivers Decision Support System (ILRDSS).

#### *Fox River Watershed Water Quality Data*

The Fox River watershed, located in the rapidly urbanizing area of northeastern Illinois, has developed water quality problems over the years. Segments of the Fox River and its tributary streams have been identified as impaired by the IEPA's water quality assessments. Since being listed in IEPA's 303(d) List leads to the development of total maximum daily loads (TMDLs) that are generally time consuming and sometimes ineffective, concerned citizens in the watershed formed the Fox River Study Group, Inc. (FRSG) in 2001 to formulate alternatives to TMDLs. Since then, the FRSG has embarked on a path to develop a comprehensive watershed management plan that includes development of databases and watershed models.

The CWS has been working with the FRSG to develop a comprehensive water quality database for the Fox River watershed since 2002. Phase I of the project focused on identifying and obtaining existing water quality data from all sources and creating a relational database, the Fox DB. The Fox DB contains data from local, state, and federal agencies including IEPA, USEPA, USGS, the Fox River Reclamation District, the Fox Metro Water Reclamation District, and the Northeastern Illinois Planning Commission. It also includes data collected from special research projects by the FRSG and the Max McGraw Wildlife Foundation. Detailed information about the sources of data and the Fox DB are available (McConkey et al., 2004).

The Fox River watershed project is expected to continue for several more years depending on the availability of funding. Plans are under development for collecting more detailed data in support of model development. The ISWS will have an extensive water quality database at the end of the project. The project is conducted in close coordination with FRSG. Yet

to be developed are procedures with FRSG for when and how these data will be made available to the public.

## **B. Groundwater**

The Center for Groundwater Science (CGS) has accumulated much groundwater quality data through GRF and G&C-funded projects. Not all of these data are a part of the CGS Groundwater Database, but rather reside in files kept by the project PIs. In some cases, the data are not formatted digitally, but most recent project data are in digital form. In some cases, the water quality data are accompanied by water level data, a current CGS focus. There is a parallel effort for water quantity data, and the Groundwater Database is designed to contain various types of data, including water well construction, water withdrawals, water levels, and water quality, all linked through common identifiers.

### *Project Data Entry*

*A focus of all CGS staff will be to enter project-related groundwater quality data into the database, first by creating a comprehensive list of the data, creating project metadata, and then inputting data of most importance to priority aquifer groundwater quality assessments.* Inputting data from projects with limited water quality data, such as the nonaquifer materials at DePue, would be lower priority. For all CGS datasets, metadata describing CGS data, the purpose for its collection, and how it was collected will be created for use with the ISWS point-and-click interface. In time, other agency data (e.g., local public health departments), particularly for priority aquifers, will be identified and incorporated into these digital datasets.

### *Improved Data Access*

*Improved water quality data access tools will be developed.* The CGS staff can access a variety of groundwater data, including groundwater quality data, in a point-and-click format using ArcIMS software (<http://gismaps.sws.uiuc.edu/cws/viewer.htm>). Currently, well water quality data can be viewed and downloaded, providing complete analytical results for wells within a user-selected area (Analytes are presented in legacy STORET code, the USEPA's original water quality data STORAGE and RETRIEVAL system nomenclature.). While this approach is workable and does allow access to the data, it does not readily allow the user to summarize the data, such as for a particular water quality parameter (e.g., nitrate or arsenic) within the region selected. Additional programming could allow a user to select a parameter and provide summary statistics (e.g., mean, standard deviation, maximum, and minimum) for the parameter within the region selected. Additional selection criteria also could include aquifer type (specific aquifer or unconsolidated versus consolidated) or well depth interval. The CGS also maintains GWINFO, a data entry and retrieval system that allows a user to access groundwater quality data by inputting Public Land Survey System location (¼-, ¼-, ¼-section, township, range, and county). Groundwater quality data within that area can be downloaded to an Excel spreadsheet for subsequent summary and analysis. These programs potentially could be made publicly accessible, although the data include community wells, a possible Homeland Security issue. Therefore, access to certain data for public wells, such as well location and construction, will be available only to ISWS staff and only on a case-by-case basis.

## Outcome

Important water quality data collected by the ISWS will be organized in a systematic and consistent manner to allow access to researchers from the ISWS and other agencies. This will provide an improved data source for any researcher interested in Illinois water quality.

## II. Emerging Contaminants

The presence in Illinois waters of substances that only recently have been recognized as harmful has not been well documented. If herbicide degradation products are considered emerging contaminants, the most recent, comprehensive data available for Illinois may be a USGS project funded in 2001-2002 by the IEPA that sampled 117 public water supply wells for herbicides and their transformation products in untreated groundwater (Mills and McMillan, 2004). Other USGS sampling in the late 1990s focused on the Upper Illinois River and the Sanitary and Ship Canal. The USEPA also has sampled some endocrine disruptors (cleaning agents mostly) on the Upper Illinois River. Therefore, most of Illinois' surface waters and groundwaters are unquantified with respect to these contaminants.

When the statewide pesticide monitoring well network was created by the ISGS/ISWS for the Illinois Department of Agriculture (IDOA) in 1998, funding was not available for degradate sampling. Since the IDOA took over the network, samples may have been collected for herbicide degradates, but the data were not made available to the Surveys. *Avenues that will be pursued include accessing and evaluating IDOA data if those samples have been collected or collecting those samples for analysis if IDOA has not.* The ISWS laboratory does not have degradate analysis capability, so samples will be sent to a laboratory that can conduct such analyses, or ISWS facilities upgraded to undertake such analyses.

Similarly, while not new, the issue of pathogenic bacteria and viruses in surface and groundwater is important. For example, fecal coliform contamination is listed as the number one cause of streamwater impairment in Illinois (IEPA, 2006). Additionally, sampling in the karst terrain of southwestern Illinois has revealed widespread fecal contamination of springs and wells, with on-site wastewater discharge systems probably being the primary sources. Confined animal feeding operations also may be an important source of pathogenic organisms to the environment (e.g., *Cryptosporidium* in Milwaukee, Wisconsin), as well as livestock antibiotics. Recent news from Wisconsin is that viruses have been found in deep bedrock aquifer groundwater near Madison. The source of such viruses is not known, but poorly sealed abandoned wells are one suspected source. Such well conditions also occur in Illinois. *Collaborations with other scientists on the UI campus will be required to bring necessary expertise and laboratory capability to microbial/virus projects that may be undertaken.*

Assessments of other emerging contaminants, such as personal hygiene products and antibiotics, have been tied most closely to surface waters receiving human wastewater discharges. The ISWS downstate pharmaceutical and personal care product (PPCP) reconnaissance project is still underway. Sampling sites were the Sangamon River near Riverton, Spoon River at Seville, and Sugar Creek near Bloomington. Samples collected were analyzed using a method specifically intended to identify antibiotics. All field samples analyzed by liquid



chromatography tandem mass spectrometry contained up to eight antibiotic residues at confirmed detection levels. *Another round of analyses looking for other types of pharmaceutical residues will be completed in summer 2006 and a report will be prepared.*

*An assessment of potentially vulnerable groundwaters, such as locations downgradient of housing subdivisions using septic systems, groundwater in karst terrain that receives waste discharges, and groundwater under the direct influence of surface water (e.g., wells that induce recharge from a nearby river), will be sampled.* If contaminated groundwater is found in one or several of these regimes, then a proposal will be prepared to take a larger, more comprehensive look at the problem in Illinois. Again, a consideration is that the ISWS does not have the laboratory capability to conduct the types of analysis required for these samples.

## **Outcome**

Results from the initial investigations being pursued will give an overview of the presence of emerging contaminants in Illinois waters. These results will help guide future research to determine the sources, transport, and fate of these compounds.

## **III. Nutrients in Illinois Waters**

Excessive nutrients, primarily nitrogen (N) and phosphorus (P), are a major contributor to surface water quality impairments in Illinois. Nutrient enrichment is thought to be an important cause of excessive algal and macrophyte production which, in turn, can be responsible for problems involving odor, reductions in ambient light, and, perhaps most importantly, exacerbations in diurnal dissolved oxygen (DO) fluctuations and the resulting deleterious effects of hypoxic and/or anoxic conditions on aquatic biota. However, quantifying the cause and effect between nutrient loads and concentrations and the onset and degree of specific response variables, such as algal blooms or loss in biotic diversity that result in water quality impairment problems, is rarely straightforward. Most stressors are not independent variables, but rather are codependent and/or confounding in their effects or influence on other physical, chemical, and biological stressors. Primary variables that can moderate or exacerbate the onset and severity of water quality impairment due to nutrient enrichment include hydrologic and other physical habitat conditions, temperature, ambient light, sedimentation, and DO regimes. *Consequently, there is a great need for focused research that better defines and quantifies the various interactions between stressors.* Such research will allow resource managers and planners to better formulate policy and planning for regulation, permitting, and restoration/mitigation activities directed toward the waters of the state.

*These research efforts will require expanded ISWS monitoring and data mining efforts to better support innovative modeling studies that strive to establish, define, and incorporate the quantitative links between nutrient loads and concentrations, and other physical, chemical, and biological stressors that lead to water quality impairment problems in Illinois.* Water quality issues and their impacts upon economic and quality of life issues were the impetus for the creation of the ISWS more than a century ago. Since that time, the ISWS has been a state and national leader on water resource-related issues. The institutional experience and the prominence

garnered over that time will allow the ISWS to allocate and/or obtain the expertise, facilities, and resources necessary to address these many water quality challenges within Illinois.

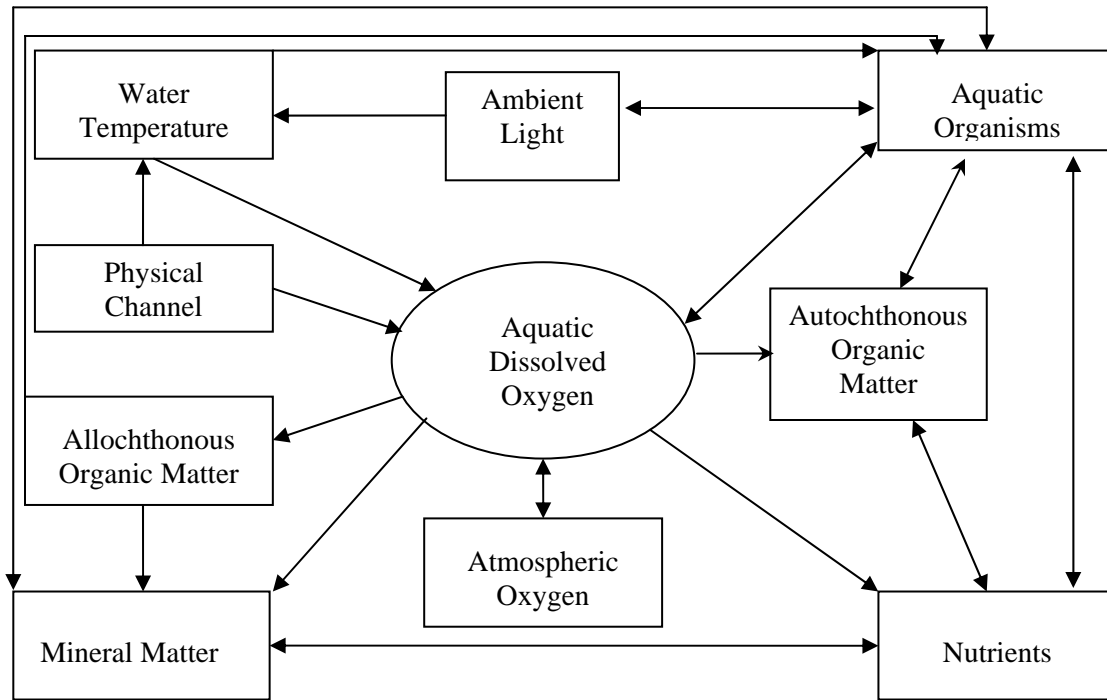
Excessive availability of nutrients and other factors is known to fuel excessive growth of algae and aquatic plants (eutrophication), which, in turn, can lead to large diurnal DO fluctuations as a result of the photosynthesis-respiration cycle. These large diurnal DO swings, and, in particular, the magnitude, duration, and spatial extent of the minimum DO concentrations, can stress and kill fish and other desirable aquatic biota. Considering that both professionals and the general public use the occurrence, numbers, and composition of desirable biota to assess the success of water quality standards and restoration activities, the information and understanding that results from research concerning nutrient impacts will have broad stakeholder appeal.

*Initial ISWS efforts will be directed toward defining a conceptual model that accurately describes the processes that drive DO regimes in aquatic systems in Illinois.* General DO models (see figure) are available and will serve as a starting point for this planning process. The process of defining a conceptual DO model that fully identifies and describes the model variables affecting DO concentrations within Illinois waters and refines the complex drivers that describe the linkages between these variables will provide substantial benefits. First, it will provide a mechanism that encourages collaborating researchers to discuss and define understandings of the various model components and their interactions, thereby providing the process through which ISWS research efforts can be prioritized. Second, once the model has been described, it will provide an overarching framework into which existing data may be interpreted so that current data and modeling needs can be better defined and prioritized. Once existing data sources have been identified and obtained, researchers will be better able to identify existing informational gaps and prioritize monitoring and research efforts designed to provide the necessary data. The following abstracts provide examples of the types of research this process can be envisioned to support.

#### **A. Biogeochemical Processing of Phosphorus in Aquatic Systems**

Water quality research and standards traditionally have been concerned with loads or concentrations of the total fraction of specific nutrients. However, it is known that only some fraction of the total nutrient load, often termed the bioavailable fraction, is actually available for primary production over appropriate time scales (days to weeks). Moreover, the bioavailable fraction of nutrients should be used to assess limiting nutrient ratios in a given stream or lake. Understanding what portion of the total N and P budgets are available as well as the sources, sinks, and processes important in determining the amounts of bioavailable N and P within a stream or lake would allow development of standards that more accurately reflect levels necessary for protection of aquatic uses, while potentially lessening economic impacts associated with meeting nutrient standards.

Research and monitoring efforts at the ISWS that focus on traditional forms of N and P existing in natural waters and sediments will be expanded to include determinations of what fraction of total phosphorus (TP) is bioavailable, as well as the role suspended and bed sediments play in influencing the bioavailability of P. In addition, important nutrient response variables



**Sources and sinks for oxygen supply and demand in aquatic environments**

such as DO and both suspended and benthic chlorophyll concentrations should be collected and incorporated into the analyses. These efforts need to be accompanied by continued and expanded efforts to monitor stream flow and ambient light regimes given the importance of these physical variables in helping to control the rates and extent of nutrient processing in a particular stream environment. This productivity information will be used to better understand those conditions driving large fluctuations in diurnal DO concentrations known to adversely impact aquatic biota. Ultimately, knowledge gained from these efforts will be invaluable to the development of nutrient standards that protect the waters of Illinois by more clearly delineating the physical, chemical, and biological factors that control linkages between nutrients (N and P) and important response variables.

## **B. Sediment Toxicity and Impacts on Aquatic Benthos**

Many aquatic systems in Illinois have experienced reductions in desirable benthic species populations, with the Illinois River as perhaps the best-known example. Prior to the 1950s, the Illinois Waterway was famous as a leg of the Mississippi Flyway, and particularly large numbers of diving ducks used the abundant fingernail clam populations as a food source. In the early 1950s, a dramatic decline in fingernail clam populations was documented, and their populations have remained depressed since then. The result is that today there has been a significant shift in the migration pattern of ducks, particularly diving ducks, due to the loss of this valuable food source. Previous research has lent support to the hypothesis that pore water ammonia and/or hydrogen sulfide concentrations are high enough to be toxic to fingernail clams over large stretches of the Illinois River, at least during certain times of the year. This link has not been

defined clearly, and the spatial and temporal scales defining the extent of conditions favorable to the production of elevated pore water ammonia and/or hydrogen sulfide also are unknown. Research that confirms the link among depressed fingernail clam populations, ambient pore water ammonia, and/or hydrogen sulfide concentrations, and describes the causative factors, including DO regimes, N transformations, and *in situ* riverine conditions leading to elevated ammonia and hydrogen sulfide concentrations, would be a significant contribution to the ecological recovery of the Illinois River and a tremendous public relations benefit for Illinois' natural resource agencies.

Other potentially important sediment toxicants include mercury and other toxic metals, various anthropogenic organic compounds such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and a variety of herbicides and pesticides, as well as their degradation products. Consequently, the ISWS must be prepared to expand studies to include other potential sediment toxicants as such needs are identified. This would require collaboration with other research groups or agencies, such as the WMRC in order to gain access to specialized instrumentation required to quantify the concentrations of these potential toxicants in sediments and their pore waters.

### **C. Nutrients in Groundwater and Surface Water/Groundwater Interactions**

Nitrate is a common groundwater constituent/contaminant, often exceeding the drinking water standard in some well waters. Nitrate and other forms of N in groundwater are derived from a wide variety of point and nonpoint, natural and anthropogenic, sources. The contribution of nitrate-N compounds from groundwater to surface water, and the mechanisms of N cycling within Illinois watersheds are not well documented or understood. Further, some point and nonpoint sources of nitrate-N also contain other contaminants (e.g., emerging contaminants, such as human and animal antibiotics contained in wastewaters, see “Emerging Contaminants” section) of which there is little knowledge regarding occurrence and fate in groundwater. Land-use changes that have been occurring in recent years, including changes in the livestock industry to concentrated feeding operations and conversion of cropland to unsewered residential areas in northeastern Illinois and MetroEast, also may have significant impacts on N (and P) behavior in subsurface and surface waters. The CGS has an active research program in this field in collaboration with scientists at the ISGS and Illinois State University. *This topic is a good focus for collaboration with others within the ISWS to attract larger G & C funding; a focus group will be created to pursue potential funding avenues.*

### **D. Northern Gulf of Mexico Hypoxia**

Hypoxia in the Northern Gulf of Mexico has been recognized as one of the major environmental problems in the United States for some time. Nutrients delivered by the Mississippi River have been identified as the main cause for the over production of phytoplankton and the resulting oxygen depletion, hypoxia. The upper Midwest, including Illinois, has been identified as the major contributor of nutrients to the Mississippi River. The Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Gulf of Mexico calls for significant reduction in nutrient loading from the Mississippi River. The initial Action Plan (2001) called for reducing primarily N input. Recent research results have shown that P also may

play a major role in the Gulf hypoxia and has resulted in the re-evaluation of the initial recommendations of the Action Plan. As any major program to reduce nutrient delivery to the Mississippi River will affect Illinois agriculture and business, the ISWS actively should participate in future research and discussions on the causes of Gulf hypoxia and potential mitigation that could reduce its extent and effects. Funding opportunities may become available as the original Action Plan is reviewed and revised. For example, characterization of the loadings, fate, transport and sources of N and P forms in the Mississippi River basin have been identified as a critical knowledge gap. Some ISWS research also has identified the impact of coastal change and marine processes as critical knowledge gaps regarding the development and extent of Gulf hypoxia. The ISWS should be prepared to take advantage of such research opportunities.

## **Outcome**

In collaboration with other university, state, and federal agencies, ISWS researchers will use the conceptual DO model to identify and develop innovative research projects that use existing data resources, directed monitoring and research efforts, and numerical modeling strategies to further expand and refine the understanding of the conceptual DO model and its various components. Advancement of the understanding of how various model components interact will provide vital information to various resource management agencies throughout Illinois and the nation. This information will help meet an existing need by providing substantive information on which to base nutrient standards required by federal regulation. In addition, this knowledge will be used to help guide development of better restoration strategies in support of activities ongoing in the Illinois River basin.

## **IV. Sediments in Illinois Streams and Lakes**

The quantity of sediment transported and deposited in Illinois streams, lakes, and wetlands is an important water quality issue. Excessive sedimentation negatively impairs or destroys desirable aquatic habitats, decreases the self-purification capacity of surface waters, and decreases the water supply and recreational capacity of lakes and reservoirs. The quantity of excess sediment transported and deposited reflects past and present land-use changes. It is also a measure of the success or failure of conservation efforts. The ISWS is recognized as the State's expert on sediment transport and sedimentation. To maintain that expertise and provide valuable information to resource planners and managers in the State, *the ISWS will continue to collect data and conduct research through the three activities outlined below.*

### **A. In-stream Sediment Transport Monitoring**

The ISWS established 50 sediment monitoring stations in 1980 as part of the Illinois Benchmark In-stream Suspended Sediment Monitoring Program. The number and location of stations were established based on the recommendation of an Interagency Task Force with representatives from all the natural resource agencies in Illinois. The 50 stations selected represent most streams throughout Illinois. The program has been reduced to 15 stations that collect samples only once a week. The present monitoring program is not adequate to provide a detailed picture of the amount of sediment being transported by Illinois streams and rivers. To

collect data from representative stations from all regions of Illinois, requires more than 15 stations. The monitoring program should be expanded to more than the present 15 stations with increased frequency of sampling so that daily average sediment loads can be calculated for each monitoring station. *A proposal to either IDNR and/or IEPA will be prepared to expand and improve the sediment monitoring network.*

## **B. Accuracy of Sediment Load Calculations**

Sediment load is the main parameter used to assess the downstream impacts of soil erosion from a watershed upstream of lake or stream segments. Some of the methods used to calculate sediment loads could be in error by as much as 100 percent. The ISWS has been working to develop methods to improve the accuracy of sediment load calculations. Even though there has been some progress, more research is necessary to develop improved methods for calculating sediment loads from different types of sediment data collected in Illinois. The goal is to reduce the error estimation to  $\pm 10$  percent. *As an initial effort, a manuscript will be prepared that compares sediment load estimates based on instantaneous samples and daily average values.* If a method can be developed that uses instantaneous sediment data to compute load consistent with daily average data, then the utility of available sediment data will be improved significantly.

**1) Sediment Load Estimation for the Upper Mississippi River Basin.** Because of the limited number of detailed long-term sediment data in Illinois, the CWS has been compiling available suspended sediment data within the Upper Mississippi River basin to compute sediment loads using different methods, and then evaluating and comparing the accuracy and uncertainties for the different datasets and methods. The expanded geographic area has provided more data than is available in Illinois and will enable the evaluation of different methods. One of the priority areas of research is to evaluate accuracy of the loads calculated by using different sediment rating curves generated from different types of datasets. The evaluation includes linear and nonlinear rating curves and their applicability for different datasets such as instantaneous suspended sediment data collected at different frequencies and daily average concentration data. *Plans include preparing a manuscript for a peer-reviewed journal within a year and a report and another manuscript within two years.*

**2) Evaluation of Sediment Sampling Methods.** *Current CWS research on the effects of sampling frequency will be continued and expanded to include event-based data impacts load estimates for different sized watersheds so that more efficient and cost-effective sampling routines can be devised.* Automated pump samplers have the potential to increase the number of suspended sediment samples collected at a given site substantially. These samplers are point samplers and rely on suction as opposed to the depth-integrating isokinetic samplers traditionally used. *Studies comparing concentration data generated through use of pump samplers and manually collected depth-integrated samples and how data frequency and quality affect load calculations will be devised.* This research not only will allow expanded use of pump samplers but also will be essential in determining how these data relate to historical values generated using traditional methods and equipment.

Another uncertainty in determining total sediment loads is associated with the estimation of the bed load fraction of the total load. Bed load transport within a stream is temporally and spatially episodic, requiring data collection efforts that are extremely labor intensive that provide results characterized by a relatively high degree of variability and uncertainty. Because estimating bed load is difficult, it often simply is assumed that a stream's bed load is 5 to 20 percent of its suspended load when developing total load calculations. Moreover, bed load transport rates are believed to be important to channel-forming processes and are estimated routinely and incorporated into effective discharge computations.

A proposal to improve sampling methods that better estimate sediment loads in Illinois streams has been included in the Illinois River monitoring plan for the Illinois River Ecosystem Restoration project. *If the proposed research is funded, the research plan will include bed load sampling and a joint pump and traditional sampling program for selected streams in the Illinois River basin.* The information will be applicable to other streams in Illinois.

### **C. Modeling of Sediment Transport and Deposition**

Sediment data monitored at gaging stations are not sufficient to assess the impacts of sediment on water quality at all places in Illinois and at different times. There is a need to develop and maintain sediment transport models for priority watersheds in Illinois. The models then can be used to guide restoration efforts and evaluate the effectiveness of management programs.

The CWS has been developing a watershed model for the Illinois River basin as part of the ILRDSS. In the initial phase, the hydrologic component of the model was developed for the entire Illinois River basin. The model is based on the USEPA's BASINS 3.0 modeling system.

To make the model applicable for assessing and evaluating the impact of climate and land-use changes on water quality and sediment transport, the ISWS has been developing the sediment transport and water quality capabilities of the Hydrologic Simulation Program Fortran (HSPF) model for the Illinois River basin. The initial effort focused on the Spoon River watershed in which two of four intensively monitored watersheds, Court Creek and Haw Creek, are located. Streamflow, sediment, and water quality data being collected at three monitoring stations in those two watersheds are being used to calibrate and test the model for the Spoon River watershed. Once the calibration and validation process is completed for the Spoon River watershed, *model parameters will be used to develop models for other similar watersheds to simulate the hydrology, sediment transport, and water quality under different climatic and land-use scenarios.* Over time, as land-use practices change significantly as a result of Conservation Reserve Enhancement Program (CREP) and other conservation practices, models being developed will provide the tools to evaluate and quantify changes in water quality and sediment delivery to the Illinois River.

Expected completion of development of the sediment transport component for the Spoon River watershed is by the end of 2006. Based on experience gained from the Spoon River watershed, *plans include continued development of the Illinois River basin model.* Progress on model development will depend on funding from IDNR or the U.S. Army Corps of Engineers.

## **Outcome**

More accurate and detailed sediment data and analyses will enable resource managers and planners to plan and manage watershed management projects more effectively that ultimately improve the water quality in streams and lakes.

## **V. Groundwater Quality**

### **A. Characterization of the State's Priority Water Supply Aquifers**

Documenting and assessing the quality of the water in the State's priority aquifers is of prime importance to local, regional, and state decision-makers and, hence, the CGS, the natural entity to conduct such evaluations. While the IEPA does maintain an "ambient" water quality network for sampling raw water quality from a selected set of community wells, their primary focus is with the safety of drinking water, so their greatest effort is examination of treated drinking water delivered to public drinking water systems. The IEPA ambient network focus is not on regional groundwater quality or aquifer-specific quality. Local municipalities tend to deal with problems local to their jurisdictions, and their consultants have similar outlooks, so regional investigations of aquifer or county size are truly the realm of the ISWS.

The CGS has a historic background of examining groundwater problems with a regional perspective, be it water quantity or water quality. Examples include work recently completed for Kane County looking at shallow groundwater quality across the county after one-time synoptic sampling (Kelly, 2005) as well as looking at groundwater quality temporal trends using historic data contained in CGS files (Kelly and Wilson, 2003). Some ongoing work within the CGS falls within this priority—most specifically, efforts related to arsenic in Mahomet aquifer groundwater. Regional assessments of groundwater quality also may feed into groundwater availability assessments and studies of groundwater flow and recharge.

*The CGS will pursue avenues, including internal resources, to support future investigations of regional groundwater quality importance.* This also could lead to the establishment of groundwater quality networks for periodic sampling to establish trends, identify problems areas, etc.

### **B. Transport Modeling**

Transport modeling of solutes in groundwater is an important tool that the ISWS, as a research agency, has the capability and expertise to do. Transport modeling often is used to assess the impact of contaminant movement toward aquifers and drinking water wells from a wide variety of pollution sources. Density-dependent models are a special type that accounts for density-difference impacts on groundwater flow. This can be especially important for highly saline groundwater, both in terms of salt movement and the impact of density on flow, such as is encountered in the deep aquifers of northeastern Illinois.



*A short proposal will be written for Joliet and Aurora, the two cities that pump the most groundwater from the deep sandstone. The intent is to get them to consider this as a future ISWS project once the regional model and Kane County products are completed in 2007.*

## **Outcome**

The knowledge will be used to guide management and future development of groundwater resources, particularly in Illinois' priority aquifers. This will help communities and industry to develop new potable water sources economically, enable existing water supplies to satisfy more stringent new regulations, and address emerging groundwater quality issues of the 21<sup>st</sup> Century.

## **VI. Water Treatment Issues**

The ISWS has a longstanding research tradition of water treatment issues. This includes research directly targeting improved, innovative, and cost-effective methods of purifying water for human consumption, as well as research more generally concerned with source water quality before treatment. An overarching goal of both groundwater and surface-water research at ISWS is to understand the complex array of interacting physical, chemical, and biological processes that affect water quality; that is, processes that control the concentrations of dissolved substances, including toxic substances. It is important to recognize that, in many cases, water treatment involves the same processes that occur naturally in streams and aquifer systems but under conditions controlled to optimize contaminant removal.

One specific water treatment-related activity concerns arsenic removal. The ISWS research has shown that the source of arsenic in some of Illinois' major aquifers is reductive dissolution of iron oxide coatings on sand grains and release of arsenic associated with the iron oxides. Water treatment plants essentially reverse this process; they remove iron by oxidizing soluble iron to insoluble iron oxide and simultaneously remove some of the arsenic. Recent ISWS research has demonstrated that arsenic removal can be improved by adding the inexpensive oxidant hydrogen peroxide and, for some groundwater, more iron. *This work is continuing, and the ISWS has been developed compact mobile pilot plant (about the size of a filing cabinet) to test arsenic removal by hydrogen peroxide and iron addition in Illinois water treatment plants with arsenic problems.*

A related research activity to reduce treatment costs concerns managing biological and chemical conditions in the vicinity of a well. Recent ISWS research in collaboration with the UI Department of Geology showed low or undetectable arsenic concentrations in wells with sulfate-reducing conditions and suggested that it may be possible to induce sulfate reduction near a high-arsenic well, thereby reducing arsenic concentrations in the well water. *This research is continuing, and ISWS personnel currently are working with the UI Department of Geology to design laboratory experiments to test the feasibility of managing the geochemical conditions near high-arsenic wells.*

A third research activity concerns taste and odor problems in drinking water reservoirs, problems exacerbated by excess nutrients (eutrophication). In some reservoirs, the sediments are

major sources of nutrients (internal loading), especially in deeper areas during the summer months as DO concentrations decrease. Past ISWS research has shown that destratification (mixing) of drinking water reservoirs can maintain adequate DO concentrations in these deeper areas, which helps minimize nutrient release from sediments, and, in turn, helps eliminate taste and odor problems caused by the excessive growth of undesirable algal species, as well as dissolved iron, manganese, and hydrogen sulfide. *Basic and applied research into the sources and effects of excessive nutrients and other contaminants in source drinking waters will continue.* One potential source of both collaboration and funding is the Midwest Technology Assistance Center for Small Public Water Systems (<http://mtac.sws.uiuc.edu>), which focuses its research efforts on finding solutions to problems of small public water systems in the Midwest and helps them to develop their capacity to address those problems.

## **Outcome**

Water treatment research will benefit water consumers directly by providing a safer, better-tasting product at reasonable cost. Likewise, research on the causes and consequences of source-water degradation ultimately will provide strategies to manage and mitigate drinking water problems at their source.

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