2001 Governor's Conference on the Management of the Illinois River System

Illinois River Resource Management

The Illinois River: Partnerships for Progress, Restoration, and Preservation

Proceedings

Eighth Biennial Conference
October 2-4, 2001
Holiday Inn City Centre
Peoria, Illinois

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Alesia M. Strawn, Editor
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Department of Agricultural and Consumer Economics
University of Illinois at Urbana-Champaign

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Illinois Department of Commerce and Community Affairs

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Brad Thompson, U.S. Army Corps of Engineers, Rock Island District

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STATE OF ILLINOIS

EXECUTIVE DEPARTMENT

Proclamation

WHEREAS, the Illinois River System [illegible] and [illegible]

WHEREAS, [illegible] have significantly altered the [illegible] River system; and

WHEREAS, the State [illegible] and is working in a coordinated and [illegible] manner for [illegible]; and

WHEREAS, the [illegible] the Conservation Reserve Enhancement Program, the Illinois Conservation [illegible] Program, [illegible], the Open Lands Trust Fund and Illinois River Sweep are [illegible] the Illinois River; and

WHEREAS, [illegible] River System [illegible] of the [illegible]; and

WHEREAS, the [illegible] River [illegible] for Progress, Restoration, and Preservation"; and

WHEREAS, citizens may take this day to [illegible] the economic, recreational, social, and environmental benefits of conserving & properly utilize the resources of the Illinois River Basin.

THEREFORE, I, George H. Ryan, Governor of the State of Illinois, proclaim [illegible] RIVER SYSTEM MANAGEMENT MONTH.

In Witness Whereof, I have hereunto set my hand and caused the Great Seal of the State of Illinois to be affixed.

Done at the Capitol in the City of Springfield, [illegible]

Jesse White

SECRETARY OF STATE

George H Ryan

GOVERNOR

MANAGING FOR EXTREME FLOW EVENTS – WATER QUALITY AND PUBLIC HEALTH

Edwin E. Herricks

Department of Civil and Environmental Engineering
University of Illinois

The management of water quality and public health impacts from extreme flow events should be based on an understanding of some fundamental issues that relate flow, pathogen and contaminant concentration, and the potential disruption of our capacity to protect the public health. When we consider the fundamental flow issues, we can focus on channel, and out-of-channel components. In channel flows can uncover and move sediment related contaminants, creating new "hot spots" for future management. The out-of-channel component can have mixed effects. Out-of-channel flows may contact contaminated areas and contribute to water quality degradation. These out-of-channel flows may also interfere with water and wastewater treatment, creating conditions that can range from inconvenient to major public health threats. We do know a lot about pathogen and contaminant concentration changes associated with storm events, but extreme flows introduce new problems. In addition to a first flush of pathogens and contaminants, new sources of concern can arise as flood waters inundate areas where pathogens or contaminants can be released. We do know that later flows can dilute contaminant concentrations but a major concern is the potential for concentration of contaminants in areas of sediment deposition, creating new "hot spots" of concern in managing the flood aftermath. Flood flows are simply disruptive and consequences, particularly public health concerns, will be high well after flood waters have receded. This discussion will examine some of these issues, relating the understanding we have developed from storm event/stormwater assessments to the potential for damage in extreme flow events.

FLOOD EMERGENCIES AND DROUGHT RESPONSE

Melvin Allison

Chief, Planning Section
Illinois Department of Natural Resources, Office of Water Resources

The Office of Water Resources is responsible from providing hydrologic information to the Emergency Operation Center during periods of floods, and providing technical assistance during droughts emergencies.

During flood emergencies various federal and state agencies gather and disseminate information relative to Illinois. The job of the Office of Water Resources is to gather all pertain information from all sources, including data collected from our own network, arrange the data in to a decision making document form the Emergency Operations Center. The document is used to insure resources are sent to the critical and high priority areas first. The information for the Mississippi and Illinois Rivers is broken down to each drainage district.

During a drought condition a Task Force is activated to develop Public Water Supply(PWS) watch List, encourage appropriate response, and offer coordinated assistance. OWR provided assistance the Village of Oakland. With 30 to 35 day of water remaining in the village reservoir, 13 days of pumping water from Walnut Point State Park solved the immediate problem.

MANAGING FOR EXTREME FLOW EVENTS: DATA-COLLECTION AND DISSEMINATION EFFORTS

Robert R. Holmes, Jr.

District Chief, U.S. Geological Survey, Illinois District
221 N. Broadway, Urbana, Illinois, 61801
Phone: (217) 344-0037, ext 3005, E-mail: bholmes@usgs.gov

Droughts and floods have been experienced in the Illinois River basin for thousands of years. To assist the local, State and other Federal water agencies with managing these extreme flow events, the U.S. Geological Survey (USGS) operates and maintains a real-time network of over 170 streamflow-gaging stations in Illinois in cooperation with these agencies. USGS makes numerous on-site field measurements of discharge (flow at a specific cross section location of the river) are made each year at the gaging stations in order to maintain relations between stage (water elevation) and discharge. These measurements sometimes are made under arduous conditions by hydrologists and technicians during floods.

The data from the network are used in addressing many of the water issues that the State presently faces. Every day the data are used to operate river-control structures for barge traffic, drinking-water intake pumps, and hydroelectric and nuclear power plants, but the availability of real-time streamflow data for these purposes especially is important and critical during droughts and floods. During floods, the data are used to make decisions such as operation of control structures, where and what type of flood-fighting efforts are needed such as sandbagging, evacuation, or road closures, and adjustment of computer models to forecast flood crests. During drought conditions, these data are used to monitor and manage drinking-water supplies, water-quality conditions, operation of hydroelectric and nuclear power plants, and other uses. The effect of shutting down a nuclear power plant because not enough water is available for cooling can cost the power industry hundreds of thousands of dollars per day and result in power outages.

The data collected from the USGS real-time network are archived and used in numerous other ways. For example, streamflow data are used to determine the low-flow characteristics of streams to facilitate determination of waste-load allocation and water-supply capacity, to determine the flood characteristics of streams for bridge design and flood inundation mapping, and to estimate trends in streamflow and (along with other data) water quality.

The real-time data for Illinois may be viewed on the Web at http://il.water.usgs.gov/ and for the Nation at http://water.usgs.gov/realtime.html .

MANAGEMENT OF NAVIGATION FACILITIES ON THE ILLINOIS WATERWAY

U.S. Army Corps of Engineers, Rock Island District

The Illinois Waterway is a part of the Inland Waterway Navigation System of the United States, linking the Mississippi River Navigation System with the Great Lakes and the St. Lawrence Seaway. The waterway is 327 miles long from its source at Lake Michigan in the City of Chicago, to its mouth on the Mississippi River at Grafton, Illinois. Navigation on the Illinois Waterway is sustained by a series of lock and dam facilities operated and maintained to provide a 9-foot navigation channel. While the U.S. Army Corps of Engineers has the ultimate responsibility for regulating the lock and dam facilities, successful management of the Illinois Waterway is made possible through the cooperative effort of a number of entities. These entities include the Metropolitan Water Reclamation District of Greater Chicago, the U.S. Geological Survey, the Illinois Department of Natural Resources, and the National Weather Service. Working together, these entities provide the necessary information to manage navigation and serve the public and all of the users of the Illinois Waterway. This presentation will provide an overview of the major operational issues, information and processes required to manage navigation and regulate flows on the Illinois Waterway.

STREAMFLOW FORECASTING

William D. Morris

Service Hydrologist, National Weather Service Chicago Forecast Office
Romeoville, Illinois

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States. its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. The streamflow forecasting program of the NWS provides river and flood forecasts and warnings for select locations on area streams. The responsibility of flood forecasting was assigned to the NWS in 1890.

The NWS utilizes a tremendous amount of data to create a river forecast. Information is collected on precipitation, soil moisture, temperature, and river stages. The NWS uses many sources of data when developing its flood forecasts. The U.S. Geological Survey (USGS) is the principal source of data on river depth and flow. This data is input into the NWS River Forecast System computer models at 13 River Forecast Centers. Hydrologists at the River Forecast Centers run the computer models and create a river forecast for select river forecast points on area streams. This river forecast guidance is then used by NWS Weather Forecast Offices to create and issue river flood products to the public. Flood warnings and river forecasts are disseminated to the public through a variety of methods including the NOAA weather radio and the internet.

OPENING ADDRESS

Robert W. Frazee

Extension Educator, Natural Resources Management, University of Illinois Extension
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Good Morning and Welcome! At this time I would like to convene the Opening Session of the 2001 Governor's Conference on the Management of the Illinois River System. I am Bob Frazee, Natural Resources Educator with University of Illinois Extension and am serving as Co-Chair for this conference. This morning as I mingled with people in the hallways, it was exciting to be a part of the interest and enthusiasm that is being generated by holding this eighth biennial conference on the Illinois River System. I am very pleased to report, that as of a few minutes ago, we now have over 250 individuals registered. This is one of our largest conferences ever - a true indication of the growing interest that is concerned about protecting our Illinois River System for the future!

In looking over the registration list, we have a very diverse group of participants in terms of their backgrounds and the groups and agencies they represent. This is tremendous! With this diversity in mind, I would like to encourage each of you, throughout this conference, to actively seek out individuals with *different* opinions and viewpoints on river management. Share your thoughts and concerns with each other, open your minds to new perspectives, and explore the opportunity for compromise. A tremendous opportunity for networking will occur this evening during our barbecue and social on the Peoria Riverfront.

As you can see from this year's conference agenda, for the first time, we are providing concurrent sessions. Our Conference Planning Committee was flooded with so many on-going Illinois River projects that we found it necessary to expand our agenda to include three time-periods for concurrent sessions. Even with this expanded format, our Planning Committee was unable to provide a speaking slot to all individuals wanting to report on their agency's Illinois River initiatives. Consequently, many of these projects are being showcased in the Exhibit Hall.

The theme for this year's conference is "The Illinois River: Partnerships for Progress, Restoration and Preservation." During the next two days, our conference speakers will be focusing on significant restoration and preservation accomplishments that have occurred during the past two years throughout the Illinois River System, that involve partnerships with local, state, and federal agencies and organizations.

The Governor of Illinois, Mr. George Ryan, recognizes the tremendous importance of the Illinois River System to our state and further realizes that it also provides Illinois with a key environmental challenge. Consequently, the 2001 Conference on the Management of the Illinois River System has been designated a Governor's Conference. A special Governor's proclamation has been issued to emphasize our state's commitment to conscientiously manage this important natural resource for the benefit of future generations. This Proclamation reads as follows:

> WHEREAS, the Illinois River System is an integral part of our state's geography, history, economy, and ecology; and
> WHEREAS, many attributes are threatened as a result of the cumulative effects of human activities that have significantly altered the Illinois River system; and
> WHEREAS, our state is embracing an integrated approach to large river management and

is working in a coordinated and continuous management for our rivers; and
WHEREAS, the implementation of the Illinois River Coordinating Council, the Conservation Reserve Enhancement Program, the Illinois Conservation 2000 Program, Illinois Rivers 2020, the Open Lands Trust Fund, and Illinois River Sweep are important milestones in efforts to protect the resources of the Illinois River; and
WHEREAS, the 2001 Conference on the Management of the Illinois River System is October 2 - 4 at the Holiday Inn City Centre in Peoria; and
WHEREAS, the theme of the Conference is "The Illinois River: Partnerships for Progress, Restoration and Preservation"; and
WHEREAS, citizens may take this day to recognize the economic, recreational, social and environmental benefits of conserving to properly utilize the resources of the Illinois River Basin;
Therefore, I, George H. Ryan, Governor of the State of Illinois, proclaim October 2001 as ILLINOIS RIVER SYSTEM MANAGEMENT MONTH.
Signed, Governor George H. Ryan

This Proclamation will be on display in the foyer throughout the conference and will also be printed in the Conference Proceedings. Unfortunately, Governor George Ryan is unable to attend this Illinois River conference, as he is out-of-state on official business.

At this time, it is my pleasure to recognize my co-chair for this conference, Steve Havera. Steve is an Animal Ecologist with the Illinois Natural History Survey and serves as Director of the Forbes Biological Station and the Frank C. Bellrose Waterfowl Research Center at Havana. Steve will be chairing the conference sessions tomorrow. Steve, thank you for the excellent leadership you have provided to this conference.

Two years ago, following the 1999 Illinois River Conference, a statewide planning committee was formed to begin making plans for the conference convening here today. These committee members, who are listed on the back inside cover of your Abstract and Speaker Information Booklet, can be identified by the blue committee ribbon on their nametags. They have done an outstanding job of developing the program and making the necessary arrangements. Would the planning committee members please stand and be recognized.

This year, we are especially indebted to a number of agencies and organizations for providing significant financial contributions to enhance the quality of this conference. Platinum, Gold, Silver and Bronze Financially Supporting Sponsors are listed on page 46 of the Speaker & Abstract Booklet. These contributions have enabled our Conference Planning Committee to waive the registration fees for our speakers and moderators - a gesture that I'm sure is greatly appreciated.

I am also pleased to announce that we have over 60 co-sponsoring agencies and organizations that have assisted in promoting this conference and are committed to protecting and preserving the Illinois River System. They are also listed on page 46 of the Abstracts and Speaker Information Booklet. We welcome each of you and thank you for helping to make this conference a success!

At this time, I would like to recognize the efforts of several individuals who have made significant contributions to the organization of this conference.

The Heartland Water Resources Council of Central Illinois has been serving as the local administrative entity for handling the many arrangements necessary to make this a successful conference. Jim Baldwin is their Executive Director and Wendy Russell is the Assistant Director. Please join me in thanking Jim and Wendy for their efforts in organizing this conference. While you are at this conference, if you should have questions or need local information, please look for a conference participant with a special Heartland Water Resources nametag and they will be happy to assist you.

I am pleased to recognize Jon Hubbert, Peoria County District Conservationist for the Natural Resources Conservation Service and Kim St. John, Executive Director for the Prairie Rivers Resource Conservation and Development Area, who were responsible for organizing the Conference Conservation Cruise which was held yesterday. This cruise, aboard the Spirit of Peoria, provided participants the opportunity to learn about the multiple uses of the river, river restoration efforts, and view the scenic river corridor. Thank you, Jon and Kim, for an outstanding Conservation Cruise.

Another event occurring yesterday, was the Pre-Conference Panel Presentation on Managing Extreme Flow Events. The U.S. Geological Survey, under the leadership of Paul Terrio, organized and conducted this very informative discussion last night. Thank you, Paul.

Another individual I would like to recognize is David Soong, with the U. S. Geological Survey, who has chaired our Exhibits Committee. This year, through David's leadership, we have 34 educational exhibits. Thank you, David for your help in organizing the exhibits.

Alesia Strawn, who compiled our Conference Speaker/Abstract Booklet, is also our Conference Proceedings Editor. Alesia will be here throughout our conference, so speakers, please be sure to make a point to see her and leave with her a CD or diskette of the paper that you are presenting. In approximately 3 months, each registered participant will receive a copy of the Conference Proceedings through the mail. Thank you Alesia for a great job.

The next three individuals are truly technology wizards. First is Jay Solomon, who is an Agricultural Engineer with University of Illinois Extension and was responsible for loading all the PowerPoint presentations onto the laptops and getting the "bugs" out of them. Also in this group is Jon Rodsater with Illinois State Water Survey and Richard Nichols with the Illinois Department of Agriculture. Throughout this conference, Jay, Jon, and Richard have been working behind the scenes to ensure that the speaker's presentations, whether they are PowerPoint, slides, video clips, or overheads, load properly and the conference is kept on schedule. Thanks Jay, Jon, and Richard for a great job!

Throughout our two-day conference, please refer to the Abstract and Speaker Information Booklet for the agenda and for more complete information regarding the speaker's topic and personal background. On behalf of the Planning Committee, I hope that you will find this conference to be exciting, informative, stimulating, and enjoyable.

At this time, it is my pleasure to introduce to you Mr. David Ransburg, Mayor for the City of Peoria. Mayor Ransburg will officially welcome you to the friendly City of Peoria, situated midway on the Illinois River between Chicago and Grafton.

It is now my pleasure to introduce the Moderator for our Opening Session, David Leitch. David is State Representative for the 93rd Representative District and is very active in legislative matters involved with the Illinois River Watershed. David will introduce the Keynote Speakers for our Opening Session.

WELCOME

David Ransburg

Mayor of the City of Peoria
419 Fulton St. Peoria. Illinois 61602

On behalf of the City Council of the City of Peoria and the Citizens of Peoria, I really want to welcome you to Peoria. You'll find that it is a very friendly community, a lot going on and hopefully a good host to your conference.

It occurred to me as I was driving here how important water is to our lives. I think it is particularly important that we are here talking about the Illinois River. Peoria is here because of the river. The Native Americans first came here and settled because there was water, and an abundance of food. Those of you who have driven around know what an important part of Peoria the river is. If you go up on our bluffs, I have never had a visitor here who hasn't been impressed with how beautiful it is. But even more important than its beauty, is what it means to this city and state economically. We have barges that go through here, we have all sorts of recreation, from fishing, boating, or bird watching, all sorts of things. Now obviously over the years we have done some things to damage the river. I think it's interesting to note, that a few years ago, a number of people began to realize, not just the Illinois River but other rivers, that it really was important to pass down a new heritage to our descendents and to say that we really need to work hard to breath new life into our river. When you look at a map of the Illinois River, it drains a large portion of Illinois. it's an important habitat for all sorts of wildlife, it is an important economical link with the rest of the world, it's a source of recreational and joy to everyone. And so I really appreciate what everyone here has done, and will do, to improve the life along the Illinois River and the life of the river itself. So I wish you great luck with your conference and hope that it is a great success and that you'll keep coming back to Peoria, and of course spend money. Thank you very much for coming.

MARINE TRANSPORTATION SYSTEM: THE CHALLENGES, THE VISION

Rear Admiral James D. Hull, Commander, Ninth Coast Guard District; Captain Raymond E. Seebald, Commanding Officer, MSO Chicago; and Lieutenant Commander George J. Pazak (Res.), MSO Chicago

1240 E. Ninth Street, Cleveland, Ohio 44199-2060
Phone: (216) 902-6001 (Capt. Seebald: (630) 986-2155)
E-mail: c/o rseebald@msochicago.uscg.mil

The Marine Transportation System (MTS) includes waterways, ports, vessels, intermodal connections, and MTS users -- a sub-system of the nation's overall transportation system. In 1998, Congress directed the formation of a MTS Task Force to assess the capability and adequacy of the current system. This initiative was launched to ensure that the United States can support the level of traffic expected in the 21st century as increasing demands place even more pressure on the current MTS infrastructure. An integrated, coordinated approach is the best method for addressing numerous waterways challenges. Safety, environmental, economic, funding, efficiency, and security issues gain critical importance. MTS must emerge into a more comprehensive planning system that represents multiple parties, despite competing interests.

According to the 1999 findings of a MTS (Marine Transportation System) Task Force, the total volume of domestic and international marine trade is expected to more than double over the next 20 years. The number of recreational users is expected to grow by over 65 percent. It is projected that high-speed ferries will relieve land-transport congestion, larger vessels will require deeper channels, and treasured natural resources will need our stewardship more than ever. From the waters of Lake Michigan to the Chicago, Calumet, and Des Plaines rivers, to man-made channels and canals, and onto the Illinois, we are already experiencing the uncomfortable affects of these growing demands.

UPPER MISSISSIPPI RIVER-ILLINOIS WATERWAY SYSTEM NAVIGATION STUDY

Denny A. Lundberg

U.S. Army Corps of Engineers
Clock Tower Building, P.O. Box 2004, Rock Island, Illinois 61204-2004
E-mail: Denny.A.Lundberg@usace.army.mil

This study began in April 1993 and is addressing the need for navigation improvements on the Upper Mississippi River (UMR) and the Illinois Waterway (IWW) System. The study area includes: 854 miles of the Upper Mississippi River, with 29 locks and dams, between Minneapolis - St. Paul and the mouth of the Ohio River: and, 348 miles of the Illinois Waterway, with 8 locks and dams, that connect the city of Chicago and the Great Lakes with the Mississippi River just upstream of the Melvin Price Lock and Dam. The study area lies within portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The system's principle problem is delays to commercial navigation traffic due to limited lockage capacity and increasing traffic. The reconnaissance studies completed for the UMR and IWW identified several locks in the study area with some of the highest average delays to commercial tows in the country. These delays continue to increase with traffic growth. Built in the 1930s, the navigation system was designed to accommodate 600-foot-long tows. Lock chambers 1200-feet in length are present at Locks 19, 26, and 27. Today, with tows routinely approximating 1,100 feet in length, double-lockages are necessary, which take more time and result in higher costs. Looking into the future, there is potential for significant traffic delays on the Upper Mississippi River and Illinois Waterway Navigation system within the 50-year planning horizon, resulting in economic losses to the nation. The study is investigating the feasibility of navigation improvements on the Upper Mississippi River and Illinois Waterway.

The Corps of Engineers and the newly established National Federal Senior Principals Task Force (NFSPTF) are reviewing the National Research Council's (NRC) review of the preliminary draft feasibility study. The NFSPTF was established by the Corps of Engineers with the purpose of providing national-level balance and guidance on important economic and environmental issues to assist in bringing this study to completion. Membership includes: USDA (Transportation and Marketing Programs); DOI (USFWS); USEPA (Office of Wetlands, Oceans and Watersheds); USDOT (Maritime Administration); and Corps of Engineers (Planning and Policy Division). The Corps of Engineers and the NFSPTF will consider the NRC report in revising the Project Study Plan (PSP) that will set the course to complete this complex System Feasibility Study. The PSP will establish a revised study schedule and cost estimate, which are not available at this time. Additional information on the study can be accessed through the Navigation Study home page at: http://www.mvr.usace.army.mil/pdw/nav_study.htm. An update of the Navigation Study will be provided at the conference.

Upper Mississippi River - Illinois Waterway Comprehensive Management Plan

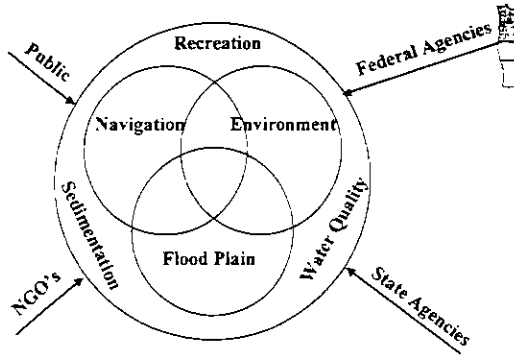
October 3, 2001

1

Agenda

- Federal Task Force engaged to review NRC Report
- Corps announces restart of Navigation Study on 2 August 2001

2



Comprehensive Management Plan

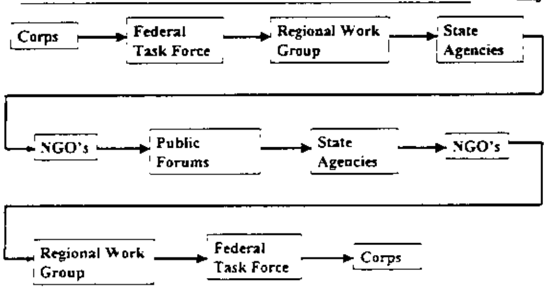
3

Collaborative Schedule

Sept 24-28	Joint session with Regional Group and Federal Task Force
Oct 11-12	Economic Coordinating Committee Navigation Environ Coord.Committee
Nov 13	Governors Liaison Committee
Dec 3-7	Regional Group
Nov 26-30	Joint ECC and NECC Meeting
Jan 14-18	Joint Collaboration Meeting including general public(3 locations)

4

Interim Report Collaborative Process



5

Products

Interim Report-July 2002

- Outline the framework for CMP
- Define navigation and environmental system goals
- Identify additional opportunities or authorizations
- Summary of Nav Study activities completed to date
- Status of scenario analysis

6

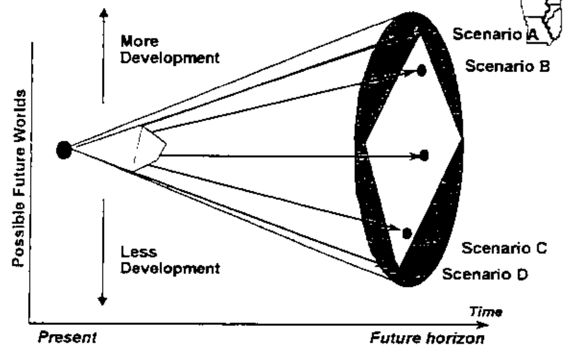
Products

Revised Navigation Study

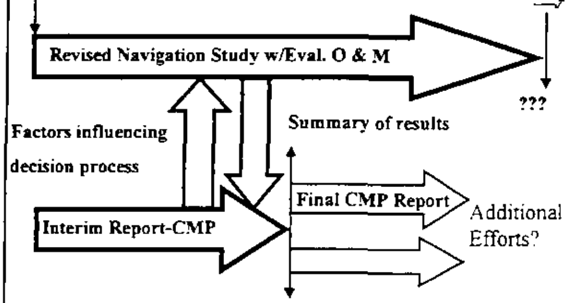
- Mod. To 9' Channel Project to improve environmental sustainability.
- Framework for modifying the navigation system to relieve lock congestion
- Scenario Based Analysis for forecasting.

7

Formulation



Revised Nav. Study & Interim Report Relationship

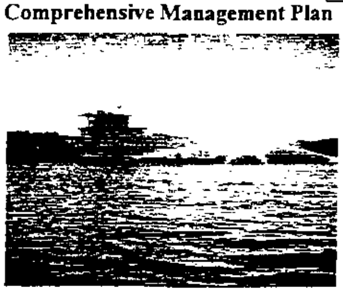


9

Interim Report Schedule

- 2 Sept 01 Submit Plan of Action & Schedule
- 18 Sept IPR with USACE
- Sep-Dec Collaboration with Stakeholders
- Jan 02 Joint Collaboration with Public
- Feb 02 Complete Draft Interim Report
- Mar-June Reviews(ITR, MVD, HQ's, NRC?)
- Jul 02 Division Commander's Public Notice
- Oct 02 Chief of Engineers Report to ASACW

Upper Mississippi River - Illinois Waterway Comprehensive Management Plan



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SAFELY TRANSPORTING BULK LIQUID COMMODITIES ON THE INLAND WATERWAYS

Mark R. Buese

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The inland waterways of the United States provide efficient and environmentally sound waterborne transportation services that significantly contribute to the economy. Barges move 16% of the nation's freight for 2% of the freight cost because water transportation is more efficient than rail or truck. One barge has the same capacity as 15 rail cars or 58 trucks. Barge transportation is also more fuel efficient than rail or truck. One gallon of fuel can move one ton of cargo 514 miles by barge, 202 miles by rail and 50 miles by truck. Consequently, less air pollution is generated because of the freight transported by barge on our inland waterways.

Barge transportation provides a valuable service by safely transporting bulk liquid commodities while reducing traffic congestion and engine emissions in our cities and on our highways. The commodities transported by barge keep millions of trucks off our highways and urban roads and mean fewer trains rolling through our urban areas. Barges and vessel personnel involved in bulk liquid commodity transportation are highly regulated with respect to equipment, operations and training. Barge transportation is the most economically and environmentally intelligent and safest way to transport the bulk liquid commodities demanded by the consumers of this nation.

THE VALUE OF FISH AND WILDLIFE RESOURCES OF THE ILLINOIS RIVER VALLEY

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With apologies to economists - How do we express value? Values are highly subjective, and ordinarily simply expressed. ...as demonstrated by any developer, affected by regulation associated with wetlands and migratory bird protection, might ponder, "What good is this swamp or the redwing blackbirds around it?". To that individual, there is no benefit in maintaining the existing land condition versus the benefits anticipated by draining and converting the land to alternative uses. To the neighborhood birdwatcher, doggedly returning to the wetland year in and year out, hoping to catch a glimpse of a yellow-headed blackbird, the undisturbed site has an intrinsic value. To that individual, the simple existence of the resource is a benefit. In valuing benefits associated with an ecological resource, a basic distinction is made between the intrinsic value of the existence of the resource and its value in use by the human population[1]. The art and science of economics include concepts of human use, intrinsic value, direct and indirect effects, impacts, or benefits realized in market or non-market environments, existence value, and option value.

Use values, or benefits, are further categorized by economists as direct and indirect. Their terminology further refines these categories: Direct benefits include both consumptive and non-consumptive, market and non market, which may be considered the point of purchase effects and are ultimately monetizable through some further economic magic. Indirect use examples include property values, industrial support services, and the ripple effect from point-of-purchase. Aesthetics can also be lumped into the indirect category. Intrinsic benefits include all benefits associated with a resource that are not directly related to the current use of the resource[2].

For this discussion, I've gathered information defined to as economic impacts, versus economic values. An economic impact addresses the business and financial activity resulting from the use of resources. Economic value measures the difference between what an individual would be willing to pay, and what they actually pay for a commodity or activity[3]. Economic impacts are made up of direct and indirect use benefits, including induced benefits expressed by Southwick Associates as those wages and salaries paid by directly and indirectly affected industries. In addition I have reviewed information from the 1991 and 1996 National Survey of Fishing Hunting and Wildlife-Associated Recreation. and other examples in order to develop a sense of magnitude regarding the benefits of a healthy river ecosystem.

First let me return to the intrinsic values or benefits that economists break into option and existence value. Option value is described as a willingness to pay for future opportunities to use or access a resource in the future. Existence value refers to the willingness to pay for existence of a resource whether future use is anticipated or not, basically the knowledge that resource services exist. The key in both of these is estimation of societal willingness to pay. In the absence of properly designed and executed surveys, and/or in-depth economic examination through contingent valuation, how might this willingness be expressed by society at large? Do Illinoisans care about the condition of the Illinois River? Is it worth something to Illinoisans to restore the health of the Illinois through improved water quality, habitat restoration, and overall biodiversity? How would we know? I will take literary license with the economic arts. In a large sense, societal goals can be manifested in public policy and through the legislative process. Do you agree? Lets explore an example:

It was worth it to somebody to go through the effort to develop the Conservation Reserve Enhancement Program agreement with the USDA specifically for the Illinois watershed. As described, the goals of the Illinois CREP are to:

- Reduce total sediment loading of the Illinois River by 20 percent
- Reduce phosphorous and nitrogen loading in the river by 10 percent
- Increase populations of waterfowl shorebirds and state and federally listed species by 15 percent within the project area
- Increase native fish and mussel stocks by 10 percent in lower reaches of the river.

The target acreage for the CREP is now up to 132,000 acres, and as of September 21, almost 81, 000 acres are enrolled with over 17,000 pending. Although an incentive-based program involving Federal funds, State funds, and a change in the landowner's management, does the CREP represent, in any sense, a societal willingness to pay? Yes or no?

Other programs that have been advanced by the public through their elected officials include the Environmental Management Program authorized by the U.S. Congress and recognizing the economic and ecological significance of the Upper Mississippi River System including the Illinois River. The Illinois River Watershed Restoration Act. Passed in 1997, the legislative purpose states that the restoration and conservation of the Illinois River Watershed is in the ecological and economic interest of the citizens of this State; and Section 519, Illinois River Basin Restoration, authorized by the 2000 Water Resources Development Act. The Illinois 2020 Initiative, building on the success of the CREP partnership is also underway. In the absence of contingent valuation examination, do these efforts at all signify societal willingness to pay? Real economists may disagree, but I would postulate that society cares.

Back to the subjective question: What good are they? Why the need for all the legislation, programs, and expense? An example: What good is a clam? The economic answer is: Blodgett et al. 1998 reviewed information on the economic and natural heritage values of Illinois River mussels. Large-scale exploitation of our native mussels began with the pearl button industry. In the paper presented to the 1997 Governor's conference, 1908 income from commercial shelling near the historic 1909 peak was equivalent to $2.3 million in 1996 dollars. As overharvest began to reduce shelling, income dropped to 1.4 million in 1913. Mussel populations, shelling and associated income dropped over the ensuing years due to the combined effects of overharvest, pollution, river regulation, and market forces from the introduction of plastic. Shelling rebounded with the growth of the Japanese cultured pearl industry, and increased through the early nineties. In addition to these obvious economic benefits of a healthy ecosystem, the authors also pointed out the intrinsic values associated with the immunology and physiology research potential of freshwater mussels.

Getting into another analysis, the Illinois component of the 1996 National Survey of Fishing Hunting and Wildlife-Associated Recreation[4] provides some State-specific information, but was not designed to analyze respondents specific to the Illinois River watershed. Therefore it is relevant to consider that the Illinois River watershed comprises over half the total land area of the state, and includes or draws recreationists from the metropolitan Chicago and St Louis areas as well as several other major urban centers. In looking at the economic impacts of recreational fishing on the State (Figure 1), the 1996 survey used trip and equipment related costs to tally $1.1 billion dollars spent on fishing in Illinois, not including the Great Lakes. This figure represents over $898 million spent on equipment, over $128 million spent on trip-related food. lodging. And transportation costs, and over $82 million spent on other trip-related costs. Where'd they spend it? Bass clubs abound on the Illinois, the sauger returned to the Starved Rock Pool years ago and support a huge recreational fishery. In terms of commercial fishing values, between 1995 and 200 the Alton, LaGrange, and Peoria Pool fishery generated amounts from $216 to $298 thousand, averaging $246 thousand dollars per year.

So what is a duck worth? (Figure 2) Again, the 1996 survey used the same cost categories and developed total expenditures of $349 thousand, with approximately $126 thousand for big game, $102 thousand for small game, almost $ 64 thousand for migratory birds and over $21 in the other animals category. When in-State expenditures for specialized and auxiliary equipment (boats motors, ATVs campers tents, etc) are added, the total spent on hunting in-State swells to $470 million.. Where is all this going on? How much may be attributable to the Illinois watershed? How much of the economic benefits are attributable Illinois River resource values? Lets look at some more information

In looking at the Southwick data and summary figures from their report, Illinois ranked third in the nation behind California and Texas in both migratory bird hunting (Figure 3) and waterfowl hunting (Figure 4), generating $54 million and $34.5 million respectively. Lets compare Illinois' overall waterfowl hunting contribution to our Flyway neighbors (Figure 5). Our Flyway aggregated the first of the four Flyways for waterfowl hunting retail sales at $223 million in 1991. This information gives me the impression that the Mississippi Flyway is creating the greatest economic impact of any Flyway and that Illinois is creating the greatest economic impact of any state within the flyway.

Going back to 1996 data on watchable wildlife retail sales. Illinois watchable wildlife generated $1.6 billion dollars[5], up from $1.1 billion in the 1991 survey. Of those respondents the number on site visited was woodlands and the number two site type identified was Lakes and/or streams. Rivers and forested wetlands were not separated out by name, but the number one wildlife category watched was "Birds". So if one considers that the primary birding periods tend to be the migrations, and that the migrations occur along the woodlands and lakes or stream corridors, one could associate the bulk of that activity with much of the habitats intact or targeted for restoration within the Illinois watershed. $1.6 billion .... How much of that might be associated with the Illinois considered its role as a major flyway component?

One more aspect of the values or benefits associated with restoring and maintaining Illinois River Valley resources should be considered. A portion of those retail sales is directly related to money back to the state for further habitat improvements or acquisition. The federal excise tax on guns and ammunition under the Pittman Robertson Act, goes to the Federal Aid in Wildlife Restoration Program. Fishing equipment generates an excise tax under the Dingell-Johnson Wallop-Breaux Act for the Federal Aid in Sport Fish Restoration Program, and Duck Stamp Revenues come as well. All these funds add up to bucks back to Illinois for habitat acquisition, research and information distribution. Now does that demonstrate another societal willingness to pay, or is an excise tax more like a good-natured arm-twisting? In all the years of PR and DJ existence, there's been no cry from those taxed to repeal that particular levy.

In summary, a portion of the real economic values of fish and wildlife in Illinois can be calculated. The contribution of the resources within the Illinois watershed can be surmised within those totals, but however they are calculated – directly, indirectly market-non market intrinsic contingent – the bottom line is what are they worth to you? That, I feel, is incalculable.

Endnotes

[1] U.S. Environmental Protection Agency. 2001. Economic Guidance for Water Quality Standards.

[2] Ibid.

[3] Southwick Associates. 1995. The Economic Contributions of Bird and Waterfowl Recreation in the United States During 1991.

[4] U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, Bureau of the Census. 1998. 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. FHW/96-IL.

[5] Southwick Associates. 1998. The Economic Benefits of Watchable Wildlife Recreation during 1996 in Illinois.

Figure 1.

Value? What's a fish worth?

- **Calculated using trip - related and equipment costs.**
- **Illinoisans spent $1.1 billion on freshwater other than the Great Lakes in 1996.**
- **Where?**

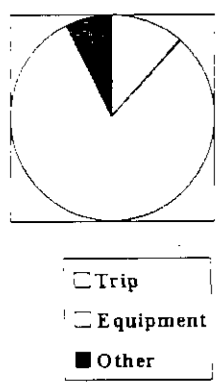


Figure 2.

Value? What's a duck worth?

- Primary measurement by equipment, trip - related, and other costs.
- Waterfowl not separated within $63.7 million 1996 mig bird expenditure.

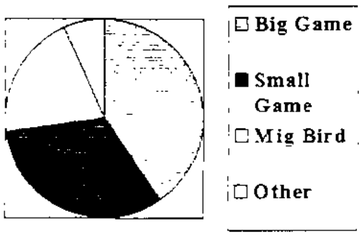
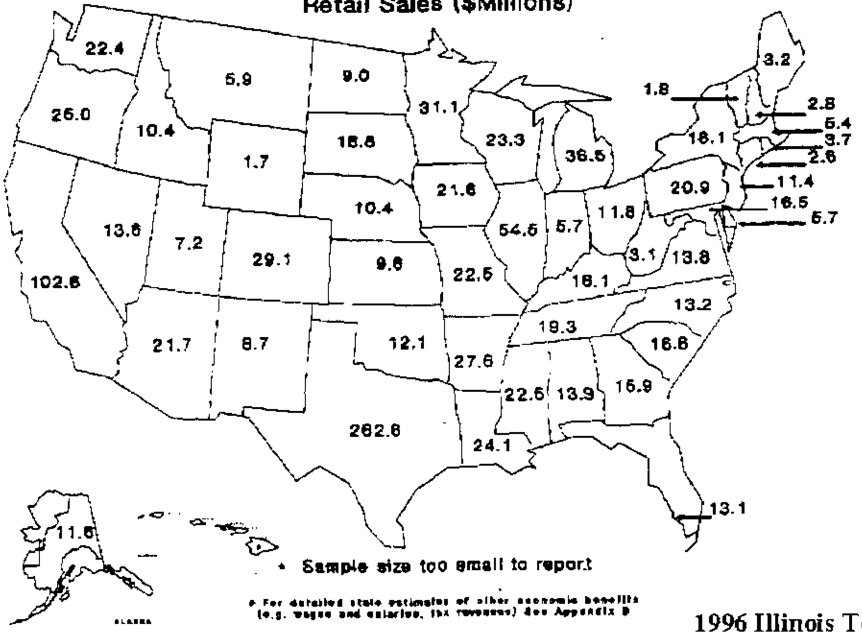


Figure 3: 1991 Migratory Bird Hunting: Retail Sales ($Millions) *



1996 Illinois Total:
$63.7 Million

Figure 4: 1991 Migratory Waterfowl Hunting: Retail Sales ($Millions)*

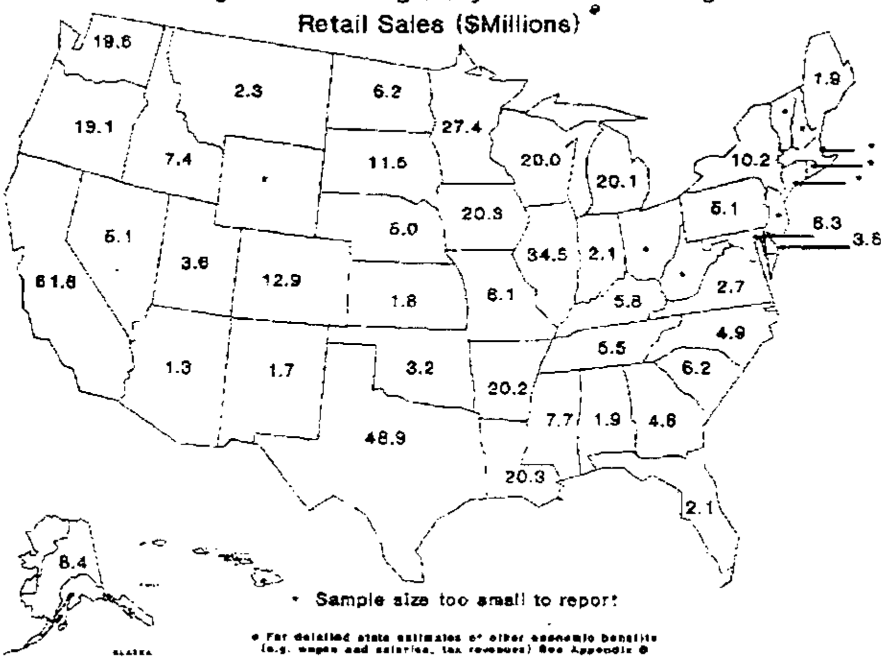
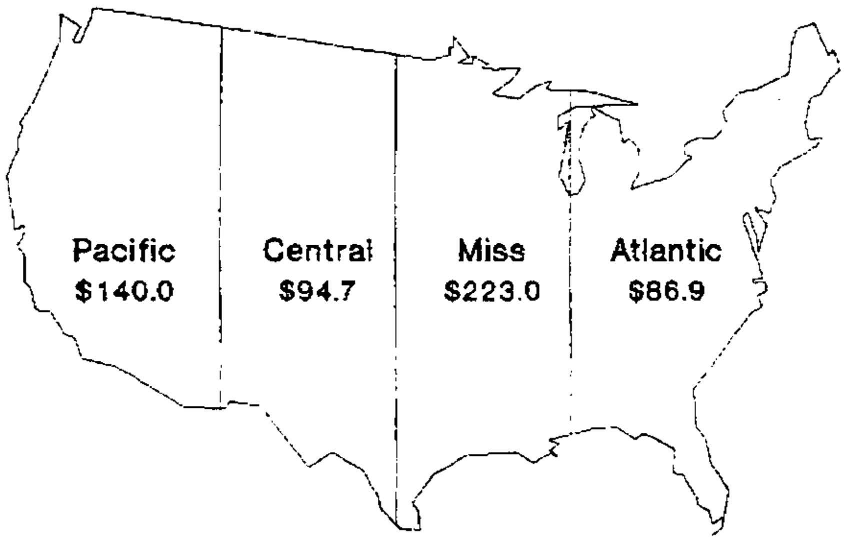


Figure 5: 1991 Distribution of Migratory Waterfowl Hunting Retail Sales by Flyway ($Millions)



FEATURED SPEAKER

Lt. Governor Corinne Wood

214 State House, Springfield, Illinois 62706

Thank you MaryAlice Erickson for your very kind introduction. Isn't it amazing that even people who are "retired", keep working and working and working. I think MaryAlice Erickson is Peoria's and the Illinois River's energizer bunny. So MaryAlice, thank you for all you've done. Let's give her a round of applause.

MaryAlice does serve on the Illinois River Coordinating Council, and there are a number of Council members here today and so if you're a member of the council, would you please stand. Don't be shy, you should be proud of all the things you've been working on. Thank you.

We wouldn't have the successes that we've had at the state level, if it weren't for some of our state legislators who have been champions. I believe that Representative Slone is here today, to again show her support for the Illinois River. And I want to say thank you to her.

I would like to recognize two others who are with us here today. When we when to Washington, and I'll explain to you a little bit about how we put this all together, it's something I didn't do alone. We partnered with three state agencies. Two of the agency directors are here today. I want to say a special thank you to Brent Manning, the Director of IDNR and Joe Hampton, the Director of the Dept of Agriculture. If you're here today, would you please stand gentlemen. Now when you see these guys stand, you'll know what I mean that when I say I went to Washington, they were my linebackers, because they were the ones who forced us through the doors and worked with me hand in hand to get this program passed.

I also want to thank all of the organizers and chairmen for today's events. As I understand, this conference continues to grow, as people become more aware of the importance of water resources and preserving our water resources. A special thank you the Heartland Water Resources Council who I know has made an enormous impact on this conference and I want to thank you for your continued focus and your commitment.

Before I talk a little bit about rivers and waters, I do want to take a moment to reflect on the last couple of weeks in American. A few a weeks ago we experienced an American tragedy. Cowardly terrorists took innocent lives, and they threatened our physical security on our homeland soil. But what has been heartening, in all of this devastating loss, is the sense of spirit. Americans becoming united as one people, us saying it's time to rebuild, heal and to move on. I have to tell you, as I have traveled throughout this state, I've seen American flags on homes, businesses and car antennas. And I think this is the silver lining in the dark cloud, that we are one people, we are united, and we will survive this. I do hope and pray that as the president and the national leaders work to insure our physical security, that we here in Illinois and all of you help make sure that we keep our economic security. And that is why it is important for us to get back to business and move on. To show that we will not give in and we will not give up, not to terrorists or a struggling economy because after all we are all Americans. There is no doubt that in the past weeks a lot of our emphasis has shifted, not only for elected officials, but also for our national leaders. And I do want to say that even though our focus is on our physical and economic security, this doesn't mean that we should not continue to be a vigilant in our fight to protect our natural resources. Will it make it more difficult to perhaps move some of the projects through Congress? Perhaps, but hopefully in a few weeks time and a few months time, we will have overcome our immediate challenge and we can get back to business. We have started something wonderful here in Illinois with the Illinois Rivers 2020 program and with all of you here in this room. And it is something that has been building and growing for many years. And despite some of our changing priorities, I can tell you that once that has passed I know that all of you will continue to join me in supporting our commitment to Illinois River restoration.

Through the Illinois River Coordinating Council, of which I chair, we have met for almost three years. One of the first things we did at the council was to take the plan that was developed by many of you in this room with your input, and say, ok, we've made a plan, now let's take some action. And because of the commitment of the Illinois River Coordinating Council members, we were able to develop the Illinois Rivers 2020 plan. I am very, very proud of the plan that was pulled together by so many different people. It truly was done on many, many levels, from federal agencies and representative to state agencies, to local planning councils, to grass roots supporters and organizers. Altogether, we put our ideas together and came up with the best restoration plan in the country. So I want to take a few minutes to talk about Illinois River 2020 and where we are going from here. I know that some of you have with us from the beginning and hopefully some of you will be joining us as of today.

I believe that Illinois Rivers 2020 is one of the most significant river related programs in Illinois since the Corp of Engineers started building bridges and locks and dams in the early 1900's. The Illinois River impacts more that half of our 102 counties and it takes a very unique approach to conservation and restoration, because rather than focusing on a single effort, we brought all these efforts together into one comprehensive plan. More importantly we have been able to bring together parties who are interested in our rivers, from agriculture and conservation to environmental interests so that we could address the needs as a whole. I believe that we have forged some very important partnerships, it's not every day that you can bring The Nature Conservancy and the Illinois Farm Bureau to sit around the table together. We were able to do this because we found what our common goals were and worked to achieve them. As I said, we have also worked with several state agencies, Dept. of Agriculture, the Dept. of Natural Resources and the Illinois EPA, to make sure that they can be our partners and we move forward in this effort. As MaryAlice noted, we received the support of the entire Illinois Congressional Delegation, democrats, republicans, upstaters, downstaters, all because they recognized how important and how vital the Illinois River system is to Illinois. The Illinois Rivers 2020 program is multifaceted. We've talked about improving the water quality in the entire 54 county river basin. We've talked about restoring, enhancing and preserving habitat for plants and wildlife. We've planned on increasing economic opportunities for our agricultural community. Protecting farmland and open space. And enhancing the Illinois River's value as a vital transportation corridor. This is indeed a comprehensive plan, more importantly this program is voluntary and it's incentive based. Our goal is never to take anyone's land or dictate how they use it, but rather we focused on a plan to provide economic incentives, so that people will participate in the programs. So we can help prevent erosion and safeguard water quality, and keep other pollutants out of our creeks and streams. And keeping the economic situation of the river strong will also help keep Illinois' economy strong. Efforts to preserve our river system are also important because of the river's impact to our entire state. Many of you know that roughly 90% of Illinois' population lives in the Illinois River Basin, nearly 1 million people depend on the Illinois River for drinking water, more than 10 million acres of the world's most productive farm land is located within the Illinois River Basin. More than half of Illinois' corn crop is transported on the Illinois River, so it is a very important vehicle for transportation. The Illinois River is one of the few rivers in the nation to still have a functioning ecosystem, one that supports a whole range of fish and wildlife. So in short, the Illinois River is one of America's most important waterways and its watershed is one of it's most fertile and most populous. But we all know in this room that it has also been in grave danger of destruction for a long, long, time. We know that everyday the equivalent of 18 thousand truckloads of eroded soil are dumped into the river basin and that destroys wildlife habitat, and compromises the waterways recreational use and clogs our transportation channels. We know that urban sprawl continues to consume thousands of acres of fertile farmland and wetlands, which increases problems with stormwater management and flooding and erosion. The costs of keeping the transportation channel open on our Illinois River are continually rising. But as I said, this is not a new problem, this is something has happened over decades, but in some areas of our river I believe it is approaching crisis levels. The benefits of implementing the Illinois Rivers 2020 program is to allow us to manage some of these problems. Again, by looking at the whole range of issues. We looked at expanding stream bank stabilization programs, enhancing flood protection, increasing biological diversity by providing better nesting, feeding and breeding habitat for waterfowl and amphibians. We've worked to improve water quality and also the safety and health aspects of the river when it is used recreationally. We also know that increased economic growth and tourism will benefit as we improve our Illinois River waterways. The original plan that was put together by the Coordinating Council is a 20-year plan, it's long range and it's comprehensive. And over the past 3 years, we have worked hard to implement the plan and to receive the funding necessary so that it can be a success. We went to Washington with the support of grassroots organizations, more than 350 mayors who signed on, the support of our congressional delegation, who by the way was lead by Congressman Ray LaHood whose done an outstanding job in getting this program through congress. For all of you might work for a federal agency or dealt with a federal government, I think you will appreciate my next comment that I'm going to make. We went to Washington with a 20-year comprehensive, 2.5 billion-dollar plan, and tried to explain why we needed it in Illinois and why we needed it now. And for those of you who have worked in the federal arena, know that it could take 10 years to pass a coma in a piece of legislation. We went with all of our partners and we got the Illinois Rivers 2020 plan passed in our very first try. Not only did we get it passed, we were authorized to begin the program with 100 million dollars and that's over the first 3-year period. And I think that it is probably unprecedented to be able to go to Washington get a plan passed, get authorization amount and to be moving forward with a program of this magnitude. We were able to do this because we had broad-based support, many of you in this room were active participants. We were also able to do this because it was the right thing, it made sense, we had built a consensus, we identified our issues, and we set goals. So together with federal agencies, state agency partners, local organizations we were successful. But now our real work begins, though passing Illinois Rivers 2020 was a tremendous victory for Illinois and environmental and conservation policy, the hardest work truly is yet before us and we will continue to need to call upon you as our appropriations move through Washington. We've had some immediate success; some funding that has come from federal agencies. A few months ago at the State Fair, Thomas Shipman, who is the acting Deputy Under Secretary of the Farm and Foreign Agricultural Services, signed an expansion of a very popular program we have in Illinois, called the Conservation Reserve Enhancement Program. In August we signed an expansion of that program and we increased the acreage that were allowed of 100,000 acres up to an additional 32,000 acres. What this means is not only will we be able to add 32,000 acres to this very popular conservation program, but it will mean that over the next 15 years about 75 million more dollars from the federal and state government in support of this program. So I do consider that an early success. The expansion of CREP came about as a direct result of a meeting we had, with then, Secretary of Agriculture, Dan Glickman. And again we went with state agency representative, our congressman and local supporters to explain why this program was so important to our Illinois Rivers 2020 plan, and why in Illinois we would be successful in implementing it. So a few short months we had something to actually deliver. and I'm very, very encouraged by that. We also received about 5 million dollars to develop some of the plans under WRDA. and for those of you who might not live and breath by initials, I will tell you a few years ago, I knew about rivers, conservation issues, restoration, but I still spoke in full words. But now when I speak it's, WRDA, CREP, WHP, EQUIP….. and all of the other acronyms that all you live by and although I am still not as good as some of the scientists on the River Coordinating Council. but I do feel I've come a long way. But one of the other instrumental parts to our Illinois Rivers 2020 program is called the WRDA program and we have already been authorized 5 million dollars to start that program. And I believe that it is actually today in Washington, the Senate Agriculture Committee is considering additional funding that will benefit the Illinois Rivers 2020 program. What we are asking in that program and is part of the Ag Committee hearing is 100 million dollars for about 200,000 acres for CRP contracts, 1.5 million to add 1,000 acres to WRP, 4 million for EQUIP, 100,000 for WHIP. But the point is, we are moving, we are continuing to find funding for our projects in the Illinois Rivers 2020 program, we're continuing to work together despite some of the immediate challenges we are facing. I will say that our defense and economy has to be our priority now, but that does not mean that here in Illinois we can't continue to support the Rivers program, whether we are in Washington supporting the increased appropriations, or whether we are in Illinois helping to clean up our Illinois River. These are important efforts to bring everyone together. I would like to invite all of you to attend our 2nd annual Illinois River Sweep, which takes place October 13th. We will be meeting from near Joliet to Grafton. Last year we had over 2000 volunteers signed up for our first ever, we had Boy Scouts and Girl Scouts and we hope to get even more people this year in helping to clean our rivers. I can tell you when you see a young child pull a tire out of the river, what that means to them, and we pulled out lot of tires, refrigerators, we pulled out some unbelievable thing. But more importantly we pulled people out to volunteer, to help us restore our river, and they're involved and invested. As important it is for us to get the money from Washington for our programs. I believe it is equally as important that we continue to build the grassroots support, because when you build from the bottom up, there's now way it's going to fail.

The CREP program continues to be what I consider to be the linchpin of our Rivers 2020 program and we continue to lead the nation in the number of sign up contracts. At the end of September we had over 4,000 agreements signed, more than 80,000 acres involved in the program, and more than 17,000 acres still pending. For those of you involved in the program, keep up the good work. It's because we are leading the nation in this program that we were able to go to Washington and say "See in Illinois we can get it done and here's proof". So we will continue to make sure that we increase and support the funding for CREP.

Some times I get asked, "What is a nice girl like you doing in business like this?" and there are times when I ask myself the same thing. Because there are a lot of challenges. But I know that if there is nothing ventured, then there is nothing changed. And whether as a legislator or as Lt. Governor, I have always worked to set aside political differences to do the right thing. Whether it was improving healthcare services for women and families in Illinois, or whether is was rebuilding our infrastructure, our transportation system, or whether it was restoring our Illinois rivers, I'm very proud of what we have been able to accomplish in three years as Lt. Governor. And I can tell you that if I am fortunate enough to be elected Governor, that I will continue to do the right thing and I will look forward then the eight years to support the Illinois Rivers 2020 program. Thank you all very much for all you've done and it's my pleasure to be here.

GEOLOGICAL HISTORY OF THE ILLINOIS RIVER WATERSHED

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The landscape of the Illinois River watershed was created by extraordinary geological processes that shaped the upper Midwest over the past million and one half years. During the Pleistocene era, great, continental-scale glaciers repeatedly entered Illinois from the northwest and northeast, having flowed from central Canada, more than 1000 miles north of the modern Illinois River. At least three major glaciations affected Illinois, and each strongly modified the landscape. Most of the glacial lobes that covered Illinois emanated regionally from the Lake Michigan basin, but there is also evidence of ice flowing in from the northwest (Fig. 1). Flowing ice and related geological phenomena, including winds and meltwater streams, are agents that sculpted bedrock and pre-existing sediments, leaving sedimentary deposits up to several hundred feet thick. Effects of the last glacial episode including creation of complex morainal topography, widening and incision of the Illinois valley by huge floods, and deposition of a layer of wind-blown silt over most of the watershed uplands are perhaps the most important to us today. Geomorphological modification of this landscape continues today by both natural and human processes. In this paper we discuss the complexity of glacial environments and sedimentary deposits, and summarize the dramatic history of the Illinois River.

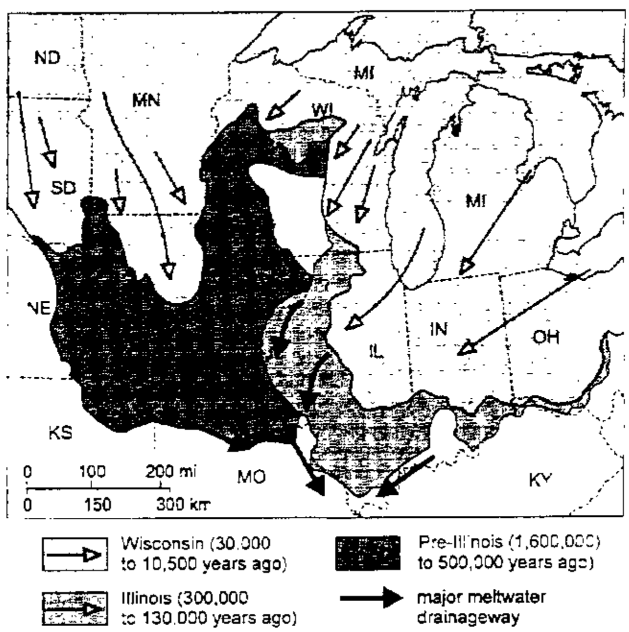

Figure 1. Furthest extent of Pleistocene ice advances across the Midwest. Open arrows indicate general ice flow directions; closed arrows indicate major meltwater drainageways. From Killey (1998).

GLACIAL ENVIRONMENTS AND PROCESSES

To understand what glacial environments are like, we can compare old landforms and sediments, such as those in Illinois (Fig. 2), to landforms and sedimentary processes occurring where glaciers presently exist. The modern analogues are not always directly comparable to the vast Pleistocene ice sheets, however, because most modern glaciers are relatively small and flow in mountain valleys. The glaciers in Antarctica and Greenland, although of appropriate continental scale, exist in much colder climates than prevailed near the Pleistocene ice margin in Illinois.

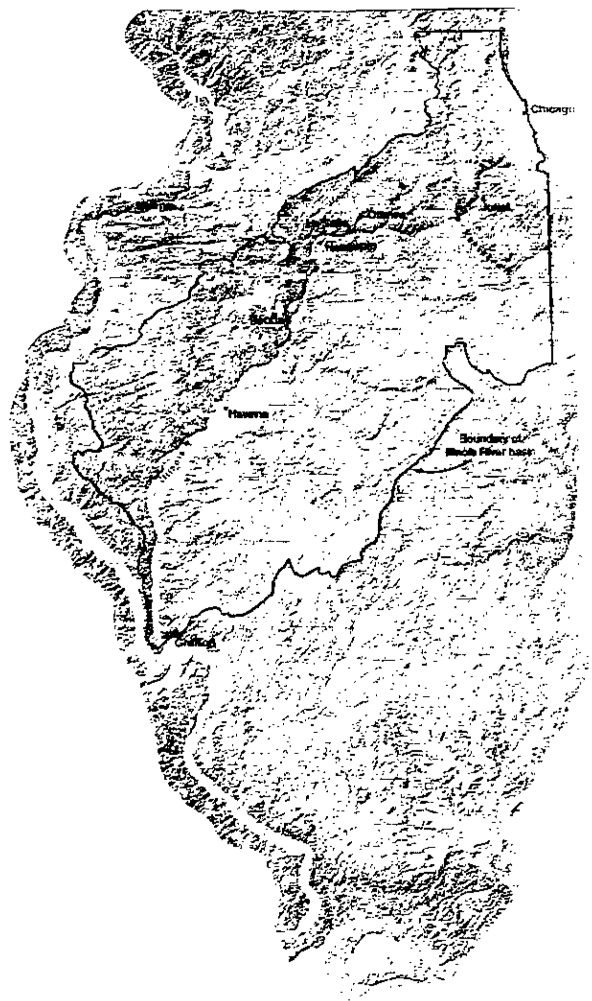

Figure 2. Shaded relief map of Illinois showing the boundary of the Illinois River watershed, included counties, selected cities, and major rivers. Base from Abert (1996).

Many different geological processes operate in glacial environments, and each leaves characteristic deposits and landforms. The processes are active before, during, and after glaciation, but higher rates of sediment production occur during maximum ice advance and retreat. The glacier moves over the subglacial surface either by sliding or by riding on a deforming mass of glacial muds. Up-ice from the glacial margin, glaciers erode pre-existing sediment and bedrock, which is crushed into clay and silt ("rock flour"), sand, pebbles, and boulders. This heterogeneous mixture is transported by ice as a stony mud towards the ice front where is deposited subglacially as till[1] blankets, mounded up at stationary ice fronts as end moraines, or washed out of the ice in meltwater streams. End moraines, composed of glacial muds and gravels, are formed when warming climate melts ice at the margin at about the rate that replacement ice flows from the source. Sediment then accumulates during this period along the quasi-stationary front during this period. The end moraine will be preserved if climate continues to warm, causing retreat of the ice margin. Repetition of this scenario resulted in the arcuate landforms that distinguish the northeastern quadrant of Illinois. These end moraines are now separated by plains of till and lake sediment.

Meltwater flows from the ice front in streams. The river environment in glacial settings is distinguished by typically abundant supplies of meltwater and sediment. As well, there is sparse or no vegetation on the landscape to hold the sediment in place on channel banks. Channels develop a braided pattern in which multiple channels exist simultaneously. Through the erosion and deposition of sediment, these channels are formed, abandoned, and migrate laterally in matters of hours. Sheets of sands and gravels are deposited by the braided system. As well, rock flour may also be deposited from the muddy meltwater during periods of low flow. When flow is confined within valley walls, the system is described as a "valley train"; when flow is unconfined, the sheets form vast outwash plains. Both of this settings can be identified on the Illinois glacial landscape.

Strong, persistent winds are characteristic of glacial environments. The winds arise in part because of the dramatic contrast between the cold ice and warmer unglaciated environments.

[1]Deposits of stony mud are described generically as "diamicton". When the deposition of diamicton can be attributed to ice, it is called "till".

These winds erode mainly fine sand, silt, and clay from the barren landscape, and especially from sandy outwash plains. Although we can observe small dust storms in modern environments, there are no modern analogues for the loess storms of glacial episodes. During those times, fine sediments were deposited as blankets and in dunes over great expanses of the landscape. The loess deposited in Illinois was the parent material that developed into the best agricultural soils in the world. At the same time, these soils are among the world's most erodible, leading to their rapid return by runoff from our heavily farmed and developed landscape to the river valleys from which they originated.

The morainal ridges and glaciers in northeastern Illinois formed natural dams that allowed temporary lakes to form between them. Sediment that filled these large lakes included sand to gravel in deltas where streams entered the lakes, and horizontal layers of silt and clay in the quieter parts. The dams failed either by lakes spilling over and eroding the dams or by shifting glacier ice. In such cases torrential floods resulted. On November 5, 1996, one of the few observed failures of a subglacial lake occurred in Iceland. In less than one day, a deposit more than 30 foot thickness of sand, gravel, and boulders larger than houses was dispersed many miles from the ice front (Smith et al. 2000). This may have been similar to floods that occurred along the Pleistocene glacier front.

THE PRE-GLACIAL ENVIRONMENT

Our story of the Illinois River Basin begins at the bedrock surface, depicted in Figure 3 as a shaded relief map. The landscape prior to the Pleistocene glaciations featured broad, shallowly-incised valleys with sandy floodplains. A thin soil covered the uplands. The relief of the terrain was much rougher than exists today at the land surface, and can be appreciated by looking at our unglaciated terrain in the northwest corner of the state (Fig. 2). The Ancient Mississippi River originally flowed in a now buried valley from the northwest corner of Illinois near Galena to Tazewell and Mason Counties, where it was joined by the westward-flowing Mahomet River. From there, the Ancient Mississippi flowed southwards down the path of the present-day Illinois River. The broadness of the valley just south of the confluence as seen in Figure 3 attests to erosion by actively migrating streams and possibly high water discharges in the early Pleistocene. The Ancient Iowa River occupied portions of the modern Mississippi Valley upstream of Grafton (Figs. 2, 4).

The bedrock surface predominantly comprises sediments deposited in shallow seas and related environments between about 100 and 500 million years ago[2]. The northern and northeastern portions of the Illinois River basin are underlain by relatively resistant dolomites and limestones, while most of the rest of the basin south of the upper Illinois River is underlain by softer shales with minor coal, sandstone, and limestone of the Pennsylvanian Period. Both these rock types and pre-glacial drainage patterns influenced the ensuing glacial events that shaped the present land surface.

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[2]The ages used here were based upon radiocarbon dating, but because the atmospheric concentration of ^{14}C has not remained constant, radiocarbon years do not correspond exactly with calendar years. Dating of tree rings and corals has made calibration of radiocarbon years to calendar years possible, but dates can still vary by up to several percent. As a general rule, radiocarbon dates older than about 3000 years are younger than the "real" ages.

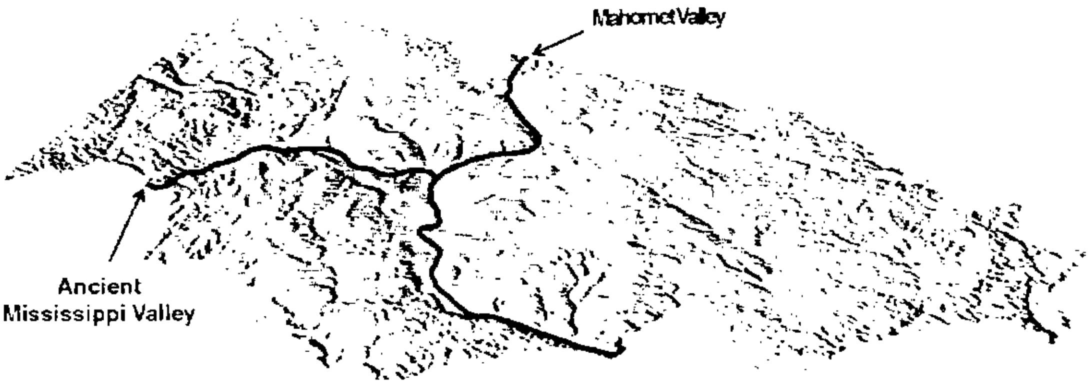

Figure 3. Shaded relief map of the bedrock surface. Map originally constructed by Barb Stiff.

THE PRE-ILLINOIS GLACIAL EPISODES

Although we have no accurately dated sediments for this period in Illinois, investigations in states west of us suggest that one or more glaciations affected our state between about 1.5 million and 425 thousand years ago, prior to the Illinois Episode,. These early glaciations are poorly known because the deposits are either deeply buried or were extensively eroded during subsequent glacial episodes. Before ice reached Illinois, abundant meltwater flowed from the glacial margin and deeply incised existing bedrock valleys. Ice flowing from the northwest overrode the Ancient Iowa River (Figs. 2, 4). Ice flowing out of bedrock depressions in the northeast reached as far south as the Shawnee Hills. This ice lobe overrode the Mahomet Valley, filling it with up to 150 ft of river sands and gravels covered by glacial till. The Mahomet Valley drainage was diverted southward to near the modern Ohio River valley (Fig. 4). The Ancient Mississippi was constrained between the two ice lobes flowing from the northwest and northeast, respectively (Fig. 4), and its valley also received a thick sequence of sand and gravel. After ice retreat and during the warm Yarmouth interglacial episode, when climate was much the same as today's, the Ancient Mississippi re-occupied its former course from Galena to Grafton, but the partially filled-in Mahomet Valley no longer served as a major drainageway.

THE ILLINOIS GLACIAL EPISODE

During the Illinois glacial episode, about 300 to 125 thousand years ago, three major ice advances from a northeastern source extended across the state (Fig. 5). Each overrode the Illinois Valley and diverted flow of the Ancient Mississippi westward. Till and lake silts near St. Louis indicate that at least one ice advance crossed the modern Mississippi and dammed that valley, as well (Goodfield 1965: Grimley et al. 2001). Portions of the lower reaches of the Illinois River functioned as the main outwash conduit at times during the Illinoian glaciations. Most of the sediments of this episode in northeastern Illinois were eroded by later ice advances, but relatively thin, sandy till and some sand and gravel (outwash) deposits were preserved in some bedrock

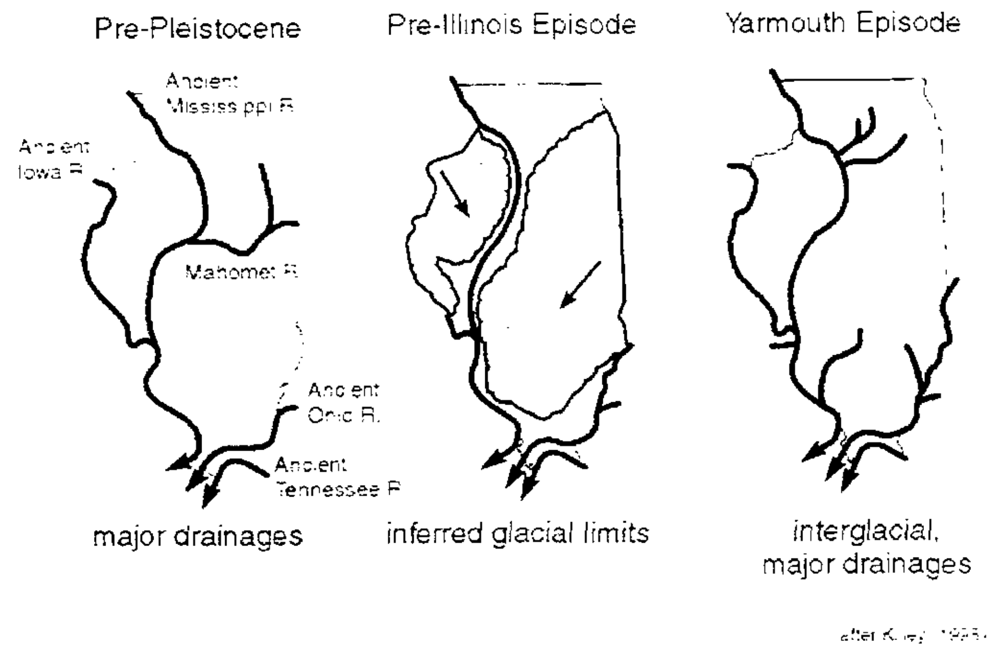

Figure 4. Drainage patterns and ice advances before the Illinois Glacial Episodes.

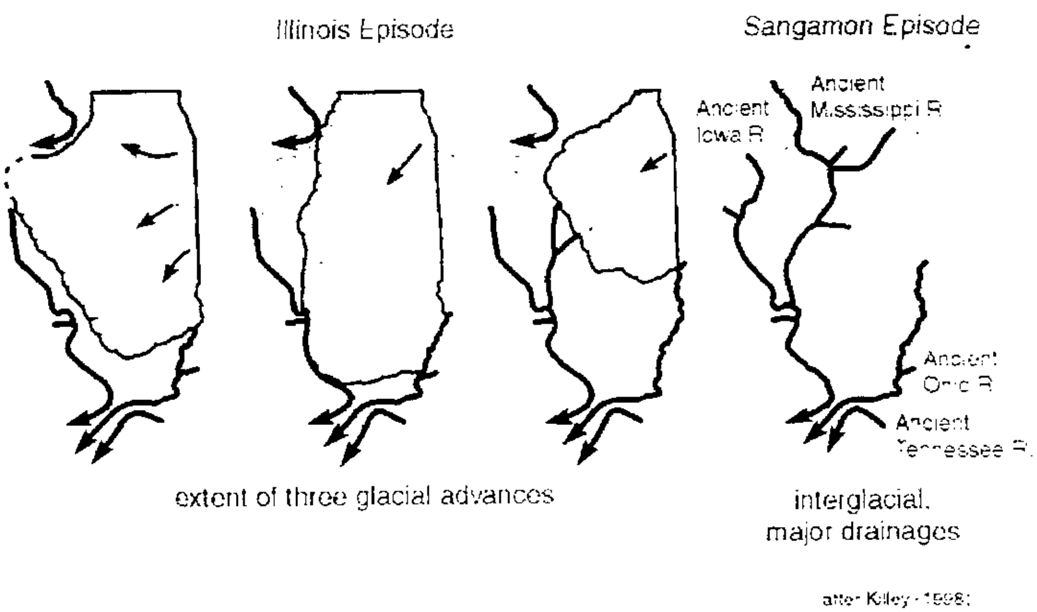

Figure 5. Drainage patterns and ice advances during the Illinois Glacial Episodes and ensuing interglacial episode.

valleys under what are now upland areas (Kempton et al. 1991; and many others). In addition, during the last Illinoian glacial stage, sand and rock flour were picked up from sandy outwash plains by strong westerly winds and deposited on uplands as dunes and blankets of loess.

The ensuing Sangamon interglacial episode was an interval of moderate climate not unlike today. It lasted about 70 thousand years. The Ancient Mississippi river resumed its course across what is now called the Green River lowlands (the low relief region west of the modern Illinois River basin and including portions of Henry and Bureau Counties, Fig. 2), and entered a bedrock valley just east of Peoria (Fig. 3; Willman 1973; Killey 1998). The ancestral Des Plaines River was a major tributary and joined the Ancient Mississippi at what is now the "Big Bend" of the Illinois River, upstream of Hennepin (Fig. 5). The Ancient Iowa River also flowed down its old valley, but the Mahomet Valley had been completely buried by glacial sediment by this time.

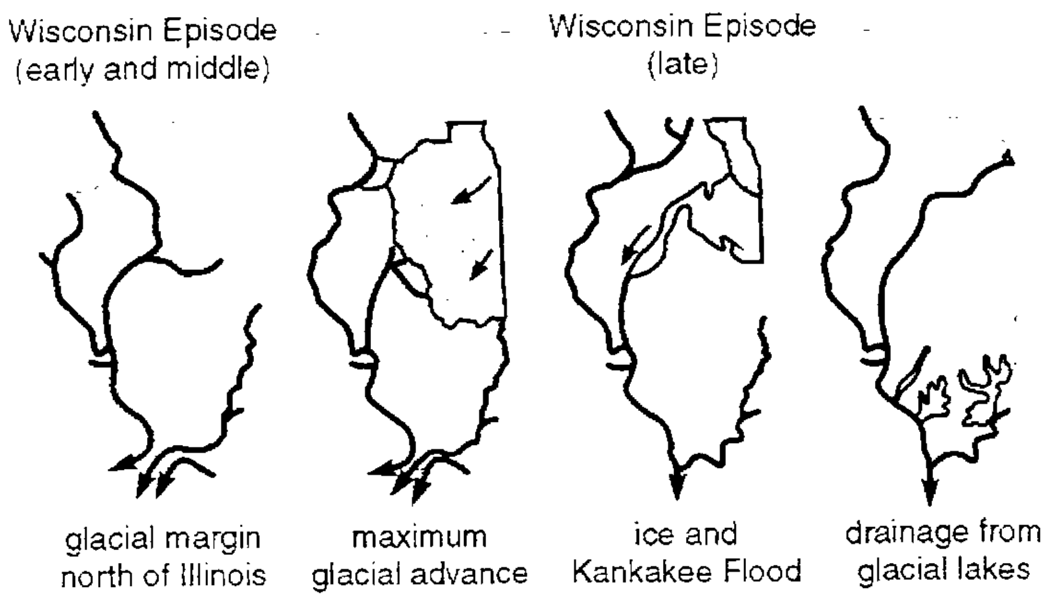

Figure 6. Drainage patterns and ice advances during the Wisconsin Glacial Episode.

THE WISCONSIN GLACIAL EPISODE

Glaciers remained north of Illinois during much of last glacial interval. the Wisconsin Episode, which occurred between about 55 thousand and 10 thousand years ago. Little is known about the early to middle parts of the Wisconsin Episode in the Illinois Valley because deposits from that interval were subsequently eroded or deeply buried (Hajic 1990). However, the Ancient Mississippi served as the main regional conduit for meltwater discharge from glaciers which loomed north of us (Fig. 6). After a period of incision prior to the last glaciation, the lower Illinois Valley was aggraded with 65 to 80 ft of sand and gravel (Hajic 1990). In the St. Louis area, for comparison, outwash streams in the earliest Wisconsin Episode flowed on bedrock 70 ft below the modern day floodplain. Sediment steadily accumulated in the valley to a point about 18,000 years ago when outwash streams were 50 feet above the modern floodplain (Curry et al. 2001).

Unlike earlier ice advances, the last glacier to enter Illinois came only from the northeast

(Figs. 1, 6). The Lake Michigan and Lake Erie lobes flowed out of the depressions now occupied by Lake Michigan and Lake Erie, respectively. The Lake Michigan lobe first entered Illinois about 24,000 years ago. Although ice ultimately covered only the northeastern quarter of the state, the effect upon the landscape was profound. Beneath the glacier, some pre-existing Pleistocene deposits were eroded completely to bedrock (Willman 1971). The present-day configurations of the Mississippi and Illinois Rivers were formed about 20,000 years ago when the ice lobe reached its furthest extent near Peoria. Water flow down the Ancient Mississippi was once again diverted westward by ice blockage to form a major meltwater outlet near Moline (Bettis 1987; Hajic 1990; Curry 1998). High discharge from the Moline outlet was sufficient to erode the Ancient Iowa River Valley down to bedrock and permanently divert the Mississippi down its present course. The bedrock valley between the moraine near Big Bend and Moline was filled mainly with outwash deposits of sand and gravel (Killey 1998). The lower Illinois River was a secondary meltwater conduit during the period of diversion.

Warming climate caused the Lake Michigan lobe to retreat from its terminal moraine by about 19,500 years ago. The exact timing of events that occurred between the beginning of the retreat and the end of the glacial period is not well known because there is little material in the deposits that may be dated using radiocarbon methods. A relative geological history is instead inferred from geomorphological and stratigraphic evidence (Hansel and Johnson 1992). It is clear that the glacier retreated back towards the Lake Michigan Basin with repeated short advances to create onlapping end moraine systems. The Illinois Valley became the main drainageway (Fig. 6), carrying meltwater and abundant sediment from the retreating glacier. Lakes formed repeatedly between the ice front and existing moraines when outlets were either blocked by sediment or by water during torrential flood events. One of the largest floods, named the "Kankakee Flood", occurred due to the failure of a dam formed by the Marseille Moraine just east of Ottawa (Fig. 2). At this time the ice front rested on moraine just west of Chicago. As melting of the glacier at this position reached its peak, meltwater was also diverted from glacial lobes to the east down the Kankakee Valley. The spillway of the Illinois Valley in the Marseilles Moraine was not large enough to accommodate the huge volumes of combined meltwater. A lake formed upstream of the spillway (Willman 1971). Rising floodwaters eventually breached the morainal dams, and additional spillways were eroded, notably in McHenry County and areas in north-central and north-east Indiana (Fig. 6). Effects of the Kankakee Flood downstream of Ottawa include benches scoured to bedrock and the transport of large bedrock clasts near Morris and LaSalle, erosional terraces on uplands where a larger river channel was temporarily created, and the deposition of large gravel bars plastered on the valley walls (Willman 1971; Hajic 1990). A large flood down the Fox River valley left similar erosional features and deposits.

With further retreat of the glacier caused by warming climate and a subsequent minor advance, Lake Chicago was impounded between the glacier and moraines bordering present-day Lake Michigan (Figs. 1, 6). Lake Chicago discharged through the morainal spillway that is the present day Des Plaines Valley (Hansel and Mickelson 1988). This outlet was abandoned and reoccupied several times in response to phases of glacial melting, precipitation, and reorganization of drainage from the Lake Huron and Lake Erie depressions towards the Atlantic Ocean by differential isostatic uplift (Hansel and Michelson 1988). During Lake Chicago's earliest and highest level, about 14,100 to 12,700 years ago, the spillway was eroded down to bedrock and the river was estimated to be 40 ft deep. Subsequent lake highstands during the latest glacial (about 12,700 to 11,000 years ago) and post-glacial periods (about 5,000 to 4,000 years ago) were progressively lower.

Throughout the Wisconsin Glacial Episode and early Hudson post-Glacial Episode, the lowermost reaches of the Illinois Valley also responded to events downstream in the Mississippi Valley. Repeated flooding, aggradation, and incision in the Mississippi Valley is attributed to discharge from Glacial Lake Agassiz, a vast impoundment containing all of the drainage from east of the Rockies that now enters Hudson Bay, Canada. This caused episodic ponding in the lower Illinois Valley and the accumulation of lake silts and sands in the Valley and its tributaries (Wanless 1957; Hajic 1990). The deposits were left as terraces along the valley walls upon re-incision of the river system.

THE HUDSON POST-GLACIAL EPISODE

Glacial events of the past created our present landscape and left up to several hundred feet of sediment beneath our feet. However, modification of this landscape continues today by action of wind, water, people, and other organisms. Indeed, many of the same processes occur today as in the glacial times, although rates tend to be more subdued. Significant environmental concerns in the Illinois River Basin in which geological processes play a role include siltation of lakes, particularly along the mainstem of the Illinois, loss of property to river erosion, damage to structures by slope failures, and restoration of ecosystems.

The loess deposited by winds during glaciation covers much of the Illinois River Basin. It is 10-20 feet thick on the uplands next to the source areas in the valley bottoms, but thins away from valleys to a blanket several feet thick. This loess provides the parent material for the fertile soils that are the foundation for the agricultural richness of Illinois. However, the silt is highly erodible, and thus is readily transported back into our waterways. Some portion of this is eroded from gulleys and rills that develop in fields, although, because of low slopes, that eroded sediment is likely not transported far in any given event. Most of the sediment transported by streams originated in mass failures along steep valley walls and from channel bank erosion when streams migrate laterally or widen their channels (Urban 2000; Simon 1989).

Alluvial fans and fan deltas are constructed of gravel, sand, and silt deposited at the mouths of tributaries where gradient abruptly lessens. Prominent fans can be found at the mouths of many of the streams that enter the lower Illinois River. They have been developing throughout the Hudson Episode. The fans are not normally eroded by the Illinois River because the river has low gradient and therefore low energy, particularly in the pools above Beardstown. The fans influence the river instead by diverting its course. They thus provide significant areas of sediment storage and are potential sediment sources when river energy level is higher during floods.

Erosion and deposition are natural processes and would occur whether or not people and their structures are part of the picture. Streams mobilize sediment by downcutting and lateral migration, though neither one necessarily indicates that the streams are doing anything abnormal. The processes only become a problem when some aspect of property or people's structures become involved. Downcutting, or incision, is more likely to occur when some aspect of the stream energy is increased. This may be an event downstream such as lowering of the water (or "base") level in the receiving basin or stream, straightening of a stream reach, or an increase in water flow without a concomitant increase in sediment load. The disturbance then tends to migrate upstream, causing deepening and narrowing of the stream channel and perhaps increasing the tendency for slumping along the channel banks. Lateral migration is more likely to occur when base level rises -- flooding is an example of short-term base level rise, when the channel bottom is composed of a relatively unerodible material such as compacted till or bedrock, or when sediment loads entering streams are too great for the carrying capacity of the channel.

People's intentional and unintentional modifications of landscape may have become the primary geomorphological force on this planet (Hooke 2000), and their effects on the Illinois River and its drainage basin are no exception. People have been moving earth in Illinois since they began living here. Their influence has increased exponentially with technological development and population increases. Today people modify the landscape through construction, mining, and agricultural activities. These activities have several potential effects. Earth moving loosens sediment from its original state. Thus, spoil from mining, dredging, and landfills is a source of relatively easily entrained sediment unless it is specially mitigated. Agricultural tilling also loosens the soil, but much of that material is on areas of low slope and so would probably not be transported very far or very quickly. Tiling of fields and development of urban and suburban drainage systems can significantly change surface and groundwater flow patterns. Structures are often built near steep slopes because those areas offer interesting views. However, the structures also increase the load on the slopes as well as alter drainage patterns, and so can increase the risk of slope failure.

Engineering of the river including construction of artificial levees in the mid-1800's, diversion of some flow from Lake Michigan into the Illinois Valley in 1900, and installation of the Lock and Dam system in the 1930's has forever changed the Illinois Valley was forever changed. Water levels are higher and flood flows more attenuated than prior to construction. A permanent navigable channel supports commercial marine traffic. Large pools created behind dams have provided magnificent habitat for waterfowl, but continued siltation is filling them in (Demissie and Bhowmik 1986).

SUMMARY

We live in an environment that was constructed by extraordinary geological processes over the past million and one half years. The resulting sedimentary deposits and landforms are of benefit for they provide the rich agricultural soil and other natural resources that help us grow. They are also are a challenge as we build, farm, and try to prevent degradation of ecosystems. Geological processes continue to modify the landscape today, and people are one of the main agents.

ACKNOWLEDGMENTS

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AN "NRI SNAPSHOT" OF LAND USE CHANGES IN THE ILLINOIS RIVER WATERSHED

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INTRODUCTION

The National Resources Inventory (NRI) provides information on the status, condition, and trends of land, soil, water, and related resources on the nation's nonfederal land. (Alaska is excluded from the inventory.) The 1997 NRI is the fifth in a series of inventories conducted by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). The '97 NRI provides a nationally consistent database that was constructed specifically to estimate 5-, 10-, and 15-year trends from 1982 to 1997.

Data for the '97 NRI were collected for more than 800,000 locations in the US. The data are statistically reliable for national, regional, state, and substate analysis.

This paper presents national, state, and river basin results from the '97 NRI for selected data elements. Included are statistics for land cover/use, prime farmland, and erosion estimates. Visit www.il.nrcs.usda.gov/soils/nri or www.nhq.nrcs.usda.gov/NRI for more data and information from the NRI.

BACKGROUND

For over 50 years, NRCS has conducted periodic inventories of the Nation's soil and water resources.

The earliest efforts in the 1930's and '40's were reconnaissance studies. The 1958 and 1967 Conservation Needs Inventories were the agency's first efforts to collect data nationally from scientifically selected sample field sites.

The Rural Development Act of 1972 authorized the National Resources Inventory activities within NRCS. It directs the Secretary of Agriculture to carry out a land inventory and monitoring program and to report on the condition of soil, water, and related resources at not less than 5-year intervals. NRI's were conducted in 1977, 1982, 1987, 1992, and 1997. The NRI is now being conducted as a continuous inventory.

DATA COLLECTION

The 1997 NRI data collection effort in Illinois began in the fall of 1996 and concluded in the summer of 1998. Data was collected on 8300 primary sample units (PSU). Each PSU is a 160-acre quarter section and contains three points where information was gathered.

Most of the 1997 sample points were part of the 1982 inventory and were field-visited at that time. Only a portion was revisited in 1997. Remote sensing techniques were used to gather much of the data in 1997.

The NRI process collects many types of data. They can be organized into ten general categories:

- Soil characteristics and interpretation
- Earth cover
- Land cover and use
- Erosion
- Land treatment
- Vegetative conditions
- Conservation treatment needs
- Extent of urban land
- Habitat diversity
- Cover maintained under CRP

THE ILLINOIS RIVER DRAINAGE BASIN

The major river basins of Illinois are:

• Great Lakes (Lake Michigan)	78,000 acres
• Wabash River	5.6 million acres
• Ohio River	1.5 million acres
• Mississippi River (direct tribs)	5.9 million acres
• Rock River	3.4 million acres
• Upper Illinois River	4.3 million acres
• Lower Illinois River	11.4 million acres
• Kaskaskia River	3.7 million acres

Combined, the Upper Illinois and the Lower Illinois comprise >40% of the state's land area. While they are the focus of this paper, national and state data are also presented.

NRI SUMMARY

Who Owns the Land?

➢ Federal land totaled 402 million acres in 1997-21% of the Nation's total

➢ 490,300 acres of Illinois' 36,060,800 acres were owned by the US Government in 1997.

➢ There are approximately 54, 200 acres of federal land in the Illinois River Basin, representing only 3% of the basin's 15.8 million acres.

Where is Uncle Sam's Land

➢ 88% of the federal land is in the 11 western states. Nevada has more federal land than any other state with nearly 60 million acres (85% of the state). Illinois ranks 36th.

➢ Only 11% of the federal land in the state is in the Illinois River Basin.

How the Land is Used

- America's nonfederal land (1.5 billion acres) is about equally divided among cropland (26%), forest-land), and rangeland (27%). with less amounts of pastureland (8%) developed land (7%), CRP (2%), and other rural land (3%). The category "other rural land" includes 51 million acres of farmsteads, farm structures, field windbreaks, barren land and marshland.

- Land use in Illinois:
  - cropland 68% (24.0 million acres)
  - *forestland 10% (3.8 million acres)*
  - pastureland 7% (2.5 million acres)
  - developed land 8% (3.2 million acres)
  - CRP land 2% (.7 million acres)
  - other rural land 2% (.7 million acres)
  - water 2% (.7 million acres)

  From 1982 to 1997 cropland acreage is down 714,700 acres (3%), developed land acreage is up 492,300 acres (16%).

  24.0 million acres of cropland ranks Illinois 5th nationally behind Texas, Kansas, Iowa, and North Dakota.

  3.2 million acres of urban and built-up land ranks Illinois 10th nationally behind Texas, *California. Florida. Pennsylvania, Georgia. North Carolina. Ohio, Michigan, and New* York.

- Land use in the Illinois River Basin in 1997:
  - cropland 69% (10.9 million acres)
  - forest land 8% (1.2 million acres)
  - pasture land 6% (.96 million acres)
  - developed lands 12% (1.9 million acres)
  - CRP 1% (.13 million acres)
  - other rural land 2% (.28 million acres)
  - water 2% (.27 million acres)

  From 1982 to 1997 cropland acreage is down 278,500 acres, forestland up 91,100 acres, and pastureland down 275,000 acres. Developed land acreage is up 324,300.

Where is the Prime Farmland?

- Prime farmland is rural land with the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oil seed crops, and is available for these uses.

  The belt of four states extending from Ohio, Indiana, and Illinois, to Iowa are the only states in the Nation in which more than half of the rural land is prime farmland.

  The 330 million acres of prime farmland in the US in 1997 was down almost 12 million acres from 1982.

- In Illinois 66% of the total rural land (20.8 million acres) is prime farmland (down 2% from 1982). Illinois ranks third behind Texas and Kansas in acreage of prime farmland. 89% of Illinois' prime farmland is used for cropland. This ranks Illinois 1st in the country.

- In the Illinois River Basin, 64% of the total rural land is prime farmland. Prime farmland acreage of 10.1 million acres was 242,300 acres less than in 1982.

Water Erosion on the Slide

- Erosion rate by water on US cropland has been reduced by 30% in the last 15 years. The average annual sheet and rill erosion rate declined from 4.0 tons/acre in 1982 to 2.8 tons/acre in 1997.

- Erosion on Illinois cropland was reduced by 37% from 1982 to 1997. Dropping from 6.3 tons/acre to 4.0 tons/acre.

- In the Illinois River Basin the erosion rate dropped form 5.7 tons/acre to 3.6 tons/acre in the 15-year period 1982-97.

Soil loss—More Work Needed

- In 1997, 1.1 billion tons of US cropland soil was lost to sheet and rill erosion, compared to 1.7 billion tons in 1982.

  Forty-five percent of cropland erosion occurred in six states, Texas, Minnesota, Iowa, Montana, Kansas, and Illinois.

- In Illinois, in 1997, 93 million tons were lost. 153 million tons were lost in 1982.

  In 1982 14.7 million acres of Illinois cropland were eroding at less than T. That acreage increased to 18.3 million acres in 1992, leaving 5.7 million acres of cropland with an erosion rate greater than T.

- Thirty-six million tons of soil was lost from the Illinois River Basin's cropland in 1997, down 27 million tons from 1982.

TRENDS IN THE TRENDS

- Cropland acreage is decreasing while developed land acreage is increasing.

- Prime farmland acreage is decreasing.

- Water erosion is on the slide.

- More and more cropland is eroding at less than T.

- While the soil loss rate in the Illinois River Basin is less than the state average—more work is needed.

MAN'S EFFECTS ON THE ECOLOGY OF THE ILLINOIS RIVER SYSTEM

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ABSTRACT

The Illinois River was one of the most productive rivers in North America, its fish and wildlife populations virtually unequaled. Today, even after experiencing drastic changes brought about by human intervention, the Illinois River remains an important river system. Its basin and tributaries total 32,081 square miles and include over half of the area of Illinois as well as parts of Wisconsin and Indiana. As a result, the Illinois River is affected by, but also affects the majority of our state's citizens.

Major changes have been imposed by our society on the Illinois River system since the turn of the century. An appreciable volume of water diverted from Lake Michigan entered the Illinois Waterway in 1900 when the Sanitary and Ship Canal was opened at Chicago. Shortly thereafter, vast quantities of untreated domestic sewage and industrial wastes from Chicago were flushed through the canal into the Illinois River and away from Lake Michigan, a source of the city's water. Thirty-eight organized drainage and levee districts and three private levees were developed for agricultural purposes between 1902 and 1929, and they greatly modified the hydrology and landscape of the valley. Six dams—five along the Illinois and another below its mouth at Alton on the Mississippi—were constructed during the 1930s to create a channel 9 feet in depth for commercial navigation. In recent decades, sedimentation, invasive nonnative species, and unnaturally fluctuating water levels have dramatically affected the biology of the river and its adjacent waters.

Restoration of wetland habitats in portions of the river valley by reclaiming selected drainage and levee districts is a plausible approach; however, any alternative must be accompanied by land-use policies and practices that are economically sound and ecologically intelligent.

INTRODUCTION

The Illinois River flows gently through the heartland of the Prairie State. This unique waterway, whose drainage basin encompasses more than half of Illinois, stretches some 300 miles from Chicago to the Mississippi River just above St. Louis. It is a vital link in the transportation of commodities, principally grain and fuel, between the Great Lakes and the Gulf of Mexico. The Illinois River valley has a remarkable history, from its geologic genesis, through it pristine youth, to its present state, which bears the heavy stamp of human intervention.

GEOLOGIC HISTORY OF THE RIVER

The "Father of Waters," the mighty Mississippi River, once occupied the Illinois Valley from above Henry to Grafton (Willman and Frye 1970). However, with the advancement of the Wisconsinan glaciation approximately 21,000 years ago, the Mississippi River was pushed westward to its present location (Willman 1973). With the ensuing warmer climate and subsequent recession of the glacier, meltwaters formed the Des Plaines and Kankakee rivers, which coalesced into the Illinois River southwest of Chicago. From this merger, the Illinois flowed westward, cutting a new channel until it reached the ancient and deep valley of the Mississippi River above Henry.

As the waters of the Illinois entered this wide basin, their relatively low volume produced a river with a remarkably gentle rate of fall, thus creating a unique floodplain river ecosystem. This low gradient resulted in a sluggish river that had difficulty moving the sediment load contributed by tributary streams. Over the centuries, therefore, sediment was deposited during overflow conditions at the interface between the faster moving water in the river channel and the slower moving waters in the bottomlands. As a result, natural levees rose, pinching off over 300 bottomland lakes and sloughs from the river channel. These lakes were generally connected with the river at their lower ends and, in concert with the fertile Illinois soil, were the principal reason for the profound richness of the Illinois River valley.

PRISTINE CONDITIONS

The fertility of the Illinois River valley with its abundance of game and fish attracted Native Americans, whose encampments dotted the basin. Explorers used the river as a highway, and settlements were established on its shorelines. After ascending the Illinois River with Louis Joliet in 1673, Pere Marquette wrote, "We have seen nothing like this river that we enter, as regards to its fertility of soil, its prairies and woods; its cattle, elk, deer, wildcats, bustards, swans, ducks, parroquets, and even beaver. There are many small lakes and rivers. That on which we sailed is wide, deep, and still, for 65 leagues " (Kenton 1925). In later accounts, Thomas Jefferson (1787:13) portrayed the Illinois as "a fine river, clear, gentle, and without rapids." and Captain Howard Stansbury (Mulvihill and Cornish 1929:27) described the Illinois Valley as "one to five miles wide, deeply overflowed in every freshet, filled with bayous, ponds, and swamps, and infested with wild beasts."

At the turn of the century, the Illinois River remained relatively unblemished and ran comparatively clear. Kofoid (1903:151–155) described bottomland lakes near Havana on the middle stretch of the river as choked with aquatic vegetation and filled with water that was clear with a brownish tinge from diatoms. At that time, turbidity in the bottomland lakes was generally a result of plankton; turbidity in the river channel, however, was often greater and resulted from both plankton and silt. The shallow and clear bottomland lakes were filled with aquatic vegetation, including pondweeds, coontail, and waterlilies (Kofoid 1903). Arrowhead, marsh smartweed, and river bulrush were abundant at the shorelines. Wild rice grew in Senachwine Lake, Rice Pond, and Rice Lake. Although some lakes were 12 to 16 ft deep, most were 4 to 6 ft, allowing sunlight to penetrate to the rich, fertile soil of their basins.

The bottomland lakes were extremely productive, and the waters of the Illinois Valley provided the livelihood for many citizens. Alvord and Burdick (1919:64) observed, "It is a fact not generally known that the fishery of the Illinois River is the most important river fishery of the country, excepting only the salmon industry of the Pacific Coast, and this is not strictly speaking, a river fish." Indeed, in 1908, nearly 24 million pounds of fish worth about 3 cents per pound were taken commercially from the Illinois River by 2,500 fishermen who worked its waters. In addition, visiting sports fishermen contributed about as much money to the economics of local communities as the commercial fishery (Alvord and Burdick 1919:64–66). Danglade (1914:8) judged the Illinois to be the most productive mussel stream per mile in the United States, and in 1910, the Illinois accommodated more than 2,600 boats engaged in mussel fishing. During the fall, the

Illinois River valley was alive with waterfowl, and market and sport hunters considered it a Mecca for hunting. The prolific days of the Illinois Valley were numbered, however.

CHANGES IN THE ILLINOIS RIVER VALLEY

Largely because of the increasing human population in the Illinois basin, the valley was undergoing major physical changes that would greatly affect the river system.

Diversion of Water from Lake Michigan

The Illinois River received an appreciable volume of water diverted from Lake Michigan on 1 January 1900 when the Sanitary and Ship Canal was opened at Chicago. This canal connected the Des Plaines and Illinois rivers to Lake Michigan and thus afforded the city of Chicago a means of flushing vast quantities of untreated domestic sewage and industrial wastes away from Lake Michigan, a source of the city's water supply, and into the Illinois River system. Between 1900 and 1938, an average of 7,200 cubic feet of Lake Michigan water was diverted each second into the Illinois River system through the Chicago Sanitary and Ship Canal. Since 1938, the average amount has been 3,200 cubic feet per second.

Diverted water briefly enhanced the aquatic habitats of the Illinois River valley. Habitat available to fishes increased dramatically as the diverted water essentially doubled the surface area of the bottomland lakes, marshes, and sloughs—from 55,660 acres to approximately 111,325 acres (Bellrose et al. 1983:11). Diverted water not only coalesced and extended water areas but deepened them as well. Low river levels in midsummer increased by more than 3 feet at Havana (Mills et al. 1966:5). A price was to be paid, however, and thousands of acres of bottomland timber, including such important species for riparian wildlife as pin oak and pecan, were inundated and eventually succumbed as many small lakes, sloughs, and marshes were united into larger bodies of water.

Sewage and Industrial Wastes

The opening of the Chicago Sanitary and Ship Canal in 1900 dramatically increased the sewage load in the Illinois River. Because it received the wastes from the sprawling Chicago metropolitan area, the upper river was heavily polluted by 1911 (Mills et al. 1966:8). During the World War I years, a bourgeoning organic load was delivered to the river, which according to Richardson (1921:33), moved downstream at a rate of 16 miles per year. Consequently, in 1923 the oxygen content of the river from below Chicago nearly to Peoria was negligible (Greenfield 1925:24–25). The construction of massive sewage treatment plants in Chicago that became operational in 1922, the completion in the 1930s of lock and dam systems that slowed the flow of water, and the recent implementation of rigorous water pollution laws have reduced the impact of urban pollution on the Illinois River.

Drainage and Levee Districts

Shortly after the diversion of Lake Michigan water into the Illinois River in 1900, drainage and levee districts began to encroach upon the floodplain of the valley. A few small districts had been organized prior to 1900 in the higher areas of the floodplain, but those that greatly modified the landscape of the valley were initiated between 1902 and 1923 (Mulvihill and Cornish 1929:38–39). By 1929, 38 organized drainage and levee districts and 3 private levees enclosed roughly half of the estimated 400,000 acres of the Illinois Valley subject to overflow between La Salle and the river's mouth (Mulvihill and Cornish 1929:36). These districts also eliminated about 43,450 acres of water surface, 39 percent of the total in the floodplain (Bellrose et al. 1983:24). Thus, the drainage and levee districts removed much of the increase in surface area of water that had resulted from diversion. Today approximately 67,700 acres of water surface remain in addition to the river proper.

Because of the removal for agricultural purposes of nearly half of the terrestrial and aquatic habitat from the floodplain of Illinois River, the drainage and levee districts influenced the remaining unleveed area. Mulvihill and Cornish (1929:37) reported that under high-water conditions the districts increased flood stages by reducing the space available for flow and storage. Walraven (Jenkins et al. 1950:39) compared river depths for two years with similar river flows during flood: 1904, before the organization of drainage and levee districts, and 1943, well after their completion. The river at Beardstown was 10 feet higher in 1943 than it had been in 1904.

Navigation Dams

Although the amount of diverted water from Lake Michigan was reduced in 1938, river levels were held in somewhat similar ranges by the construction of navigation dams. Before 1900, five low dams had been built along the Illinois River, but their effects were comparatively minimal and were usually felt only during periods of low water. During the 1930s, however, five higher navigation dams were built along the Illinois; a sixth was built at Alton, just below the mouth of the Illinois on the Mississippi. These "high dams," constructed to create a 9-foot channel for commercial navigation, had a marked impact on the Illinois River. Not only did they maintain the high levels of water established by diversion, but they also created pools along the river, slowing even more the rate of flow of the sluggish Illinois. Starrett (1971:272) reported the water velocity of the Illinois as only 0.6 miles per hour at normal river stages.

Sedimentation

Although large-scale alterations of the Illinois River valley by increased diversion of Lake Michigan water, by navigation dams, and by drainage and levee districts had been completed by 1939, the river remained biologically significant; it continued to support a viable fishery and to host thousands of waterfowl during fall and spring migrations. In more recent decades, however, human activity has had an irreversible effect on the river and its adjacent waters. The current degradation and destruction of the aquatic communities, the lifeblood of the Illinois River valley, was facilitated by excessive sedimentation associated with intensive land use.

Its fertile prairie soils have placed Illinois at the forefront of the nation as a producer of corn and soybeans, and the intensive land-use practices associated with the production of these row crops have increased since the 1930s. Soils planted to row crops, particularly soybeans, are susceptible to wind and water erosion for much of the year, especially when fields are moldboard plowed soon after harvest. Because past economic policies encouraged maximum production, lands of marginal fertility (pastures, wood lots, waterways, fence rows, windbreaks, and green belts of protective vegetation along streams) have been converted to croplands. Accordingly, soil erosion has increased with agricultural production. The Illinois River valley in particular suffers the consequences of increased agricultural production because its drainage basin encompasses the heartland of the rich prairie soils of the state. In the Illinois River basin, row cropland increased about 67 percent between 1945 and 1976 (Bellrose et al. 1979:34).

The sedimentation problem is further complicated by the sluggishness of the Illinois River. Because the velocities of the tributaries entering the Illinois are much greater than the velocity of the Illinois itself, much of the sediments generated from sheet erosion of agricultural lands and bank erosion of streams are carried by the tributaries and delivered to the Illinois, whose slow flow allows the clay and fine silt particles to settle in the bottomland lakes. N. Bhowmik (ISWS, pers. commun.) estimates that about 13.8 million tons of sediment are delivered to the Illinois River each year, of which approximately 8.2 million tons remain while the rest is passed along to the Mississippi River.

Intensive studies of the surface areas, volumes, depths, and amounts and rates of sedimentation in bottomland lakes of the Illinois River valley have disclosed alarming data. Between 1976 and 1979, Bellrose and his colleagues (1979, 1983) resurveyed the bottom elevations of selected bottomland lakes that had been investigated in 1903. Their studies showed that between 1903 and 1976–1979, sediments had accumulated at a yearly average amount of between 0.10 and 0.75 inches, with an average for all lakes investigated of 0.42 inches. The sedimentation rate has been greater in recent decades, undoubtedly a result of more intensive agricultural practices (Bellrose et al. 1983:24).

Sedimentation has changed the once diverse bottoms of the lakes along the Illinois to uniformly shallow, concave accumulations of loosely coagulated silt. Thus, the structural diversity of the lake bottoms is lost, blanketed with thick and ever increasing layers of sediment. The average depth of the bottomland lakes in the late 1970s was only 2.0 feet (Bellrose et al. 1983:17). Most of the current biological and recreational values of the Illinois River valley will likely disappear in the 21st century.

The effects of sedimentation, however, are more far reaching than filling in the bottomland water areas. Sedimentation has had a cataclysmic effect on the aquatic plant communities of the Illinois Valley, undoubtedly the keystone of the river's productivity and richness. Mills et al (1966:13) reported an abundance of vegetation along the central stretches of the river from the late 1930s until the middle 1950s. Since then, aquatic vegetation has disappeared except for scattered remnants. When Mills et al. (1966:7) compared turbidity readings taken in 1963 and 1964 with benchmark values recorded in1896, they found that turbidity had increased two to three times at low-river stage. They realized that sedimentation decimated aquatic plant communities by generating turbidity, which in turn prevents the penetration of sunlight necessary for photosynthesis, and by creating soft bottom conditions that are unsuitable for anchorage when plants are subjected to wave and fish action.

The species of wetland plants found in the bottomland lakes were affected principally by fluctuating water levels, turbidity, water depth, and competition by other plants (Bellrose et al. 1979). Bellrose (1941) documented the importance of stabilized water levels to submergent aquatic plants, such as pondweeds, in the Illinois Valley. He also noted that American lotus, river bulrush, marsh smartweed, and arrowhead were among the aquatic species most tolerant to variable environmental conditions. From 1938 to 1940, sago and longleaf pondweeds, coontail, and marsh smartweeds were abundant in those bottomland lakes that had stable water levels and were generally protected from the river. In lakes separated from the river at low water stages and thus with semistable water levels, river bulrush, American lotus, and coontail were most abundant. In lakes connected to the river at all water stages and, correspondingly, with fluctuating water levels, river bulrush, American lotus and moist-soil plants were prevalent.

Unfortunately, after the 1950s, aquatic plants virtually disappeared even in those lakes that were separated from the river and that had minimal fluctuation of water levels. Turbidity and softness of lake beds, which resulted from sedimentation and altered water levels, were responsible for the decline in vegetation (Bellrose et al. 1979). By the 1970s, generally only beds of plants most tolerant to fluctuating water levels and turbidity—American lotus, river bulrush, and marsh smartweed, all poor duck foods—remained (Bellrose et al. 1979). An inventory in the 1970s revealed that submergent and floating aquatic plants were not common, representing only 958 acres, or 0.5 percent, of the waterfowl habitat in the Illinois River floodplain (Havera 1999). Submergent and floating aquatic plants continued to be rare in La Grange Pool in 1990 (Peitzmeier-Romano et al. 1992), and none were recorded in 1998 (Yin et al. 2001).

As plant communities were gradually eliminated from the waters of the Illinois, their departure actually accelerated the turbidity that had caused them to disappear. Jackson and Starrett (1959:162) demonstrated that the effect of wind on turbidity was reduced by rooted aquatic plants. With the disappearance of aquatic plants, wave and fish action were less buffered and more likely to encourage the resuspension of sediment. Thus, aquatic plants are prohibited from reestablishing in bottomland lakes so shallow that their entire depth falls within the euphotic zone.

The Illinois Natural History Survey made extensive experimental plantings of aquatic and moist-soil plants in various parts of the Illinois and Mississippi river valleys from 1939 to 1942 when the Illinois River still supported abundant aquatic vegetation. About 97 percent of the plantings failed to perpetuate the species planted, although the species planted were those that appeared most adapted for the particular habitat. The researchers found that if environmental conditions were suitable, plants were already growing there; and if nothing was growing on an area, it was quite evident that supplemental plantings would fail (Bellrose 1941, Anonymous 1945).

Bellrose (1941) concluded that with the exception of fluctuating water levels, turbidity was the most important factor affecting aquatic plant beds in the Illinois Valley. Many other factors, including soil character, sedimentation, and wave action, influenced the abundance of aquatic plants. More recent revegetation experiments conducted with arrowhead and sago pondweed in Peoria Lake from 1986 and 1989 (Roseboom et al. 1989) and with wild celery in 1990 in backwaters near Havana (Peitzmeier-Romano et al. 1991) were also largely unsuccessful in accomplishing long-term establishment.

With the virtual removal of the aquatic plant communities and their functions from the Illinois River valley, the disintegration of the structure of the riverine system accelerated. Aside from curtailing turbidity, aquatic plants had provided a variety of fish species with spawning sites and protection for fry; they had cleansed the water of such toxins as ammonia; and they had provided habitat for a host of invertebrates and zooplankton essential in the food web of higher organisms. The plants themselves along with their fruits had been used as food by waterfowl. Unfortunately, the Illinois River floodplain ecosystem is now in a steadily deteriorating situation dictated by the sediments that precipitate from its fluctuating turbid waters. It is unable to recover unless the conditions required for the reestablishment of aquatic communities are restored.

Unnaturally Fluctuating Water Levels

Today, the water levels of the Illinois River system fluctuate in an unnatural manner compared with previous time periods (M. Schwar, USACOE, pers. commun.). The combined effects of the loss of 90 percent of our state's wetlands, channelizing many of our streams, increased row crop production, tiling of our farm fields, creation of drainage and levee districts, and urban sprawl have caused the river to often fluctuate at undesirable levels and frequencies at critical times of the year, especially the mid-to-late summer growing season. Untimely increases in river levels during the growing season and longer than normal durations can have detrimental effects on the ecological health of various plant communities in the floodplain.

THE FUTURE

During the last century, human activity has degraded the Illinois River floodplain ecosystem from a high level of productivity and diversity to a level of subsistence. The river maintained a respectable ecological balance after 40 years of changes, including increased water levels, the construction of drainage and levee districts, navigation dams, and the dumping of domestic and industrial wastes. Since World War II, however, the life functions of the Illinois River have been increasingly eliminated by the accumulation of sediment and water levels that fluctuate in an undesirable manner. Because of its gently sloping floodplain, the Illinois River would have, over a long time, eventually filled in; however, its premature filling with sediment is clearly predicted.

The tons of sediment deposited over the lake bottoms of the Illinois Valley are irretrievable, and restructuring the ecological integrity of the Illinois River valley is virtually impossible. Some of the depth, clarity, and plant life of certain lakes might be reclaimed by draining them and allowing the bottoms to dry and compact or, perhaps, by selective dredging. More water might also be diverted from Lake Michigan to increase the water levels of bottomland lakes; but increased diversion may accentuate flooding problems and would adversely affect terrestrial habitat (Havera et al. 1980, Havera et al. 1983, Kilburn 1981). These remedies are, however, only temporary unless sedimentation is reduced. Numerous recommendations for preserving and restoring the wetlands in the Illinois Valley have been made since the early 1900s (Havera 1993). Jenkins et al. (1950) offered a long range alternative. They suggested that selected drainage and levee districts be allowed to revert to aquatic habitat.

Following Forbes' (1910, 1919) philosophy, the Illinois River would probably benefit from being less constrained by levees in some portions of the floodplain. Drainage districts with lower ecological potential or biologically less important locations could be acquired and the levees modified or removed to allow access by the river to sustain and enhance its productivity and to provide for storage of floodwaters. Moreover, in today's environment, selected drainage and levee districts in critical locations and with high restoration potential should be acquired and restored to aquatic habitat with the levees retained to protect the established wetlands from the excessive sediment loads, invasive nonnative species, water quality concerns (i.e., nitrogen, atrazine, chemical spills) and unnaturally fluctuating levels of the river. The latter scenario is the most feasible means to reestablish high quality wetland habitats in the floodplain. These activities should be coordinated with land-use policies that are both economically and ecologically sound (Havera and Bellrose 1985).

Those who would restore the Illinois River must be cognizant of the history of this once fabulous system but also its present limitations. The aquatic and terrestrial floodplain communities associated with its numerous bottomland lakes, sloughs, and side channels were undoubtedly a primary factor in making this river one of the most productive in North America. We need to do what we can to restore these communities and the multiple benefits they provide.

AUTHOR'S COMMENTS

This manuscript is a current revision of an original paper by the author presented at the first Governor's Conference on the Management of the Illinois River System in 1987 (Havera 1987) along with information included from another paper presented at the 1993 (Havera 1993) conference.

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CULTURAL RESOURCES ON A DYNAMIC ILLINOIS RIVER LANDSCAPE

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This paper looks at Illinois River valley management from an archaeologist's perspective. Cultural resources add to the quality of our lives by providing information about our past and the artifacts of the people who lived in this river valley before us. Cultural sites are non-renewable resources that need to be wisely managed in the river environs. Those of you that have the responsibility for making management decisions need to be aware of the nature of the resource, its location on the landscape, and how changes in the river affect these sites.

Just as our future is not static, the past wasn't either. As the Illinois River and its valley epitomize change in the modern environment and the challenge of managing on-going human development, the ancient river, and the people who coexisted with it, also exhibit change--change in the environment and change in human adaptations. Change in the one affected change in the other.

INTRODUCTION

Archaeological research in the intensely occupied Illinois River valley has defined many cultural traditions and artifact types for eastern North American archaeology. Sites have been recorded in this valley since the late 1800s and the archaeological record present here has been studied and appreciated by archaeologists throughout North America. It is here in the Illinois valley that modern archaeological methods were developed in the 1930s by University of Chicago scientists (Cole and Deuel 1937).

What is a cultural resource? It is the remains of human activity. The type of cultural resources we find in the Illinois River valley are archaeological sites, both from the prehistoric period, Native American sites, and historic remains, post 1673. Most sites are not recognizable by untrained people, but thousands are located in the soil of our river valley. Cultural material is visible on the surface of non-accumulating landscapes and other sites are buried below alluvium and colluvium. Cultural sites represent 12,000 years of human activity in this river valley, and they mark the activities of town life, small homesteads, cemeteries, ceremonial centers, resource procurement areas, and in historic times, military posts and transportation infrastructure.

Ages of sites are determined primarily by artifact styles. In the early archaeological sites the form of spearpoints and selected stone tools are distinctive to time period and cultural affiliation. The style changes through time. After potterymaking comes to the Illinois valley, at about 600 B.C., the shapes and designs of vessels change more frequently so that archaeologists can date sites within about 100 years, using ceramic artifacts.

RIVER VALLEY LANDFORMS

People did not produce a coherent archaeological record in the Illinois River valley until after the recession of the Wisconsinan glaciation, well after the Kankakee torrent and the shift of the Mississippi River to its current valley along the western side of the state. With the recession of the Lake Michigan lobe, we see that people were in the river valley at about 11,500 B.C.

Holocene dynamics in the river valley created a series of buried cultural horizons and some spots where sites were simply washed away as the river shifted across the valley floor, finally settling into its course at about 9,000 years ago.

The natural meandering of the Illinois River across the river valley floor would have created new living surfaces for Native Americans, while burying earlier sites, and eroding away others. The creation of the backwater lakes provided an unprecedented paradise for early people to exploit wetland and riverine resources in both the central Illinois valley and the American Bottom. These are the two places in Illinois where prehistoric settlement is at its densest.

The Illinois River stabilized at 3,000 years ago and settled into the channel that it now uses. This consistency allowed for numerous natural levee and backwater lakeshore sites to accumulate and become quite complex, with cultural components from subsequent time periods using the same locations over and over again for habitation, resource procurement and even burial of the dead (e.g. Hassen and Farnsworth 1987).

Maps of landform sediments along the valley show the dynamic history of sediment accumulation and river valley formation. These recent subsurface studies are demonstrating the dynamic nature of the floodplain that influenced the use of the river valley by early people (Hajic 2000).

Prehistoric use of river valley resources resulted in sites situated primarily in five topographical settings. Bluff tops overlooking the valley are preferred locations for large Mississippian towns and are also favored locations through time for burial mounds used by some peoples to mark their territory (Charles and Buikstra 1983). Bluff base locations are areas of sometimes impressive deposition burying cultural layers in 30 to 40 feet of colluvium and secondary stream alluvium. Terraces above flood stage offered stability for permanent settlements and ceremonial centers along with proximity to rich riverine plant and animal resources. Sand ridges of backwater lakes and sloughs, although inundated in some times of the year, offered immediate access to resources on a temporary basis. Finally, sites were also situated on the natural levee, a higher area built up by sediment from annual floods. The following discussion highlights examples of sites in these different landscape settings, following a cultural chronology from our early prehistoric sites to recent historic sites in the valley.

CULTURAL CHRONOLOGY OF RIVER VALLEY USE

Technological changes and social changes led to different uses of the river valley at different times in human history. At the earliest stages people are nomadic hunters and gatherers, leaving behind ephemeral site deposits as small groups traveled across the landscape stopping for brief periods of time to exploit the abundant resources of the river valley. Many of the early sites are buried in deep alluvium or have been washed away completely by the river. Paleo-indian sites, dating to 11,000-12,000 years ago, that have been identified tend to be in the high valley terraces (Rickers 1999).

Archaic Period

Initial research into the early hunting and gathering people began in Illinois with investigation of a deeply-stratified bluff base site called Modoc Rock Shelter. This site is actually situated at the base of the limestone bluffs of the Mississippi valley in Randolph County. Excavated in the 1950s (Fowler 1959) and revisited by Illinois State Museum archaeologists in 1987 (Ahler, et al. 1992), this excavation greatly enhanced our understanding of Archaic cultures and revealed a sequence of projectile points and other tool types and subsistence strategies that changed through time. This relative dating of artifacts in stratigraphic levels, along with accompanying radiocarbon dates, helped set out the sequence of artifact types that is still used to date surface finds today.

The Koster site in Greene County continued this investigation into deep stratified sites during the 1960s and 1970s. Here archaeologists from the Foundation for Illinois Archeology (later called Center for American Archeology) worked at Koster Creek as it enters the Illinois River valley. The site was layered with colluvium and secondary stream alluvium interspersed with 28 cultural layers. The deepest human occupation reached was 34 feet below the present day ground surface (Struever and Holton 1979).

While researchers in the first half of the 20th century focused on the mortuary patterns of prehistoric societies, archaeologists in the 1960s partnered with botanists, biologists, and paleoenvironmental experts to understand more thoroughly the daily subsistence activities engaged in by prehistoric peoples and how these activities responded to environmental changes through time.

During Archaic times population grew and horticulture began. Archaic sites are numerous throughout the river valley in nearly all topographic settings, as people with broad adaptations exploited all environmental niches. Exceptions are the current natural levees, most of which are formed near the end of the Archaic period (Hajic 1990). Archaeological sites can be large and dense with artifacts indicating repetitive use of favorite resource procurement sites and living spaces. Fish hooks and fishnets, procurement of mussels and deposition of shells forming thick shell middens, indicate the focus on the river proper. We find turtle and muskrat remains from the still floodplain backwaters, and the discarded bones of deer, turkey, and squirrel indicate continued use of nearby upland environs. Koster is an example of these deeply stratified sites which tell us how people have adapted to the river valley through time and how lifestyles and artifact styles change through time. It is archaeologist's belief that the Koster site is not unique, but that the potential for these deeply stratified sites is substantial.

Another bluff base site is Tree Row near Little America in Fulton County. In 1989 IDOT archaeologists tested the site for a borrow area, finding an Archaic cultural component which included 4,000 year old human burials partially buried under a wedge of colluvium (Evans 2001).

Woodland Period

Entering the Woodland period about 2500 years ago, we see increased concentration on plant production, the arrival of pottery making, and for the first time the building of burial mounds to mark the location of their cemeteries. Settlements become more stable with year-round villages appearing in the river valley (Charles and Buikstra 1983).

The earliest scientific expeditions to the Illinois valley occurred during the 1920s and 1930s by the University of Illinois (Baker, et al. 1941) and University of Chicago (Cole and Deuel 1937). During this phase of archaeological research the emphasis was on the impressive mound sites that dominated the river valley and some of the large, densely occupied village sites. Many of these sites were located on the edge of the terrace close to the river. The known cultural sequence in the 1930s only went back to 3,000 years ago, with the earliest recorded sites dating the end of the Archaic period and the beginning of the Woodland period. At the base of the excavation of one of the mounds at Liverpool in Fulton County, University of Chicago researchers found an earlier habitation component they named Black Sand.

Terrace sites, elevated above the floodplain proper, were favorable locations for proximity to marsh, backwater and riverine resources, while affording an opportunity for long term stability for residential communities and ceremonial centers serving a widespread population.

Ceremonial centers, such as the mounds in Liverpool, are situated on low terraces at the river's edge (Bullington 1988). Certainly we cannot imagine a people who intentionally would bury their dead and build their ceremonial structures in areas of repeated flooding. But today's river conditions and flood levels are not what they were in the past. In the prehistoric past the river was not as high and not as prone to the severity of flooding that we have seen in the last century. If you travel to the town of Naples in Scott County, you can see several of the mounds supporting modern buildings.

Social changes, from an egalitarian to a social system that recognized hereditary status required the procurement of rare items to mark the status of certain individuals in a community. The river systems became highways for the transport of raw materials and finished products from throughout North America. Copper from the Great Lakes area, mica from Appalachia, marine shell from the Gulf of Mexico or south Atlantic Ocean, and obsidian from the Yellowstone Park area are but a few foreign resources to be traded to the Illinois valley (Brose, et al. 1985). In Peoria County, the Dickison Mounds, reconstructed along Highway 29 in front of the Mossville Caterpillar Plant, yielded some of the most spectacular mortuary materials ever found in North America (Walker 1952).

Middle Woodland village sites sat in the river valley on terraces and high shores, like those at Havana in Mason County, with multiple mounds indicating complex ceremonial centers with high residential populations. The type site of the Havana Middle Woodland Tradition, the Neteler site, is completely destroyed by the power plant (McGregor 1952). For modern industry requiring large amounts of water, another management concern is careful placement to avoid impacting major prehistoric ceremonial sites that utilized the river shores.

The Twin Mounds at Havana were so visually impressive that French explorers used them as a landmark during their travels up the Illinois. French navigational accounts from the 1770s warn that in the Spoon River-Thompson Lake area, the stream was so braided that it was easy to lose your way off the main course of the river and end up in the backwater lakes. Canoers were advised to take note of the "Two Breasts," as the true way to stay on course with the main channel of the "river of the Illinois" (Margry 1876-86, Esarey 1998).

The arrival of the bow-and-arrow to Illinois circa A.D. 600 was a major technological change affecting both hunting patterns and human warfare. We see an increase in upland sites during Late Woodland times and, for the first time, corn agriculture is practiced in the Illinois river valley at A.D.700-800 (Emerson, et al. 2000). Large, deep pits for corn storage are found in sites, such as Rench, in Peoria County, situated on the terrace north of Peoria (McConoughey 1993).

Mississippian Period

Shortly, thereafter, a new way of living arrived in the Illinois River valley. Beginning around A.D.1000, the Mississippian culture emerges in Illinois (Conrad 1991). With an economy based on corn agriculture supplemented with other cultigens and the continued gathering of wild foods and hunting, the prehistoric Native American population expanded to its greatest extent. Large, fortified towns appeared in the central Illinois valley ranging from the Hildemeyer site in the floodplain terrace in Tazewell County, to the Walsh site on the Brown County bluff opposite Naples.

Complete community settlements were the focus of emergency salvage excavations at the Orendorf site, a Mississippian bluff top site in Fulton County. Here entire towns of several acres in size were exposed by earthmoving equipment to map entire communities. This large scale type of excavation, conducted in response to imminent destruction by strip-mining, was a novel approach to settlement studies (Santure 1981).

These town sites had central ceremonial rectangular plazas faced with large public buildings or a platform mound supporting the chief's house or temple. Rows of single room rectangular houses surrounded the plaza on all sides. Most town sites were surrounded with wooden bastioned palisades, the earliest forts in the valley. Burial mounds were conical or crescent-shaped, while platform mounds for temples and chief's buildings were flat-topped four-sided pyramids (Conrad 1991). Many of these sites situated on the bluff edge are subject to severe bluff edge erosion that has occurred over 170 years of cultivation and runoff.

While often situated on the bluff edge, other towns are on floodplain terraces, like the Star Bridge site at the confluence of the LaMoine River with the Illinois valley in Brown County. This Mississippian town, which was destroyed by fire, has severely impacted by deep plowing bringing to the surface the charred timbers of the prehistoric homes. This damage did however, provide a rare opportunity to observe an entire town plan at once in an aerial view.

In addition to the procurement of wild riverine resources, such as cattails for mats and baskets, lotus tubers for food, pecans from floodplain forests, turtle, waterfowl, and fish, floodplain agriculture was the hallmark of Mississippian success and the rivers were widely traveled for the transport of goods and people.

Historic Period

The prehistoric record passes into the historic period in 1673, with the travels of Marquette and Joliet along the Illinois River. Their encounter with the Kaskaskia is recorded at their main village at the Zimmerman site on the banks of the Illinois across from Starved Rock in LaSalle County. The Illinois, of which the Kaskaskia were one of the component groups, was an Algonkian-speaking tribe who had migrated from further east and were not direct descendants of the Mississippians who lived in the river valley until about 1500 (Esarey and Conrad 1998). Their longhouse villages are well documented and historic accounts from this French exploration period tell in detail about the rich animal resources of the Illinois valley, which at this time included bison.

Richard Hagen (1952) reconstructed a 1680s view of the Kaskaskia village, the French Fort St. Louis on Starved Rock, and Delbridge Island in the Illinois River. Hagen illustrates cornfields on the island, but at other times Delbridge Island was part of the village according to French explorer accounts. Charlevoix (1761) wrote that in 1720 he spent the night in a Indian dwelling on an island at the base of the Rock.

HISTORIC CHANGES IN RIVER SYSTEM

With the settlement of the river valley by Euro-Americans, emphasis shifts from use of the river valley resources serving local economies to providing for broader statewide and midwestern markets. The Illinois River was a major transportation route for goods between French Canada and the Louisiana Country. European goods delivered at New Orleans traveled up the Mississippi and Illinois to the country's interior consumers.

In the late 1600s and 1700s French, Spanish and then English built fortifications at Fort Creve Coeur at Peoria, Fort St. Louis at Starved Rock, Fort St. Louis at Pimetoui (Lake Peoria), and Fort Clark at Peoria (Franke 1995).

The changes in human use and adaptation to the river continues into the present and the recent historic period of the last 170 years is the time when the most massive and most rapid changes have taken place in both river environment and the condition of cultural resources.

In the 1800s the local economy turned to the river for mass extraction of fish and fowl for urban populations. Shell button technology focused on the mussel beds of the Illinois. A shell button extraction site is visible in archaeological form along the riverbank just north of the town of Meredosia in Morgan County.

Today the river is a major artery for barge traffic of goods, such as, grain, and coal, and the eight locks and dams and navigational channel of the river are built and maintained by the Army Corps of Engineers. We have switched from subsistence economies to industrial economy resulting in intentional and unintentional alterations to the river valley system. How have these changes altered the archaeological record? The Starved Rock locale is a good example of the effect of modern alterations of the river system on the cultural resources.

The creation of the lock and dam system, flood control levees, and the Lake Michigan diversion has raised the river to unprecedented levels. River edge sites that were positioned on natural levees are perpetually underwater in the lower reaches of the pools. Significant examples of this phenomenon are the islands in the vicinity of Starved Rock.

Plum Island, immediately below the Starved Rock lock and dam, was intensely occupied many times during the last 2,000 years (Fenner 1963). These archaeological deposits sit high and dry during most parts of the year. In contrast, Delbridge Island, directly above the lock and dam, is almost always submerged today. Delbridge Island likely had an occupational history similar to Plum Island, but has not been available for archaeological study. Nevertheless, the potential for archaeological remains on this island is still high. It is a submerged archaeological resource that needs to be managed.

Zimmerman site, the main Illinois Indian village on the right bank of the river opposite the Rock, has been the object of much archaeological exploration, starting in the 1940s by the University of Chicago (Brown 1961). It has recently been saved from marina development by the Illinois State Historic Preservation Agency (Rohrbaugh, et al. 2000). Zimmerman is considered one of the most important archaeological sites in Illinois. The village was described in 1677 by Jesuit priest Allouez as having 351 longhouses, easily counted along the river shore (Thwaites 1900). Because most of these were perched on the terrace edge, consequently, the elevated level of the Starved Rock pool initiated a cycle of bank erosion that took away a significant portion of the site. This degradation of the site continues today. Within the last decade important deposits, including human burials have been exposed on this shore.

In Peoria archaeologists are currently digging in an area historically called Averyville, at the north end of downtown, looking for the 300 year old French and Peoria Indian village. At this location LaSalle's lieutenant, Henri de Tonti, established a French trading post and fort in 1691. In subsequent decades this location was alternately a Peoria Indian village, a village of French settlers, home to Canadian traders, and abandoned by the 1790s in favor of a new village where downtown Peoria stands today (Franke 1995).

We have maps of where this village should be, standing at the edge of Lake Peoria, but so far have had no luck finding archaeological evidence of it. Why? The Lake Michigan diversion approximately doubled the surface area of backwater lakes in the Illinois River valley and would have raised the Lake Peoria level appreciably. The Peoria lock and dam permanently impounded Peoria Lake at an elevation that put the prehistoric and early historic shoreline permanently under water (Bellrose, et al. 1983). Why are we having difficulty finding the old village? It is further downslope.

Elsewhere in the valley this pattern is repeated with the relative position in the pool being the important factor. In the Havana region, the history of human occupation is intimately tied to the distribution of elevated living surfaces in the floodplain. Thompson Lake, the largest backwater lake in the Illinois valley, was a focus of habitation and resource procurement for at least 5,000 years (Esarey 1998). Environmental conditions in 1817, based on the General Land Office records (Nelson and Sparks 2000), indicate adjacent low areas of the floodplain as marsh and swamp.

As Euroamerican settlement progressed, higher parts of this bottomland were cleared for home sites and cultivation. On the low ground opposite Havana, sits the platted community of Point Isabel. The narrow gage railroad runs from there across the bottoms to the bluff, and the lower wetter parts of the floodplain remained in bottomland timber.

Shortly after 1900, Woermann maps show even more encroachment of low lying bottomlands for agricultural fields, yet at the same time water levels, raised by the Lake Michigan diversion, had substantially increased the size of Thompson Lake, created a new lake, called Flag Lake, and rendered Point Isabel uninhabitable. Within 20 years after this, flood control levees and draining of these backwater lakes was well underway. Seventy years of row crop production ensued on these floodplain lakes and now the region is slated for restoration to a more natural environment. But the cultural resources in this area--the historic farmhouses and railway, as well as the prehistoric sites--endure.

As has been discussed, the archaeological research has progressed on sites located on the bluff tops, at the bluff bases, on terraces and floodplain ridges. But one location that has been poorly understood until recently is the river edge. Sand ridge and natural levee sites are subject to seasonal flooding, and may have been sites of seasonal camps or resource procurement sites.

These are areas made increasingly difficult to access for research throughout the 20th century. Increasing water levels from the Lake Michigan diversion and the lock and dam impoundments, and increased siltation inside of a floodplain tightly constricted by flood control levees, have submerged and buried these sites ever more out of our reach. Lateral expansion of the Illinois River channel through bank instability and increased water volumes have also cut across the natural levees sometimes exposing, sometimes destroying cultural layers.

During the drought of 1988, Dickson Mounds Museum organized a pedestrian survey of both sides of the shoreline from Naples to Starved Rock, for a total 160 miles. During those low water conditions, 200 new sites were discovered. These sites ranged from 19th century habitations and landings through 3,000 year old villages, illustrating the remarkable geomorphological stability of the Illinois River in its present course (Esarey 1990).

The distribution of these riverbank sites, shows significant gaps resulting from their position in the pool, with fewer sites being found immediately upstream from a lock and dam. Regardless of environmental or physiographical changes in the river, there were also differential cultural preferences for natural levee use. Early Woodland sites are common on the natural levees, but Middle Woodland sites were restricted to terraces and bluff bases.

Most notable of sites discovered in this survey was a series of large Late Woodland villages (1200 years old), some of which contained thousands of archaeological pit-features and stretched over a kilometer of riverbank. The best example of these was the Liverpool Lake site (Esarey, et al. 2000), excavated by Western Illinois University and Dickson Mounds Museum.

At this site archaeological deposits were found to be constrained in a band that demonstrates that a portion of the site is buried by modern alluvium, a portion is exposed on the riverbank slope which is usually submerged, and an unknown portion has been washed away. Following this band of archaeological deposits back into the riverbank, archaeologists found that almost 3 meters of alluvium now covered the site. This silt largely represents accumulation from the last 200 years of agricultural runoff. Some of the site is destroyed, some is endangered and some is safe. In general, this typifies the state of cultural resources in the Illinois River valley.

CLOSING

Recreational use of the river and rejuvenation of riverfront parks and other public use facilities in urban settings are currently the focus of many community efforts and state and/or federal grants. Governmental programs and private enterprise are bringing environmental restoration to our river valley.

Cultural resources can be amazingly durable, and at the same time fragile, depending on their landscape positions in the face of flood plain changes. As non-renewable resources, we must be vigilant to protect and preserve these records of our past. Our rivers are rich in the history of human development by nature of their attraction to human societies all through time.

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HISTORY OF HYDROLOGIC AND HYDRAULIC CHANGES OF THE ILLINOIS RIVER

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ABSTRACT

The Illinois River, one of the major tributaries to the Mississippi River in the Central United States, has a drainage area of 75,156 square kilometers (28,906 square miles) that covers portions of Illinois, Indiana, and Wisconsin. Except for about a 10,360 square kilometers (4,000 square miles) area in Indiana and Wisconsin, the Illinois River watershed is located within the state of Illinois. As a result of repeated leveling by glaciers, most of the Illinois River watershed is flat and covered with fine loess soil, making it one of the best agricultural regions in North America. More than 80 percent of the Illinois River basin is presently used for agricultural purposes. Most of the significant rivers in the state such as the DesPlaines, Fox, Kankakee, DuPage, Vermillion, Mackinaw, Spoon, Sangamon, and LaMoine Rivers all drain into the Illinois River.

Because of its strategic location in the state and because it is downward of the Chicago metropolitan area, the Illinois River has experienced significant changes over the years. Most of the changes are related to commercial navigation, municipal and industrial waste discharges, and agricultural practices in the watershed. These changes have resulted in various degrees of environmental and ecological degradation along the river. With this realization, major efforts are underway to "restore" some of the ecological functions of the river. One of the most important factors will be the management of the hydrology and hydraulics of the river so that it promotes and sustains ecological restoration while maintaining the economical functions of the river.

Restoration of the Illinois River will require proper understanding of the natural factors and how human-induced changes that control the hydrology of the watershed and the hydraulics of the river over time. This paper summarizes the historical changes that have affected the hydrology and hydraulics of the Illinois River basin and evaluate their influence on restoration efforts in the future.

INTRODUCTION

The Illinois River is one of the major tributaries of the Mississippi River in the Central United Sates with a drainage area of 75,156 square kilometers (28,906 square miles). The drainage basin covers parts of three states: Illinois, Indiana and Wisconsin, as shown in Figure 1. The major tributaries that drain into the Illinois River include the DesPlaines River with a drainage area of 5,467 square kilometers (2,111 square miles), the Kankakee River with a drainage area of 13,377 square kilometers (5,467 square miles), and the Fox River with a drainage area of 6,884 square kilometers (2,658 square miles), all draining northern Illinois, southern Wisconsin and north western Indiana. The central and lower parts of the watershed are

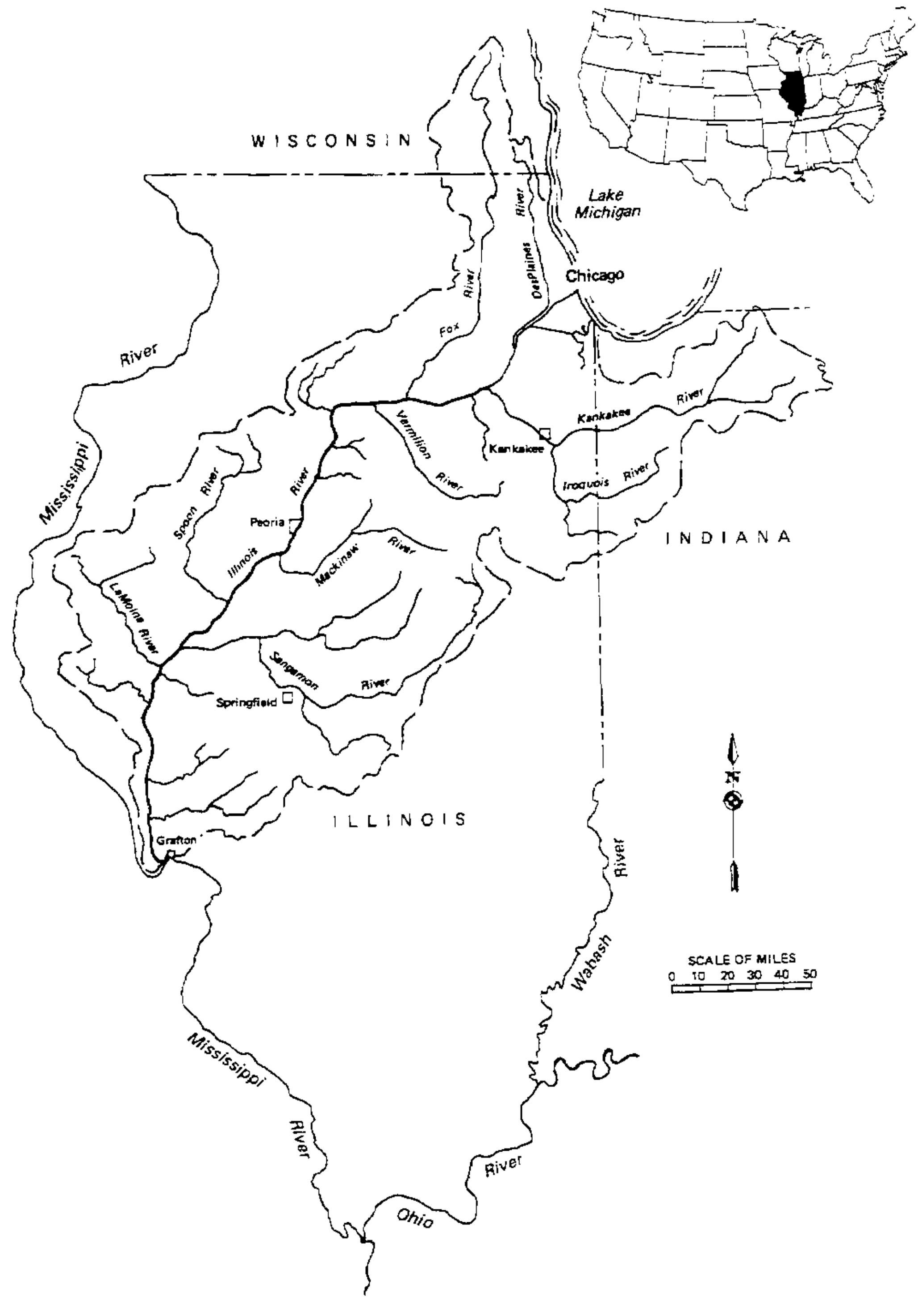

Figure 1. Location of the Illinois River.

drained by the Vermillion River with a drainage area of 3,447 square kilometers (1,331 square miles), the Mackinaw River with a drainage area of 2,942 square kilometers (1,136 square miles), the Spoon river with a drainage area of 8,408 square kilometers (1,855 square miles), the Sangamon river with a drainage area of 14,027 square kilometers (5,416 square miles) and the LaMoine River with a drainage area of 3,497 square kilometers (1,350 square miles). The Illinois River joins the Mississippi River at Grafton, about 50 kilometers upstream of St. Louis, Missouri.

Over the last one hundred years, there have been numerous attempts to control and manage how water levels along the Illinois River, for the purposes of providing river navigation between the Great Lakes and the Gulf of Mexico. The initial effort was in the late 1800s when four low-head dams were constructed to provide a 7-foot navigation channel in the lower Illinois River. In the 1930s, seven modern locks and dams were completed on the Illinois, Mississippi and DesPlaines Rivers to create the Illinois Waterway as we know it today. These locks and dams provide a navigation channel with a minimum of 9-foot depth from Lake Michigan to the Mississippi River.

Another major factor that has had significant influence on water levels along the Illinois River is the diversion of water from Lake Michigan to the Illinois River. The Lake Michigan diversion started in 1900 when the construction of the Chicago Sanitary and Ship Canal was completed primarily for the purposes of diverting diluted sewage from Lake Michigan to the Illinois River following the typhoid and cholera epidemic in Chicago in the late 1800s.

PRECIPITATION AND STREAMFLOW TRENDS

In general, streamflow in the Illinois River is driven by precipitation in the river basin. This is illustrated in Figure 2 where the 10-year moving average precipitation in the basin compared to the 10-year moving average streamflow near Peoria. As shown in the figure, the long-term average streamflow generally follows the average trend in precipitation.

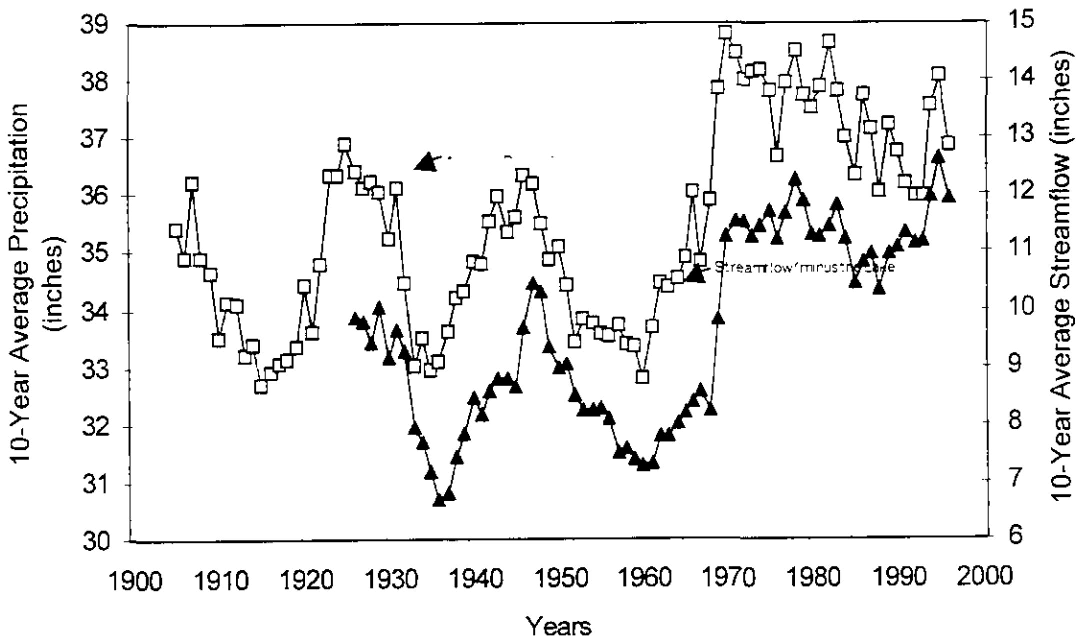

Figure 2. Trends in Streamflow and Precipitation in the Illinois River.

Even though the streamflow record is not as long as the precipitation, it is long enough to show that there is a high correlation between precipitation and streamflow in the basin. One of the most significant observation in the trends is that the most recent period, starting around 1970 to the present, has been significantly wetter than the period from 1900-1965.

The fact that the average streamflows are strongly influenced by precipitation does not, however, mean that other factors related to land use changes and hydraulic modifications did not influenced streamflow in the basin. More rigorous analysis of the streamflow records is needed to isolate and quantify the influence of factors such as land use changes in the watershed and hydraulic modifications along the Illinois River.

A very good example is the changes in streamflow in the upper Illinois River and the major tributaries in Northeastern Illinois. Figure 3 shows the 10-year moving average of peak discharge rates for the upper Illinois River at Marseilles, the Kankakee River near Wilmington, and the Des Plaines River near Riverside. As shown in the figure, peak discharge rates in the upper Illinois River have increased over the last 75 years, and much of this increase corresponds to similar increases in peak discharge from the Kankakee River. The Des Plaines River, which drains much of the western suburban areas in Cook and Du Page Counties, has both much lower peak discharge rates and a comparatively small increase in these rates over time. Although small watersheds in the Chicago area have experienced increases in peak flows with an increase in urbanization, much of these increases have been offset by detention storage facilities, and it does not appear that the trends in these smaller streams have significantly impacted the overall peak flow rates of the Des Plaines River, and other major streams in the Chicago metropolitan area.

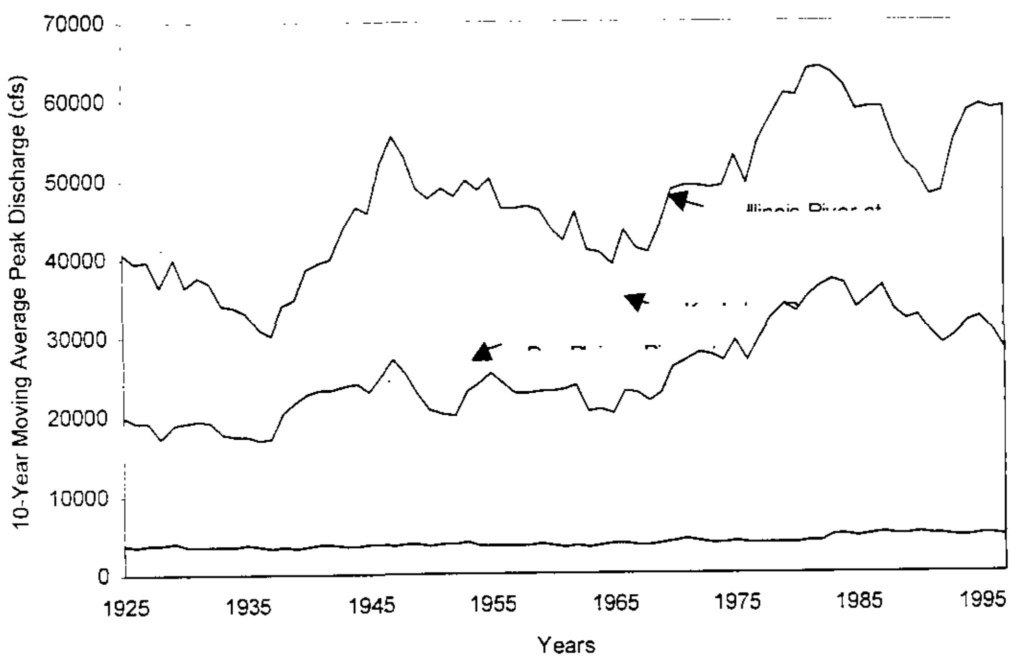

Figure 3. Moving averages of peak discharge rates; Illinois, Kankakee, and Des Plaines Rivers, 1925-2000.

Low flows in northeastern Illinois streams are impacted to a degree by corresponding increases in average precipitation and average flow rates; however, changes in water use, including both the diversion of Lake Michigan water for Chicago's water supply and an increase in the volume of treated wastewaters discharged to streams, play a much larger role in defining low flow trends in the region. Figure 4 shows the trend in the 7-day low flow rates for the Des Plaines River from 1943 to 2000. The flow records in the 1940s and 1950s show that the Des Plaines River originally had very low streamflows during drought condition. However, as the population and water use within the watershed increased, wastewater treatment plants were built along the Des Plaines River and its tributaries. Today, the minimum low flows in the river exceed 140 cubic feet per second (cfs), and are almost entirely comprised of treated wastewaters. Similar low flow trends can be seen in major streams throughout the Chicago area.

WATER-LEVEL REGULATION ALONG THE ILLINOIS RIVER FOR NAVIGATION

Over the last one hundred years, there have been numerous attempts to regulate water levels along the Illinois River for the purposes of providing river navigation between the Great Lakes and the Gulf of Mexico. The history of Lock and Dam construction on the Illinois River for navigation purposes is summarized in Table 1. The initial effort was in the late 1800s when four low-head dams were constructed to provide a 7-foot navigation channel in the lower Illinois River. The first dam was constructed in 1871 at Henry about 40 miles upstream of Peoria, Illinois. The other three were at Copperas Creek (R.M. 137.4) completed in 1877, at LaGrange (R.M. 79.5) completed in 1888, and at Kampsville (R.M. 31.0) completed in 1893. These low-head dams provided adequate navigation depth during periods of low water in the lower Illinois River for some time. However, they were soon outdated and were not sufficient to support modern navigation that required more depth. Plans were then developed and finally authorized by Congress for a 9-foot navigation channel along the Illinois River in 1927. In the 1930s, seven

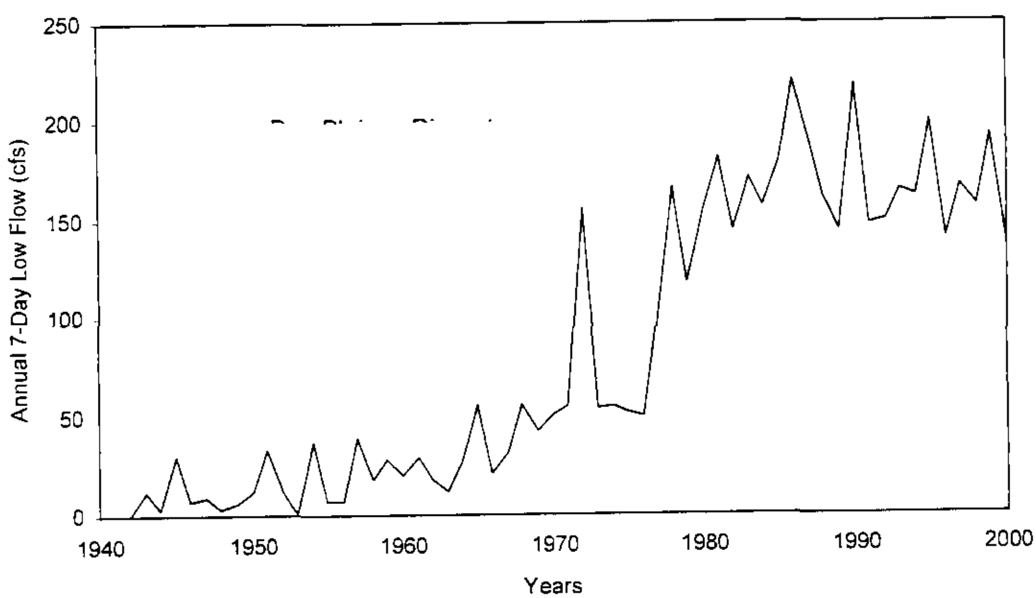

Figure 4. Annual 7-Day Low flows for the Des Plaines River, 1943-2000.

Table 1. History of Lock & Dam Construction on the Illinois River.

Lock & Dam	*Location (RM)*	*Date*
Henry Lock & Dam	195.0	1871
Copperas Creek Lock & Dam	137.4	1877
Old La Grange Lock & Dam	79.5	1882-1888
Kampsville Lock & Dam	31.0	1880-1893
Lockport	291.0	1923-1930
Starved Rock Lock & Dam	231.0	1926-1930
Dresden Island Lock & Dam	272.5	1928-1930
Marseilles Dam	244.5	1920-1933
Brandon Road Lock & Dam	244.5	1920-1933
Peoria Lock & Dam	157.7	1936-1939
New La Grange Lock & Dam	80.0	1939
Alton Lock & Dam (Mississippi River)		1938

modern locks and dams were completed on the Illinois, Mississippi, and DesPlaines Rivers to create the Illinois Waterway as we know it today. These locks and dams provide a navigation channel with a minimum of 9-foot depth from Lake Michigan to the Mississippi River as shown in figure 5.

The lower 80 miles of the waterway is controlled by the Alton Lock & Dam on the Mississippi River. The locks and dams at LaGrange (R.M. 80) and Peoria (R.M. 157.7) are controlled by Wicket Dams that are lowered to the river bottom during periods of high flow.

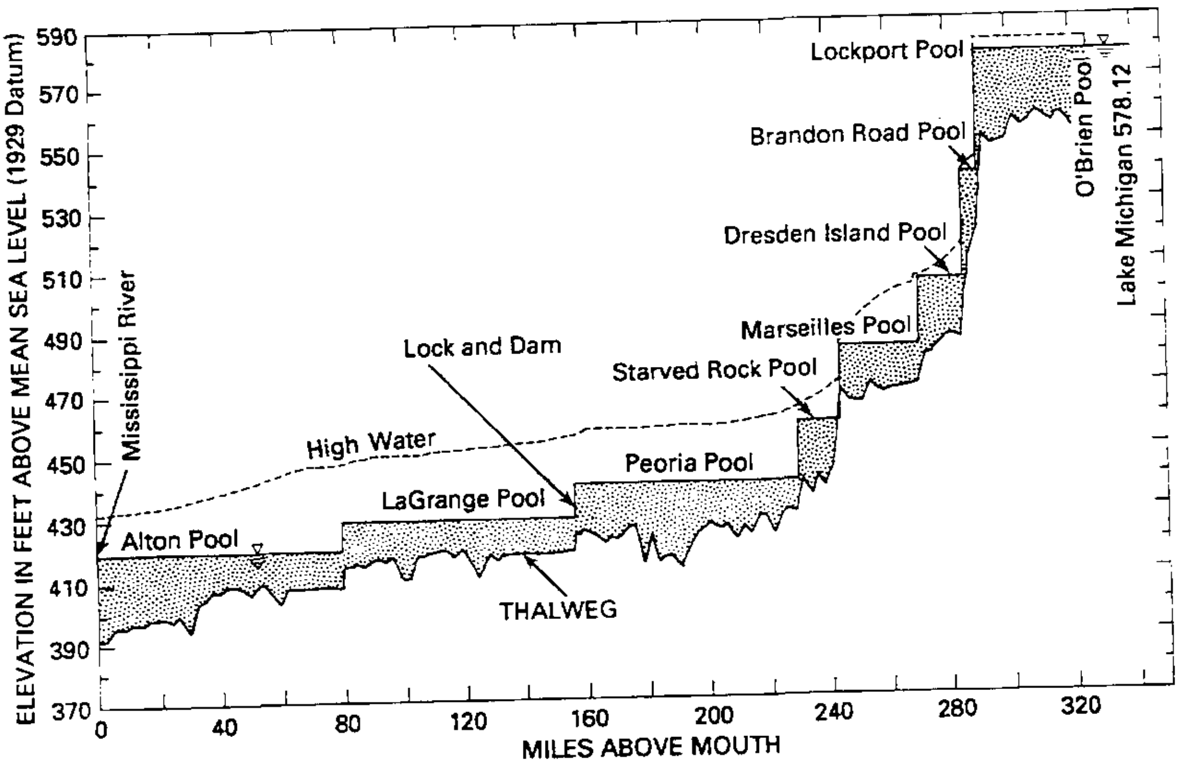

Figure 5. Profile of the Illinois Waterway.

Thus, for most of the high flow periods the locks and dams in the lower 230 miles of the Illinois River do not have any significant impact on water levels. Their importance to navigation is during periods of low flow where they maintain the required 9-foot navigation depth.

WATER DIVERSION FROM LAKE MICHIGAN INTO THE ILLINOIS RIVER

Another major factor that has had significant influence on water levels along the Illinois River is the diversion of water form Lake Michigan to the Illinois River. The Lake Michigan diversion started in 1900 when the construction of the Chicago Sanitary and Ship Canal was completed primarily for the purposes of diverting diluted sewage from Lake Michigan to the Illinois River following the typhoid and cholera epidemic in Chicago in the late 1800s (Vonnahme, 1996).

The annual diversion from Lake Michigan to the Illinois River varied from 3,000 to 10,000 cubic feet per second (cfs) for the period from 1900 to 1939 as shown in Figure 6 (Injerd, 1998). After 1939, the total diversion was limited to an average of 3,200 cfs by the Supreme Court with an exception during an extended period of draught in the 1950s. One thousand five hundred cfs of the diverted water was allocated for dilution and the remaining 1,700 cfs for domestic water supply.

WATER LEVEL CHANGES

Lock and dam construction and Lake Michigan water diversion have had significant impact on water-levels along the Illinois River (Demissie, Xia, and Knapp, 1999). To illustrate these

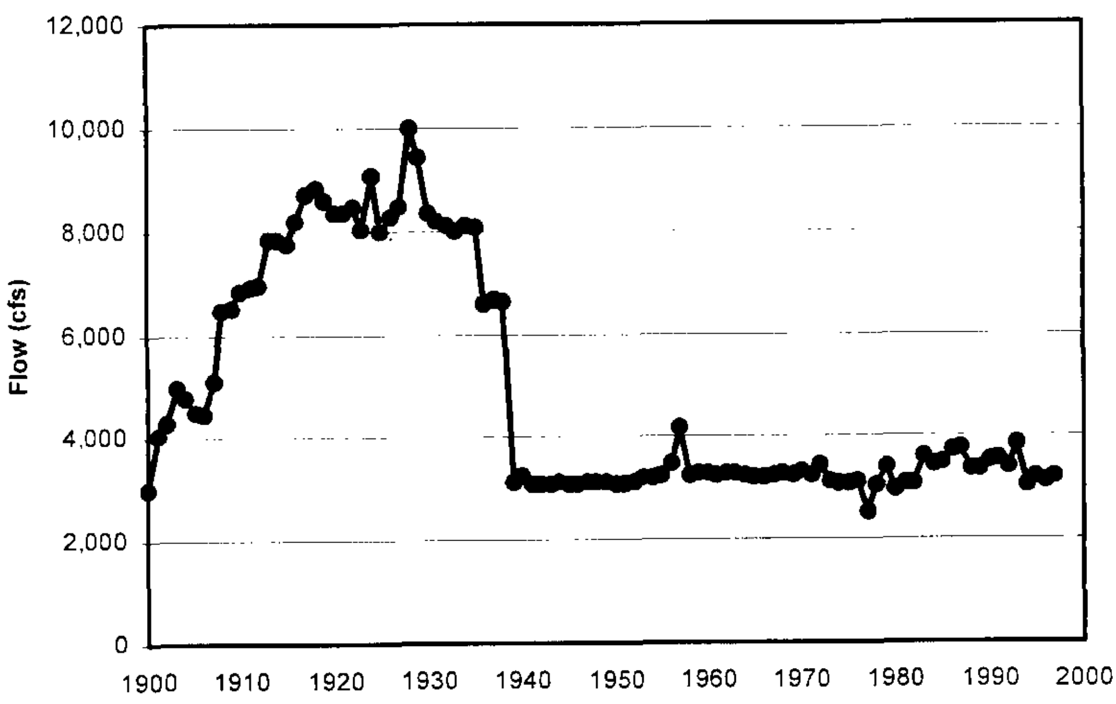

Figure 6. Annual Water Diversion from Lake Michigan to the Illinois River.

impacts, historical water levels at several points along the LaGrange and Peoria Pools of the Illinois River were analyzed. The LaGrange Pool is located in the Lower Illinois River between river miles (RM) 80 and 157.7. The downstream control is the LaGrange Lock & Dam at RM 80 while the upstream control is the Peoria Lock & Dam at RM 157.7. Peoria Pool is located upstream of the LaGrange Pool from RM 157.7 to Starved Rock Lock & Dam at RM 231. The operation of both the upstream and downstream locks and dams affect low water levels in the LaGrange and Peoria Pools.

Figure 7 shows the historical changes in average daily water elevations at three locations in the LaGrange Pool for different periods starting in 1887. The three locations, Beardstown, Havana, and Copperas Creek, all located in the LaGrange Pool, represent three segments of the river within the pool; the lower, middle, and upper. The reason for the segmentation of the pool is the difference in how the water levels have changed at the three locations as a result of the same factors imposed on the Illinois River. This is an important consideration in any restoration effort of a regulated river similar to the Illinois River.

For the lower segment of the pool represented by the Beardstown station (figure 5c) the records show that for the period of 1878-1889, the lowest water levels averaged around 421.7 feet above msl. After the construction of the old LaGrange Lock & Dam in 1888, the low water level was raised by about 4.5 feet to 426.2 feet. Then for the period from 1900-1939 when the Lake Michigan diversion varied from 3,000 to 10,000 cfs, the low water levels were further raised by about 2.5 feet to 429 feet. For the latest period from 1940-1998, after the construction of the new LaGrange Lock & Dam and the reduction of Lake Michigan diversion to 3,200 cfs, the low water levels were raised slightly by about 0.5 foot to 429.5 feet. Thus low water levels have increased by about 8 feet from the late 1800s to the present period.

For the mid-pool segment as represented by the Havana station at RM 119.6 (figure 5b), the records show that the low water levels averaged around 428.7 feet above msl for the period 1878-1888. The construction of the old LaGrange Lock & Dam raised the low water level at Havana by more than 3 feet to 432 feet. The diversion from Lake Michigan further raised the low water level by about a foot to 433 feet. For the period from 1940-1998, after the construction of the new LaGrange Lock & Dam and the reduction in Lake Michigan diversion, the low water levels were lowered by almost 2 feet to 431.2 feet. The change in low water levels at Havana from the early period to the present is only 2.5 feet, which is significantly less than the 8-foot change at Beardstown.

For the upper segment as represented by Copperas Creek at RM 137.4 (figure 5a), the low water levels for the period 1878-1888 were about 432 ft above msl. The construction of the old LaGrange Lock & Dam in 1888 hardly changed the low water levels at Copperas Creek. However, the diversion of Lake Michigan water raised the low water levels by more than 3 ft to 435.3 ft. After the Lake Michigan diversion was lowered in 1939, the low water levels at Copperas Creek dropped by similar amounts as they were raised. The low water levels for the most recent period, 1940-1998, are almost the same as the earliest period, 1878-1888.

The historical stage records show that the dams and the diversion of water from Lake Michigan have changed the low water levels along the Illinois River by different magnitudes depending on the location with respect to the locks and dams. This knowledge has to be incorporated into any restoration effort for the Illinois River.

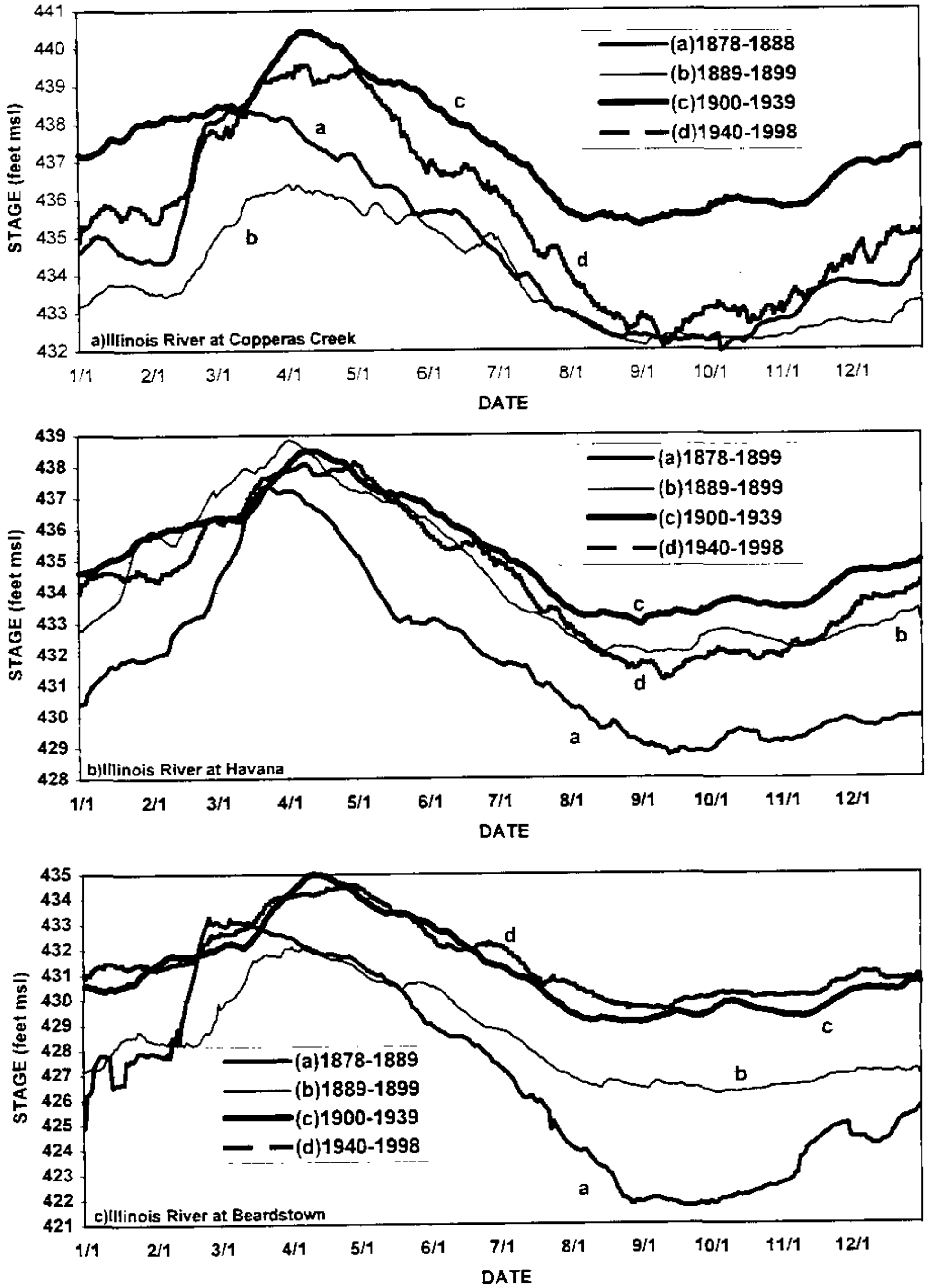

Figure 7. Average stage hydrographs of the Illinois River at Copperas Creek, Havana, and Beardstown.

SUMMARY AND CONCLUSIONS

The hydrology and hydraulics of the Illinois River are controlled by both natural human induced factors. The long-term average flows in the river are primarily controlled by precipitation in the river basin. However, water diversion from Lake Michigan and lock and dam construction along the river have had major impacts on river flows and water levels, especially during periods of low flows.

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HISTORICAL CHANGES IN THE ILLINOIS RIVER SYSTEM

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The Illinois River has become an increasingly important component of the Illinois economy. Thanks to the foresight of the State of Illinois in building the locks and dams, the Illinois River has become a corridor for recreation, economic development, and a major component in a higher quality of life for our residents.

Unfortunately, due to a lack of federal commitment, the lock system is deteriorating rapidly. The system can no longer serve the barge industry and their customers in a cost-efficient and timely manner. The resultant delays in transportation surge through the economy dramatically increasing costs for goods and services.

With the globalization of agriculture and the exponential growth of production agriculture in other regions, especially South America, the United States no longer has the ability to set prices for agricultural commodities. Significant investments in the river systems of countries in South America and China are emulating the infrastructure found in the Illinois and Mississippi River Systems. Thus making our foreign counterparts more competitive while our infrastructure degrades at an alarming rate.

Without immediate action to upgrade the antiquated lock system, the economy of Illinois, especially the agricultural element is threatened. If construction began today, it would be fifteen years before any major improvement becomes noticeable. Time is running out and the economy of Illinois and the United States is at stake.

The Importance of the Upper Mississippi and Illinois River to Illinois Agriculture and Industry

Greg Guenther
National Corn Growers Association

NCGA's Goal

- Enhance U.S. growers competitive position in world markets by increasing the efficiency of the Upper Mississippi and Illinois Rivers
  - Extension of 7 locks (Mississippi 20-25 and LaGrange and Peoria Locks) from the current 600 foot structures to 1,200 foot chambers
  - Guidewall extension at Mississippi L&D 14-18

Lock Delays = Inefficiency

Inefficiency = Lower price for grain and higher costs for industrial products

Why is the Illinois River Important?

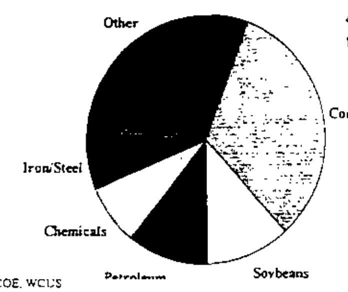
- Primary export corridor for Illinois grains
  - Low-cost transportation mode
    - Increased bid prices for farmers
    - Competitive pressure on rail rates
    - Marketing flexibility
  - Year round availability
    - Allows Illinois farmers to take advantage of export markets when most of the Upper Midwest is frozen in
- Key avenue for bulk industrial commodities to reach Chicago-land industries

Average Lock Delays, 1999

Lock	% tows delayed	Avg. delay (hours)
Miss 20	76	2.86
Miss. 21	76	2.55
Miss 22	85	4.51
Miss 24	82	3.56
Miss 25	84	4.53
Peoria	38	3.41
LaGrange	55	5.07
Mel Price	**56**	**1.22**

Source COE

Commerce on the Illinois River, 1999



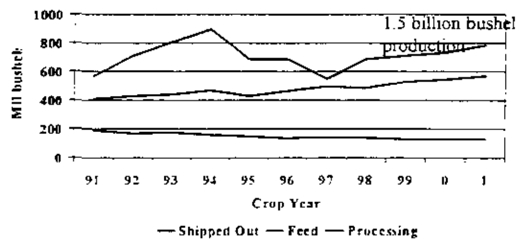
40.7 Mil tons total traffic

Source COE, WCUS

Illinois Corn and Soybeans

- How are they used?
- What influence does the River have on price?
- Where do they move from?

Illinois Corn Usage



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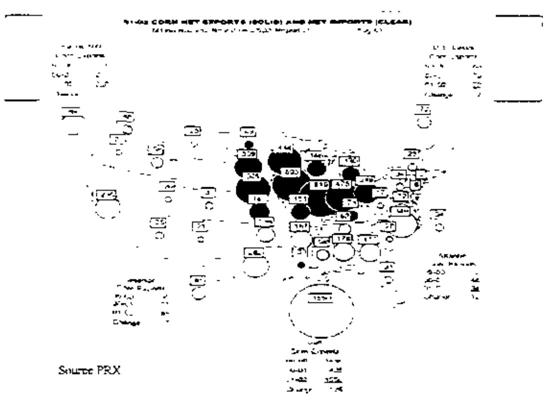
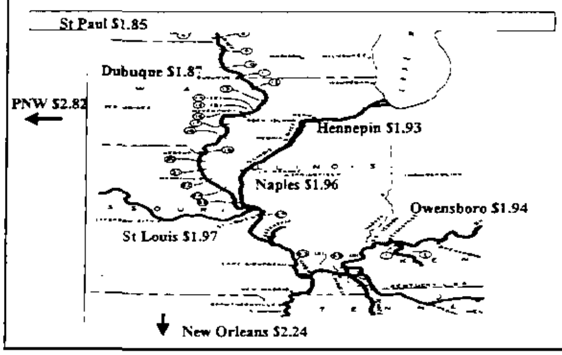
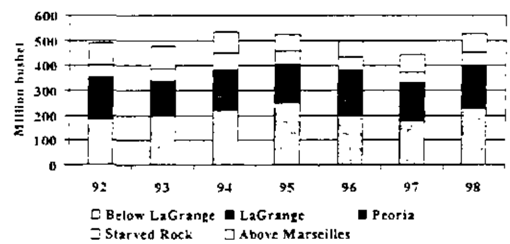


Corn bid prices, 9/17/01



Corn shipments by pool



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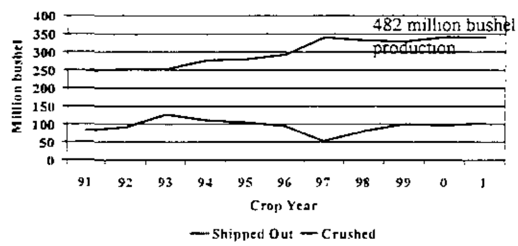
Illinois Soybean Usage



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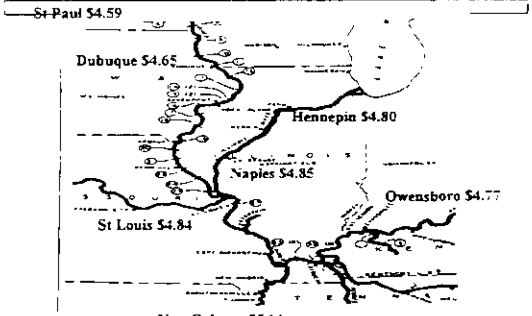
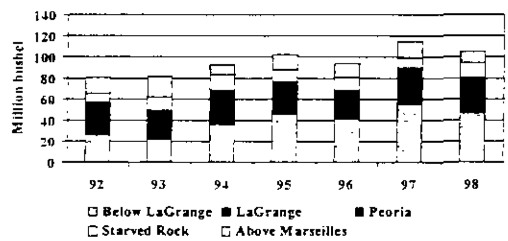
Soybean bid prices, 9/17/01



Soybean shipments by pool



Data Source: PRX

Benefits from lock improvements

- Agriculture
  - Reduced lock delays equals lower transportation rates
    - Higher commodity prices to farmers
    - Increased international competitiveness
    - Greater market access
    - Reduced costs of agricultural inputs
  - Greater transportation efficiency will encourage new agricultural markets
    - Ethanol production for California and New York markets

Benefits from lock improvements

- Jobs
  - Each lock will take 3 years to construct
    - + 1,000 skilled position/year
    - Davis/Bacon projects (Prevailing wages)
  - Each of the 7 locks and 5 guidewalls is in or borders Illinois
    - Some percentage of the jobs would go to Illinois residents

Benefits from lock improvements

- Quality of life
  - The Illinois River moves the commodities that make our cities run
  - Ex. Cement
    - 1.54 million tons on the Illinois R.
    - 1.35 million tons (88%) moved to destinations above Lockport
    - **Equals 46,551 fewer trucks on Chicago area roads**

Source COE, WCUS

Benefits from lock improvements

- Environment
  - Barge to rail comparisons
    - 331% less fuel usage, 470% lower emissions, 290% reduction in probable accidents
  - Barge to truck comparisons
    - 826% less fuel usage, 709% lower emissions, 5,967% reduction in probable accidents
  - Increasing lock capacity will decrease lock delays further reducing air emissions and sediment suspension in the channels.

Source US EPA

Action Needed

- Citizens of Illinois must support Upper Mississippi and Illinois River lock improvements
  - Corps of Engineers must complete study by July 2002
  - Congress must authorize locks in WRDA 2002
  - **Our livelihoods and quality of life require immediate action.**

SELECTED RESULTS FROM THE INTENSIVE DATA COLLECTION PHASE, 1995-98, OF THE LOWER ILLINOIS RIVER BASIN, ILLINOIS, NATIONAL WATER-QUALITY ASSESSMENT

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In 1994, the Illinois district of the U.S. Geological Survey began a study of the water quality in the lower Illinois River Basin. Defined as the part of the Illinois River Basin between Ottawa, Illinois and Grafton Illinois, were the Illinois River enters the Mississippi River, the basin is one of the most intensively cultivated areas of the United States for corn and soybean production. The basin is about 18,000 square miles and includes the cities of Peoria, Bloomington, Normal, Decatur, and Springfield. Eight sites on streams and rivers were sampled from December 1995 through September 1998 for water-quality including nutrients, pesticides and sediment contaminants. About 117 wells were sampled during this time period to characterize water quality in two major aquifers and in recently recharged ground water. 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 during 1995-98. 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. Ina 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 maximum contaminant level (MCL) for nitrate was exceeded in 15 percent of samples from all streams and rivers. 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). 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. 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 100feet deep) and drinking-water wells only rarely exceeded the nitrate MCL. Major corn and soybean herbicides were not as frequently detected in ground-water samples as they were in stream-water samples. No ground-water sample exceeded drinking-water standards or guidelines for pesticides. Naturally occurring arsenic exceeded the current MCL of 50 mg/L (micrograms per liter) in 2 of 30 wells sampled in the Mahomet aquifer, a major drinking-water source.

SEDIMENT AND NUTRIENT LOADING IN LA GRANGE REACH OF THE ILLINOIS RIVER

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ABSTRACT

Considerable attention has recently been focused on hypoxia in the Gulf of Mexico. Excess nutrient loading from the Mississippi River basin has been targeted as a major contributor to this situation. Due to liberal fertilizer application and intensive agricultural practices, Illinois contributes large amounts of nutrients and sediments to the Illinois and Mississippi River systems. Beginning in 1989, the Illinois Natural History Survey's Long Term Resource Monitoring Program (LTRMP) began monitoring various limnological parameters on the La Grange Reach of the Illinois River. Water passing through this reach originates from a basin area of approximately 63,672 km^2. In 1993, our monitoring effort was expanded to include five Illinois River tributaries with a total drainage area of 25,979 km^2: Quiver (676 km^2), Mackinaw (2,952 km^2), La Moine (3,498 km^2), Spoon (4,817 km^2), and Sangamon (14,037 km^2) rivers. Preliminary results indicate that, on average, Sangamon River contributed the highest nitrogen loads while Spoon River was the primary contributor of suspended solids into the Illinois River. For example, in 1993 approximately 11,000,000 metric tons of suspended solids entered La Grange reach from the entire basin. Of this total, nearly 5,500,000 metric tons originated from the Spoon River basin. In summary, La Grange reach tributaries contribute considerable amounts of nitrogen and suspended solids to the Illinois River. Between 1993 and 1998, nitrogen from tributary input contributed 28 to 45 percent of total nitrogen loads into La Grange reach; suspended solids from tributary input contributed 54 to 83 percent of the total loads with a large portion of that being retained within the system.

INTRODUCTION

Within the past decade, considerable attention has been focused on hypoxia in the Gulf of Mexico. Hypoxia is defined as an area where dissolved oxygen levels fall below 2 mg/L (milligrams per liter) and becomes an unsuitable habitat for aquatic organisms. It is believed that excessive nutrients, particularly nitrogen and phosphorus, entering the Gulf of Mexico from the Mississippi and Atchafalaya Rivers are the major cause of hypoxia (Goolsby and Battaglin, 2000). Nutrients promote massive algal blooms that die and settle on bottom sediments. Bacteria, which feed on organic matter supplied by dead algae, consume large quantities of dissolved oxygen through respiratory processes leaving the bottom layers of water low in oxygen. Hypoxia in the Gulf of Mexico generally coincides with high water events in the spring that transport large quantities of nutrients. The largest area of hypoxic zone to date occurred in 2001 which covered 20,720 km^2 (Rabalais, 2001).

Major sources of nutrients that enter the Mississippi River system are located in the upper portions of the Mississippi River basin. Nutrient concentrations in this area have increased dramatically during the past 100 years, and the annual delivery of nitrate from the Mississippi River to the Gulf has nearly tripled since the late 1950's (Goolsby and others, 1999). Between 1980 and 1996, approximately 16 to 19 percent of total nitrogen flux to the Gulf of Mexico originated from Iowa, with similar percentages coming from Illinois (USGS, unpublished information).

The Long Term Resource Monitoring Program (LTRMP) has six field stations located within the five states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Each field station is responsible for standardized monitoring of the water quality, benthic invertebrate, vegetation, and fish. The primary objectives of the LTRMP water quality component are to 1) determine suitability of habitat to aquatic organisms and 2) monitor concentrations of sediments and nutrients within the upper Mississippi River system. The primary goals of this presentation are to 1) characterize spatial and temporal patterns of nitrogen, phosphorus, and suspended solid concentrations within La Grange Reach, Illinois River, and 2) estimate contributions of nitrogen, phosphorus and suspended solid loading from LaGrange Reach tributaries.

STUDY AREA

The Illinois River is a major tributary to the Mississippi River and has a basin area of 74,516 km^2. La Grange Reach is approximately 78 miles long extending from La Grange Lock and Dam (river mile 80.1) to Peoria Lock and Dam (river mile 157.8). Five tributaries with a drainage area of 25,979 km^2 empty in to La Grange Reach: Quiver (676 km^2), Mackinaw (2,952 km^2), La Moine (3,498 km^2), Spoon (4,817 km^2), and Sangamon (14,037 km^2) Rivers. Between 96 and 99 percent of the land use within each sub-basin is devoted to agricultural. Forest and urban areas comprised the majority of remaining land use within the Sangamon (1.40% and 1.33%); Spoon (1.41% and 0.51%); La Moine (2.99% and 0.27%); and Mackinaw (0.76% and 0.81%) River drainages. In addition to forest and urban areas, Spoon River basin contains approximately 1.05 percent mined areas.

METHODS

Water samples were collected at fixed sites near the mouth of each tributary, below the Peoria Lock and Dam, and just above LaGrange Lock and Dam. *In situ* and laboratory parameters were collected at each site. *In situ* measurements included water temperature, dissolved oxygen, conductivity, pH, and turbidity. Laboratory measurements included total nitrogen, NO_x (nitrate and nitrite), NH_x (ammonia and ammonium), total phosphorus, soluble reactive phosphorus, silica, chloride, calcium, magnesium, potassium, total suspended solids, volatile suspended solids and chlorophyll-*a*. Concentrations for nitrogen, phosphorus, and suspended solids are recorded in mg/L. Using collected nutrient concentrations and flow data provided by USGS, estimated loads for nitrogen, phosphorus, and suspended solids were calculated for La Grange Reach and its tributaries.

RESULTS

We used Pearson Correlation Coefficients to compare relations between discharge and nitrogen, phosphorus, and suspended solids. Data collected from the five tributaries showed significant, positive relations of nitrogen, phosphorus, and suspended solids with discharge; data from main channel sites indicate a significant positive correlation of nitrogen and suspended solids with discharge, but a weak, negative correlation with phosphorus and discharge.

Nitrogen

Historical records indicate that mean annual nitrate concentrations were between 1.0 and 2.0 mg/L in the early 1900's on the lower Illinois River (Dole 1909, Palmer 1903). Our data from the Illinois River near Peoria, Illinois indicate that annual total nitrogen concentrations have tripled with mean concentrations between 4 and 6 mg/L. The five tributaries also show high levels of total nitrogen. Mean annual total nitrogen concentrations were highest for Mackinaw and Spoon Rivers (4 - 8 mg/L), and lowest for Quiver Creek (2 - 3 mg/L). Sangamon and Spoon Rivers occasionally had total nitrogen concentrations that exceeded the Maximum Contaminant Level (MCL) of 10 mg/L nitrate established for drinking water standards by the U.S. Environmental Protection Agency (USEPA) (USEPA, 2000). Mackinaw River frequently exceeded this MCL every year.

Concentrations of total nitrogen were related to stream discharge in all tributaries. Total nitrogen concentrations were highest during spring flooding (May and June) with lower values occurring during the low discharge months of August and September.

The nitrogen load leaving La Grange Reach always exceeded the nitrogen load entering La Grange, with excess nitrogen most likely coming from tributaries. Between 55.9 and 76.1 percent of the nitrogen load entering La Grange reach originated upstream of the Peoria Lock and Dam. Nitrogen contributions from tributaries were always higher during years that experienced extended flood period (42.8 % in 1993 and 44.1% in 1998) and lowest during drought year (23.9% in 2000).

Phosphorus

USEPA guidelines recommend phosphorus levels $\leq$ 0.1 mg/L are required to prevent eutrophication in aquatic systems. Tributary phosphorus concentrations varied considerably from year to year and seasonally. Mean annual phosphorus concentrations were highest for the Sangamon River (0.25 - 0.6 mg/L) and lowest for Quiver Creek (0.1 - 0.2 mg/L). Mean annual phosphorus concentration at La Grange Lock and Dam seemed to exhibit an increasing trend with mean annual concentrations near 0.3 mg/L in 1993 and rising to nearly 0.5 mg/L in 2000.

Phosphorus loads leaving La Grange Reach were always higher than phosphorus loads entering the system at Peoria Lock and Dam. The difference between these two values must come from phosphorus entering from tributaries. Tributary phosphorus loads are more important to overall loading during high water years (57.4% in 1993 and 48.2% in 1995) than during low water (19.1% of total load in 2000). Phosphorus loads entering La Grange Reach at Peoria Lock and Dam remained relatively stable during most years (between 4,000 and 5,000 metric tons/year), but increased slightly during 1993 (7,362 metric tons) and 1998 (6,302 metric tons). Retention of phosphorus within La Grange Reach occurred during six of the eight years sampled. Phosphorus retention reached a peak of 5,359 metric tons in 1993, with 1994 and 1997 experiencing near equilibrium of phosphorus inflow and outflow.

Suspended Solids

High suspended solid concentrations in aquatic systems can have detrimental effects on the biotic communities. Suspended sediments can reduce water clarity, thus reducing primary productivity, and promote adverse conditions for primary and secondary consumers by interfering with respiration, reduce visibility for feeding, and fill in quiescent backwater areas that provide valuable nursery and overwinter habitats for fishes.

Suspended solids concentrations for Sangamon, Spoon, La Moine and Mackinaw rivers were highly variable throughout the study period. This high variability is associated with high concentrations during spring flood events. Quiver Creek and Peoria Lock and Dam sites exhibited less variation with suspended solids loads with mean annual concentrations for Quiver Creek between 25 and 50 mg/L and mean annual concentrations for Peoria Lock and Dam between 60 and 90 mg/L.

Suspended sediment loads leaving La Grange Reach were always higher than suspended solid loads entering the system at Peoria Lock and Dam. During 1993, 1995, 1996, 1998, and 1999 tributary inputs provided between 60 and 83.5 percent of the suspended sediments entering the system. Considerable retention of suspended solids also coincided with these years. During these years, vast amounts of floodplain were inundated allowing these sediments to settle in side channel and backwater areas. During the 1993 flood, an estimated 7 million metric tons of sediments were retained with La Grange Reach. During 1994, 1997, and 2000 suspended solids accounted for approximately half of the load entering the system with the remainder entering La Grange Reach from Peoria Lock and Dam. Sediment deposition was about equal to erosional processes and there was no net gain of sediments retained during these years. Suspended solid loads entering from Peoria lock and dam remain fairly stable throughout the study. A possible explanation for this could be that upstream sediments settle out in upper and lower Peoria Lakes before they can be transported downstream to the La Grange Reach.

CONCLUSIONS

The Long Term Resource Monitoring Program sampled water quality measurements at inflow and outflow stations on La Grange Reach, Illinois River. Five streams that emptied into La Grange Reach were also sampled. Total nitrogen, phosphorus and suspended solids were analyzed to determine concentrations (mg/L). Daily average flows were subsequently obtained from the United States Geological Survey, and used in conjunction with nutrient and suspended solid concentrations to calculate average daily loads for each of the parameters.

Analyses using Pearson Correlation Coefficient indicate that significant, positive relations existed between discharge and total nitrogen, phosphorus and suspended solids for tributary sites. Main channel sites exhibited significant, positive relations between discharge and total nitrogen and suspended solids, but a slight negative relationship was observed for discharge and phosphorus concentrations.

Total nitrogen concentrations varied considerably between tributaries. Sangamon and Spoon Rivers occasionally had total nitrogen concentrations greater 10 mg/L. Mackinaw River's total nitrogen concentration often exceeded 10 mg/L which corresponded to high flow events early in the year (January-July). Between 56 and 76 percent of total nitrogen loads came from upstream sources above Peoria Lock and Dam. The remainder of nitrogen loading came from the five tributaries.

Total phosphorus concentrations varied between years and among the separate tributaries. The mean annual phosphorus concentrations were highest for the Sangamon River (0.25 - 0.6 mg/L) and lowest for Quiver Creek (0.1 - 0.2 mg/L). Between 42.6 and 80.9 percent of the total phosphorus loads originated upstream of the Peoria Lock and Dam. The remainder of phosphorus loading came form the five tributaries.

Annual total suspended solid concentrations varied considerably for Sangamon, Spoon, La Moine, and Mackinaw Rivers with relatively predictable mean annual concentrations between 25 and 50 mg/L occurring for Quiver Creek. The Peoria Lock and Dam site also exhibited relatively stable mean annual total suspended solid concentrations between 60 and 90 mg/L. Between 16.5 and 56.6 percent of the total suspended solid load originated upstream of the Peoria Lock and Dam. A majority of the sediments entering La Grange Reach originated from tributary sources during high water years with and a large portion of these sediments were retained within the system.

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SEDIMENT, NUTRIENTS AND AGRICULTURE: SOLVING THE RIGHT PROBLEM

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Agricultural land, which covers 77.1 percent of the state, has been identified as a primary source of impairment of designated uses for 76.1 percent of the nearly 6,000 miles of impaired streams in Illinois. Nutrients, siltation and suspended solids are listed as principal causes of those water quality impairments.

With limited state and federal resources for technical assistance and cost-sharing and an agricultural economy buffeted by high input costs and low commodity prices, accurate targeting will be critical to achieving water quality improvements. However, because aquatic system dynamics, particularly those of rivers and streams, are complex and often not well understood, identification of the true cause of an impairment and prediction of system responses to changes in inputs of potential pollutants are difficult. Some streams and lakes may have high nutrient concentrations, but not exhibit eutrophication because of limited light availability due to shading or high inorganic turbidity.

Accurate targeting to achieve reductions in agricultural nonpoint sources is further complicated because potential pollutants from agriculture may have different chemistries and, consequently, different pathways to water bodies. For example, nitrate is a soluble, non-reactive chemical and is readily leached through soils, while phosphorus is slightly soluble and reactive in soils and the highest concentrations are in the upper soil layers. In Illinois, nitrate concentrations in streams and reservoirs are much higher in those areas of the state underlain by flat, black (tile-drained) and sandy soils, while phosphorus loads attributable to agricultural nonpoint sources are highest in areas of the state with high runoff or erosion rates. In addition, different management practices are often necessary to reduce nitrate and phosphorus movement to surface water: nitrate BMPs modify infiltration, leaching and soil water content; phosphorus BMPs modify surface runoff and erosion. In some instances, practices to reduce nitrate leaching and movement to surface waters may increase losses of phosphorus.

ASSESSMENT OF SEDIMENT QUALITY AND SEDIMENTATION RATES IN PEORIA LAKE

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The history of contaminant input into the lakes along the Illinois River is recorded in their sediments. The sediments in the lakes contain trace metals that are essential for life but toxic at excessive concentrations. Organic contaminants are also present in the sediment, but less is known about them in the deeper, older sediments. Chemical conditions influence the form of trace metals and the stability of organic compounds in the sediments. Dredging has been proposed as one of the components in plans to restore the ecosystems of the Illinois River. Information about the composition of these sediments is needed to predict the potential impacts of the dredging. Dredging of sediments could produce materials that can be reused beneficially but could also release potentially toxic contaminants into the water column.

Cesium-137 is present in the sediment as a result of fallout from the atmospheric testing of nuclear weapons. The sediment layer in a core that contains maximum activity of ^{137}Cs was deposited during the period of maximum atmospheric nuclear testing, approximately 1963. The onset of measurable activity from ^{137}Cs in the sediment corresponds to the start of atmospheric nuclear testing in 1954. The length of sediment in the core between these two points can be used to calculate an average sedimentation rate for the overlying sediment layers in the core. Such measurements can be used to identify areas of Peoria Lake where excessive rates of sediment accumulation may require more frequent dredging and erosion control measures. Sedimentation rate measurements estimate the approximate year sediments were deposited. When sedimentation rate estimates are combined with plots of an element's concentration versus its depth, information about what was deposited at various times can be obtained. These plots also provide insight about natural or background concentrations of elements.

PREVIOUS WORK

The Illinois State Geological Survey (ISGS) has been studying the sediment composition in the Peoria Pool of the Illinois River since 1971. As part of a pilot study, Collinson and Shimp (1972) collected 8 surface sediment samples from Peoria Lake. Those researchers compared concentrations of trace metals in the sediments from Peoria Lake with those in sediments from southern Lake Michigan and found that the Peoria Lake sediments contained higher concentrations of Pb, Zn, and Cr and lower concentrations of As and Br than did the sediments from Lake Michigan. Between 1975 and 1983, Cahill and Steele (1986) collected 27 sediment cores from 18 backwater lakes, including Peoria Lake, along the length of the Illinois River. Cahill and Steele noted that the concentrations of Zn, Pb, and Cd were greater in sediments from the upstream lakes than in downstream lakes. Sedimentation rate estimates, however, were made at only two locations in Peoria Lake. These studies focused primarily on (1) nutrients supplying energy to ecosystems and (2) trace elements documenting human-induced stressors in the Illinois River system (Cahill and Steel 1986).

In 1998, 14 sediment cores were collected between river mile 202 (Senachwine Lake) and river mile 164 in Peoria Lake. The gravity cores that were collected averaged about 50 cm in length. The sediment samples were analyzed for the total extractable concentrations of 22 metals by an Illinois Environmental Protection Agency (IEPA)-approved contract laboratory (Laboratory A). In addition, the samples were analyzed by the ISGS for total concentrations of 46 major, minor, and trace elements by multiple techniques. Most of the gravity cores collected in Peoria Lake in 1998 could not be used for the determination of sedimentation rates based on ^{137}Cs activity because the cores did not reach the depth of maximum activity (1963).

METHODS

To assess possible impacts of dredging, sediment cores must be long enough to extend below the proposed 2-m depth of dredging. A portable vibracoring system fitted with aluminum pipe to avoid organic contamination was used to collect 10 cores up to 2.4 m long. Coring locations were selected in areas of Peoria Lake where dredging has been proposed and near bathymetric profiles that had been established by the Illinois State Water Survey (ISWS). The locations of the coring sites were established using a portable GPS system. All cores were capped, sealed, and labeled in the field and then processed in the laboratory. The cores were first divided lengthwise. One half of the core was then divided into segments approximately 1 m in length, and the other half was divided into 10-cm long sections.

The 20 1-m segments of the 10 cores were analyzed by the ISGS for organic carbon and total metals. Laboratory A analyzed the sediment samples for grain size, bulk density, nitrogen, phosphorus, and organic compounds, including volatiles (acetone, benzene, etc.), pesticides (Aldrin, Heptachlor, etc.), PCBs (polychlorinated biphenyls; Aroclors), chlorinated herbicides (2,4-D, Dicamba, etc.), and polycyclic aromatic hydrocarbons (PAHs). Laboratory A and the ISGS also used the standard U.S. EPA method to determine the total extractable concentrations of trace metals in the 1-m sediment samples. The results were reported by Cahill (2001). The vibracores were split into 175 10-cm lengths that were analyzed for their ^{137}Cs content and for concentrations of total metals and organic carbon.

RESULTS AND DISCUSSION

The mean total concentrations of several environmentally important trace metals in Peoria Lake sediments are listed in Table 1. Included in the table are average concentrations of constituents in samples collected between 1978 and 1985 (Cahill and Steele, 1986) and the results from the analyses of gravity cores and vibracores collected in 1998. Total and total extractable concentrations are reported for the elements As, Ba, Cd, Cr, Cu, Ni, Pb, Se, Sb, and Zn.

The mean concentrations of the various metals in the sediments of Peoria Lake are uniform in the different depth groupings. The mean concentrations of organic carbon, Cd, Cu, Pb, and Hg are somewhat greater in the deeper, older Peoria Lake sediments than in the shallower sediments. The total concentrations of Ba, Cr, and Ni are much greater than the total extractable concentrations, which is expected and is consistent with the extractable concentrations for these elements reported for standard reference soils (Gill, 1993).

Table 1. Mean total concentrations of trace metals in sediments from Peoria Lake. All values in milligrams per kilogram unless noted. n = number of samples used to calculate mean values. Values in ( ) are total extractable metal concentrations determined by inductively coupled plasma emission spectrometry. * Values reported by Cahill and Steele (1986).

	*1978–1985 n = 34	0–20 cm n = 9	20–50 cm n = 23	0–100 cm n = 11	>100 cm n = 9
Org. C	2.56 %	2.66 %	2.80 %	2.51 %	3.28 %
Tot. P	1,900	1,400	1,700	1,600	1,400
Sb	1.6	1.3	1.4	(<25)	(<25)
As	12.2	9.9 (7.6)	11.7 (8)	(<50)	(<50)
Ba	526	525 (200)	571 (207)	569 (214)	539 (207)
Cd	4.0	(2.8)	(3.6)	(4.4)	(4.8)
Cr	126	97 (38)	107 (45)	(52)	(50)
Cu	53	53 (50)	57 (52)	57 (48)	55 (48)
Pb	82	(42)	(49)	(55)	(56)
Hg	0.32	0.25	0.31	0.31	0.41
Ni	81	53 (35)	56 (38)	60 (52)	51 (42)
Se	<2	1.0	1.5	(1.5)	(1.5)
Ag	1.0	1.2	1.4	<2	<2
Zn	310	281 (256)	295 (274)	315 (307)	304 (300)

All of the vibracores were of sufficient length to reach sediment layers with no detectable ^{137}Cs activity (pre-1954). Average sedimentation rates determined for these cores ranged from 0.7 to 3.3 cm/yr. The sedimentation rates determined by the ^{137}Cs method are comparable with previous estimates based on ISWS bathymetric profiles (Demissie and Bhowmik, 1986). No cores were collected in the areas of Peoria Lake where river deltas are actively forming near the mouths of Richland, Partridge, Blue, Dickison, and Farm Creeks. In these areas, sedimentation rates are expected to be higher.

In Figure 1, the concentrations of organic carbon in 10-cm sediment intervals subsampled from a core collected near river mile 169 are plotted versus their approximate date of deposition. The concentration of organic carbon is uniform in the upper segments of the sediment core but increases at the base of the core. This core was of sufficient length to penetrate the top of the original floodplain soils that were present before completion of the Peoria Lock and Dam at river mile 157.6 in 1939.

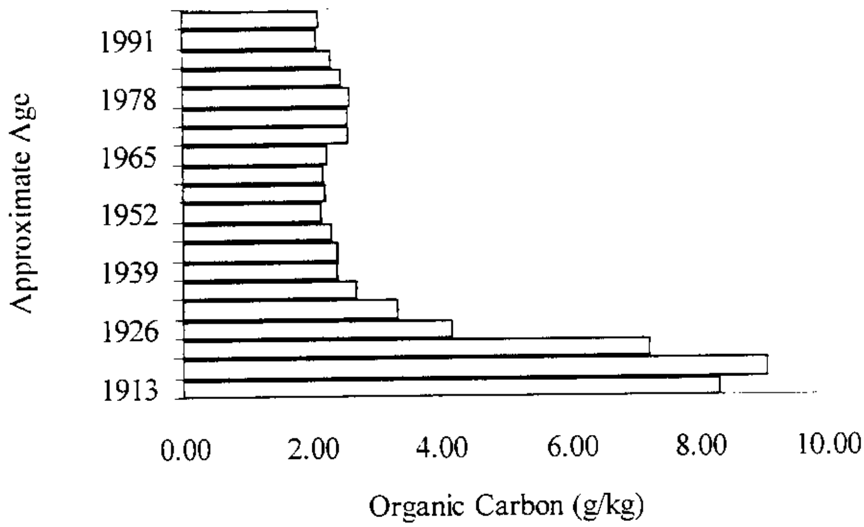

Figure 1. Organic carbon distribution in a sediment virbracore collected near river mile 169 in Peoria Lake. Each increment is 10 cm, and the core was 204 cm in length.

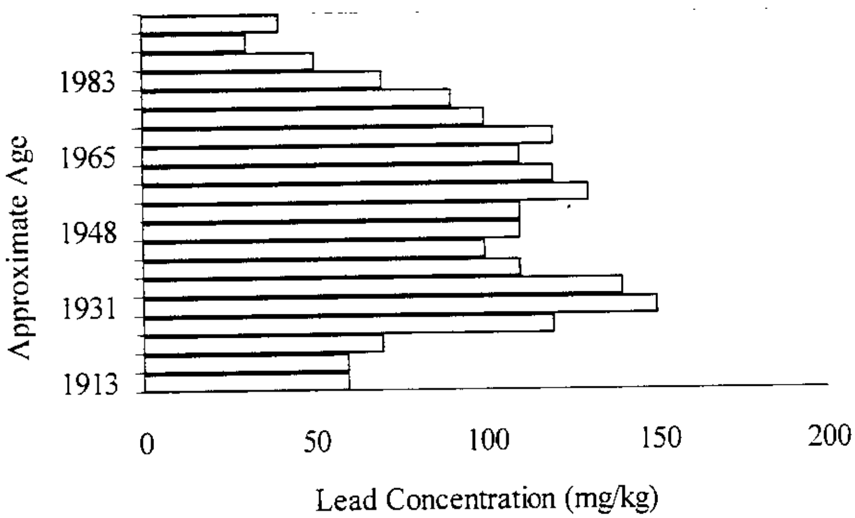

Figure 2. Lead distribution in a sediment virbracore collected near river mile 169 in Peoria Lake. Each increment is 10 cm, and the core was 204 cm in length.

The concentrations of lead in the 10-cm segments of the same sediment core from Peoria Lake versus the approximate date of deposition are plotted in Figure 2. The plot shows that the amount of lead entering Peoria Lake has decreased dramatically since the 1970s, and lead concentrations of the most recent sediments are close to background levels. Organic lead compounds were added to gasoline starting in the 1920s. The U.S. EPA ordered incremental reductions of these compounds beginning in 1973 and the total removal from gasoline by 1986.

Organic Pollutants in Peoria Lake Sediments

Of the 34 volatile organic compounds tested in the 20 1-m segments, only acetone, 2-butanone, and methylene chloride were detected in some of the samples. No pesticides or PCB compounds were detected. Of the 12 chlorinated herbicides assayed for in the samples, 2,4-D was detected in 4 samples, dalapon in 5 samples, and dicamba in 1 sample. The mean, minimum, and maximum concentrations of the PAH compounds are shown in Table 2. PAH compounds, a class of very stable organic compounds that are both naturally occurring and of anthropogenic origin, were detected in most of the sediment samples. Some PAHs are suspected of being carcinogenic. Forest fires, prairie fires, and fossil-fuel combustion are the major contributors of PAHs to the environment.

Table 2. Mean, minimum, and maximum concentrations, and number (no.) of values above detection limit for PAHs in sediments from Peoria Lake determined by Laboratory A (U.S. EPA Method 8310). Values are in micrograms per kilogram.

	Mean	Minimum	Maximum	no.
Acenaphthene	943	<1,200	3,500	10
Acenaphthylene	<1,300	<1,300		0
Anthracene	126	<130	420	10
Benzo(a) anthracene	<420	<420	3,100	8
Benzo(a)pyrene	642	<130	2,200	17
Benzo(b)fluoranthene	3,060	260	5,800	20
Benzo(g, h, i) perylene	<130	<130	1,500	9
Benzo(k)-fluoranthene	252	<130	690	17
Chrysene	830	<130	3,500	16
Dibenz(a, h)anthracene	<120	<120	2,800	7
Fluoranthene	894	<6	3,800	18
Fluorene	<1,200	<1,200		0
Indeno(1,2,3-c, d)pyrene	428	<100	1,200	13
Naphthalene	<1,100	<1,100		0
Phenanthrene	307	<130	1,400	17
Pyrene	911	<130	3,500	12

Comparison of Results to Various Sediment Quality Guidelines

The ISGS measured the background concentrations of 48 inorganic elements in 192 soil samples from 77 counties in Illinois (Frost, 1995). Included in the study were 18 soil samples collected in seven of the counties that border the Peoria Pool of the Illinois River. The soil samples were collected at depths of 10 to 20 cm and 70 to 80 cm. The IEPA determined the concentration of inorganic elements in 775 soil samples from all 102 counties of Illinois (IEPA, 1994). The soils were collected at various depths, with different sampling techniques, at sites judged by the field staff to be undisturbed by site-related activities. The analytical method used by the IEPA was not a total digestion procedure, so the IEPA results are not directly comparable with those of the ISGS.

The IEPA has classified Illinois lake sediment quality based on analyses of 1,876 sediment samples collected since 1977 from 307 lakes in Illinois. In the IEPA classification, an analyte concentration is referred to as "elevated" if is it between one and two standard deviations greater than the analyte's mean concentration. Sediments were considered to have "highly elevated" concentrations if the concentration was greater than two standard deviations above the mean (Mitzelfelt, 1996).

Listed in Table 3 are the mean background concentrations of metals in undisturbed soils in the Peoria area, background concentrations of metals in Illinois soils determined by ISGS and IEPA, and the concentration values classified by the IEPA as elevated and highly elevated for Illinois lake sediments.

Table 3. Mean background (Bkg.) concentrations of metals in undisturbed soils in the Peoria area. Mean concentrations in Illinois soils determined by ISGS and IEPA, and elevated and highly elevated classifications of metal concentrations in Illinois lake sediments. All values in milligrams per kilogram.

	Bkg. for Soils in Peoria Area (ISGS)	Bkg. for Soils, Statewide (ISGS)	Bkg. for Soils Statewide (IEPA)	Elevated Sediment Concentrations (IEPA)	Highly Elevated Sediment Concentrations (IEPA)
As	12	10	7	14 to 95	>95
Cd	<3	<1	1	5 to 14	>14
Cr	63	57	17	27 to 49	>49
Cu	26	30	20	100 to 590	>590
Pb	15	24	49	59 to 339	>339
Hg			0.11	0.15 to 0.70	>0.70
Ni	14	24	17	31 to 43	>43
Zn	77	77	73	103	145 to

The trace metal contents of the Illinois River sediments will influence decisions on whether dredged sediments can be reused. Regulatory agencies require information about the quality of sediments before dredged sediments can be applied to land to replenish lost topsoil or revitalize contaminated industrial sites known as "brownfields." The levels of metals and organic compounds regulated at these locations are given in the TACO statute (Illinois Compiled Statutes, 1997). TACO, an acronym for tiered approach to corrective action objectives, is a tool for deciding the degree of remediation a contaminated site must undergo in order to protect human health. Tables 4 and 5 list consensus-based sediment quality guidelines for freshwater ecosystems recently developed for the U.S. EPA (MacDonald et al., 2000). The tables also list the number of times the consensus-based probable effect concentrations were exceeded in Peoria Lake sediment samples.

Table 4. Consensus-based sediment quality guidelines for freshwater ecosystems and the number of sediment samples (n) from Peoria Lake above the probable effect concentration (PEC) based on values from Laboratory A and values from ISGS for metals. NM = not measured. *MacDonald (2000). @ Value under review. Values in milligram per kilogram.

	TACO Tier 1 Soil Ingestion	Consensus-Based PEC*	n > PEC Laboratory A	n > PEC ISGS
As	0.4@	33	5/20	0/20
Cd	78	5	8/20	11/20
Cr	390	111	0/20	0/20
Cu	2,900	149	NM	0/20
Pb	400	128	0/20	0/20
Hg	23	1.06	0/20	NM
Ni	1,600	49	NM	11/20
Zn		23.000	459	NM 1/20

Additional Sediment Quality Information for PAHs in Peoria Lake at River Mile 165

There is considerable interest in the sediment quality near river mile 165 in Peoria Lake. Limited dredging was conducted in this area in May 2000 to create a channel for the Spindler Marina. Additional large-scale dredging has been proposed for the area. Sediment samples were collected in 1999 and 2000 as part of the Peoria River Front Environmental Restoration Project. These samples were tested for a similar comprehensive list of parameters by Laboratory A as well as by a second contract laboratory (Laboratory B). In January 2001, the IEPA collected 3 samples of sediment that had been dredged for the Spindler project. The sediment had weathered outside for about nine months while being stored at a gravel pit. These samples were analyzed by the IEPA laboratories.

Table 5. Consensus-based sediment quality guidelines for freshwater ecosystems and the number of sediment samples (n) from Peoria Lake above the probable effect concentration based on values from laboratory A for PAHs. Values in milligram per kilogram. NC = not classified.

	TACO Tier I Soil Ingestion	Consensus-Based PEC	n > PEC Laboratory A
Acenaphthene	4,700	NC	
Anthracene	23,000	0.85	0/20
Benzo(a) anthracene	0.9	1.05	4/20
Benzo(a)pyrene	NC	1.45	2/20
Benzo(b)fluoranthene	0.9	NC	
Benzo(k)fluoranthene	9	NC	
Chrysene	88	1.29	6/20
Dibenz(a,h)anthracene	0.09	NC	
Fluoranthene	3,100	2.23	0/20
Fluorene	3,100	0.54	1/20
Indeno(1,2,3-c,d) pyrene	0.9	NC	
Naphthalene	3,100	0.56	0/20
Phenanthrene	NC	1.17	1/20
Pyrene	2,300	1.52	2/20

The concentrations of PAH compounds in samples collected near RM 165 in Peoria Lake are listed in Table 6. It should be noted that the results are for sediment samples collected by different coring techniques, at different depths, and at different times.

Laboratory B found much lower concentrations of PAH compounds than did laboratory A. The concentrations of some PAH compounds determined by the IEPA on the dredged sediment were comparable with those determined by laboratory A and, in a few cases, were higher. The high concentrations of benzo(a)pyrene and dibenz(a,h)anthracene found by laboratory A were not confirmed by the other laboratories.

Table 6. Concentrations of PAH compounds according to U.S. EPA Method 8310 in Peoria Lake sediment collected near river mile 165 determined by IEPA and Laboratories A and B. All values in milligrams per kilogram.

	Lab A 11/98	Lab A 2/99	Lab B 10/00	IEPA 1/01
Acenaphthene	<0.9	0.423	0.051	<0.08
Acenaphthylene	<0.9	<0.076	<0.18	<0.08
Anthracene	<0.09	0.053	<0.01	<0.07
Benzo(a)anthracene	0.31	0.195	<0.075	0.19
Benzo(a)pyrene	0.24	0.385	0.025	0.12
Benzo(b)fluoranthene	3.1	2.05	0.016	0.23
Benzo(g,h,i)perylene	<0.6	0.68	0.036	<0.12
Benzo(k)fluoranthene	0.13	0.21	0.024	0.25
Chrysene	0.12	0.25	0.018	0.26
Dibenz(a,h)anthracene	<0.094	2.8	0.006	<0.08
Fluoranthene	0.36	0.32	0.033	0.50
Fluorene	<0.94	0.093	<0.025	<0.08
Indeno(1,2,3-c,d) pyrene	<0.094	0.53	0.019	<0.14
Naphthalene	<0.093	0.26	<0.20	<0.08
Phenanthrene	0.12	0.195	0.011	0.36
Pyrene	<0.094	0.52	0.026	0.43

CONCLUSIONS

- The sediment quality in Peoria Lake has improved during the last twenty years.
- The concentrations of metals in the sediment of Peoria Lake are above background soil levels. Cadmium and nickel concentrations are above consensus-based probable effect concentration levels but below TACO guidelines.
- Only limited information exists about the organic compounds present in the sediments. PCB and pesticide compounds were not detected. Chlorinated herbicides were detected in a few samples. The concentrations of PAHs exceeded consensus-based probable effect concentration levels in some cases, but the agreement between determinations by different laboratories is poor.
- Long-term sedimentation rates are high—about 1 foot of sediment is deposited every ten years. Improved erosion control practices are needed in conjunction with any proposed dredging, or the sedimentation problems will recur in a few years.

RECOMMENDATIONS

Our reconnaissance effort indicates the need for the further studies for the following purposes:

- Detailed sampling and analysis of sediment cores from areas proposed for dredging to determine the extent of contaminated sediments.
- Determination of realistic background levels for organic compounds in Illinois River sediments in order to improve our understanding of their distribution and fate

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THE PORE WATER CHEMISTRY OF RECENT PEORIA LAKE SEDIMENTS

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ABSTRACT

The composition of sediment pore waters reflects the biogeochemical conditions of those sediments. Chemical species present in pore waters are also directly available to sediment-dwelling organisms, and can diffuse into the overlying water column or mix with overlying water during sediment resuspension events due to storms, boat and barge traffic, or dredging operations.

There appears to have been little previous information on Peoria Lake pore water chemistry prior to our study. However, several previous and ongoing studies have characterized the chemistry of sediment solids in Peoria Lake, primarily as a prelude to proposed restoration efforts. Consequently, our research complements those efforts.

Specifically, we have characterized the concentrations and potential toxicity of several heavy metals (cadmium, copper, nickel, lead, and zinc) and ammonia in pore waters of Peoria Lake to a depth of 30 cm. Pore water measurements also included dissolved organic carbon and pH. Complementary sediment solid analyses included Acid-Volatile Sulfide (AVS) and Simultaneously Extracted Metals (SEM) concentrations. Sediment cores were collected in both April and October of 2000 to permit a first-order assessment of seasonal differences.

Significant results included: 1) All sediment sections contained detectable AVS indicating Peoria Lake sediments are strongly reducing below a depth of about 3 cm. 2) Pore water ammonia concentrations were high, ranging from about 0.5-36 mg/L (as N), while overlying water concentrations were much lower ($\leq$ 0.2 mg/L). Also, ammonia pore water concentrations generally increased with depth, and were higher in October than April. 3) Pore water pH values ranged from about 7.5 to 6.8 and generally decreased with depth. These pH values were lower than those of the overlying water column (7.8-8.5). 4) Dissolved concentrations of cadmium, copper, nickel, lead, and zinc were low in pore waters (<15 μg/L), and these concentrations were generally lower than those present in the overlying water column. The formation of sparingly soluble metal sulfides is at least partially responsible for the low pore water concentrations of these metals. From these results, dissolved ammonia is potentially more toxic to sensitive indigenous species than dissolved cadmium, copper, nickel, lead or zinc.

INTRODUCTION

Peoria Lake has undergone severe sedimentation for the past century. The Lake had lost 68% of its 1903 capacity by 1985 (ISWS, 1994) and consequently, dredging and other restoration efforts are planned. To collect background information before dredging, numerous sediment cores were collected and analyzed for a variety of chemical constituents including metals, nutrients and organic compounds on a total sediment basis (Cahill, 2001). These data provide important background information that will help ensure that the proposed dredging and disposal operations are conducted in an environmentally safe manner.

The contaminants of concern in Peoria Lake sediments include metals and ammonia. The U.S. EPA recently assessed the incidence and severity of sediment contamination in U.S. waterways

(USEPA, 1997). Elevated concentrations of Zn, Ni, Cu, Pb, and Cd in some sediment samples contributed to the Lower Illinois River (including Peoria Lake) being designated as an area of probable concern for sediment contamination. A related concern is the potential toxicity of Peoria Lake sediments to aquatic organisms. Sparks and Ross (1992) attempted to identify the toxic substances that may have been responsible for the rapid decline in several species of aquatic organisms in the upper Illinois River during the mid-1950's. Toxicity tests with both the fingernail clam and water flea (*Ceriodaphnia dubia*) using pore waters from various locations between river miles 6 and 248 strongly implicated ammonia as the species primarily responsible for the observed acute toxic effects. The total ammonia concentrations in the pore waters used typically ranged between about 20 and 60 mg/L (as N). Unfortunately, Sparks and Ross (1992) were unable to precisely characterize ammonia toxicity because their pH measurements were unstable. Accurate pH measurements are required to determine the fraction of the total ammonia that exists in the highly toxic un-ionized form (i.e., NH_3). Still, their evidence for the importance of ammonia to sediment toxicity of Illinois River sediments is strong.

Since the mid-1980's the U.S. EPA has also been heavily involved in attempting to establish sediment quality criteria for metals, including Cu, Pb, Cd, Zn, and Ni (Hansen et al., 1996). This effort has been driven by the desire to identify sediment quality criteria that are better predictors of potential toxicity than total metal concentrations in sediments. That is, the potentially bioavailable fraction of metals is usually not closely correlated with total metal concentrations. Rather, toxic effects are more closely correlated with pore water metal concentrations.

In anoxic sediments, acid-volatile sulfides (AVS) are key phases that help control pore water concentrations of Cu, Pb, Cd, Zn, and Ni (Ankley et al. 1996, Chapman et al. 1998, DiToro et al. 1992). Determination of sediment AVS concentrations, as well as the concentrations of simultaneously extracted Cu, Pb, Cd, Zn, and Ni, (collectively termed simultaneously extracted metals, or SEM) is performed using a cold 1N HCL extraction, followed by determination of sulfide and SEM concentrations in the extracts (Allen et al. 1993). Several studies have demonstrated that sediments with SEM/AVS molar ratios less than one are seldom toxic, while SEM/AVS ratios greater than one more often result in sediment toxicity (Berry et al. 1996, Hansen et al. 1996). An excess of AVS usually results in low pore water Cu, Pb, Cd, Zn, and Ni concentrations because sufficient sulfide is available to form sparingly soluble metal sulfides from these metals (e.g., CuS). Conversely, SEM/AVS ratios greater than one suggest that free sulfide concentrations are not high enough to bind all available Cu, Pb, Cd, Zn, and Ni as insoluble metal sulfides. In this instance, the bioavailable fraction of these metals may be greater, although other phases such as organic matter or ferric- and manganese-oxide phases may act to keep the bioavailable fraction of these metals relatively low. Consequently, sediments with SEM/AVS ratios greater than one are not necessarily toxic.

The overall objective of this study was to provide a comprehensive assessment of ammonia, Cu, Pb, Cd, Zn, and Ni concentrations in the pore waters of Peoria Lake sediments, as well as AVS and SEM concentrations in these same sediments. The results and expertise gained should also prove useful for future studies focused on other portions of the Illinois River watershed, or other watersheds within the State.

METHODS

The ten sediment coring locations between River Miles 179 and 164 were located using a hand held Global Positioning System (GPS) unit and were close to the 1998 vibracore locations given in Table 1 of Cahill (2001). Two cores were collected at each station, and disturbance was minimal during collection as evidenced by visual confirmation of a distinct sediment-water interface. One core was used to determine sediment pH and temperature immediately after collection, and the other was sectioned into 6 cm intervals to a depth of 30 cm. These 6cm core sections were sealed, stored at 4°C, and processed at the State Water Survey (SWS) Peoria Laboratory within three days of collection.

Filtered samples of overlying river water were also collected. Sediments were processed in glove bags flushed with nitrogen gas to minimize sediment oxidation. Sediment pore waters were isolated using a high-speed centrifuge followed by filtration (0.2 μm filtration for metals and ammonia, 1.0 μm filtration for dissolved organic carbon). Sediment samples isolated for AVS and SEM determinations were placed in glass jars and frozen until analysis. Sediment cores were collected in early April and October 2000.

Pore waters were analyzed for dissolved cadmium, calcium, copper, lead, nickel, organic carbon, and zinc in the laboratories of the Waste Management and Research Center (WMRC) in Champaign. Dissolved ammonia in all pore water samples and dissolved iron, phosphate, and nitrate in selected pore water samples were determined at the SWS laboratories. AVS and SEM were extracted at the SWS, and analyzed at the SWS and WMRC, respectively. Other solid-phase analyses included total organic carbon and total recoverable metals (results not presented here) from extraction with hot, concentrated nitric acid. These analyses were done at both the WMRC and the State Geological Survey in Champaign (the top and bottom sections from each core only). Analytical protocols included QA/QC procedures for analysis of field and laboratory blanks, duplicate samples, and analytical spike recoveries.

RESULTS AND DISCUSSION

In the Figures below, results are summarized as "Box and Whisker" plots, with April data in gray and October in black. The length of each box encompasses the 25th and 75th percentiles of all the values used at a given depth. The solid square indicates the average data value, and the vertical line within each box is the median value. Maximum and minimum data values are given by (∗), and the length of the whiskers is 1.5 times greater and less than the 75th and 25th percentiles, respectively. Values falling outside the width of the whiskers can be considered statistical outliers. When outliers occur it is usually the maximum and/or minimum values of a particular data set at a given depth. However, other data values are also sometimes outliers and these are given by (Λ). Between 8 and 14 points were used to generate each box and whisker.

Pore water and surface water pH values are summarized in Figure 1. The horizontal dotted line indicates the sediment-water interface, and positive and negative depth values indicate depth below and above this interface, respectively. The pH values decreased systematically from about 7.8 to 8.5 in the surface water to about 6.8 to 7.1 at 27 cm depth. It is also apparent that both mean and median pH values were lower in October than April, especially at sediment depths of 15 cm and greater. These lower pH values probably result primarily from increased microbial metabolism of available organic matter since sediment temperatures were 5 to 6 °C warmer during our October sampling dates than those in April. Increased metabolism of organic matter results in a greater net production of dissolved carbon dioxide, and this decreases sediment pH values.

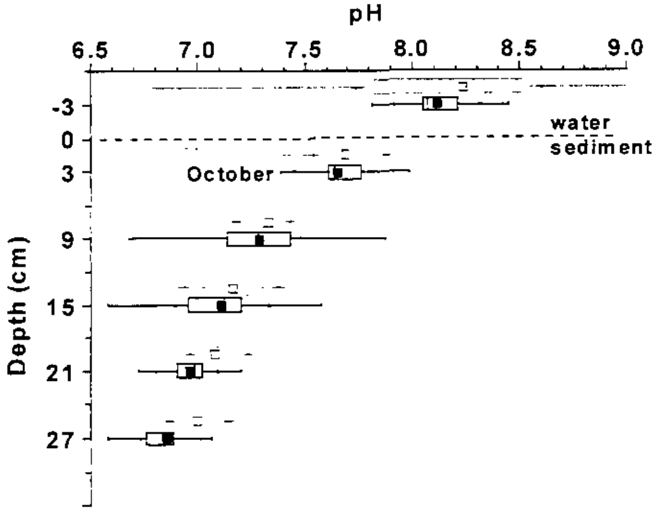

Figure 1. Surface water and sediment pore water pH values.

Dissolved organic carbon concentrations are summarized in Figure 2. The primary source of this dissolved organic carbon is the solubilization and metabolism of particulate organic carbon. Concentrations were higher in sediment pore waters than in the overlying water, and mean and median pore water concentrations increased with depth. However, the boxes and whiskers are very long which indicates that dissolved organic carbon concentrations varied widely at all depths. Part of this variability may have been due to the passage of colloidal organic matter through the 1 micron filters used for filtration. Also, given this large variability, dissolved organic carbon concentrations were not significantly different between April and October. Finally, since pore water values are greater than those in the overlying water, the sediments represent a net source of dissolved organic carbon to the overlying waters through both diffusional and turbulent mixing processes.

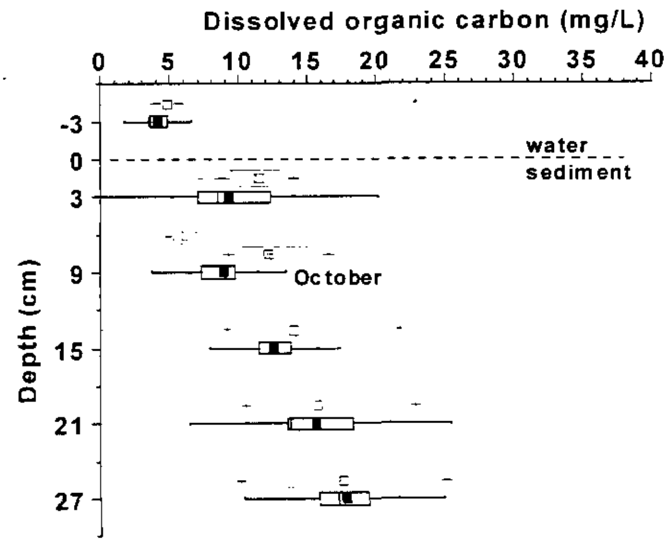

Figure 2. Dissolved organic carbon concentrations. Average sediment depth refers to the average depth of the 6 cm sediment core sections from which pore waters were isolated.

Dissolved ammonium concentrations are summarized in Figure 3. The primary source of this pore water NH_4-N is typically the solubilization and anoxic metabolism of particulate organic nitrogen (Berner, 1980, DiToro, 2001). Overlying water column values were usually less than the analytical detection limit of 0.07 mg/L as NH_4-N. Mean and median pore water concentrations, however, increased from about 1-2 mg/L NH_4-N at an average sediment depth of 3 cm, to about 10 to 20 mg/L NH_4-N at 27 cm average sediment depth. It is also apparent that average and median NH_4-N concentrations below 15 cm average sediment depth were significantly higher during our October sampling dates than those in April. Consequently, the higher October concentrations could reflect greater microbiological activity during this period due to the warmer sediment temperatures.

Figure 3 also contains a dotted line that indicates the Chronic Criterion Concentration (CCC) for NH_4-N as defined by the U.S. EPA (U.S. EPA, 1999a). This CCC value represents that dissolved NH_4-N concentration that should not be exceeded more than once every three years on average, when juvenile fish are present. The CCC value is temperature- and especially pH-dependent since both of these variables determine what fraction of total dissolved ammonia is present as the toxic NH_3 form. The line given in Figure 3 is calculated based on a temperature of 19 °C, and the mean pH values given in Figure 1. The equation used to perform this calculation is given elsewhere (U.S. EPA, 1999a). Mean and median pore water NH_4-N concentrations exceeded the CCC at and below 15 cm average sediment depth. Above 15 cm, pore water NH_4-N concentrations were generally less than the CCC. Futhermore, fingernail clams, which are indigenous to the Illinois River and which burrow to several centimeters depth in sediments may be impaired at ammonia concentrations lower than the CCC (Sparks and Sandusky, 1981, U.S. EPA, 1999a). Consequently, pore water ammonia concentrations may be toxic to sensitive indigenous species in Peoria Lake.

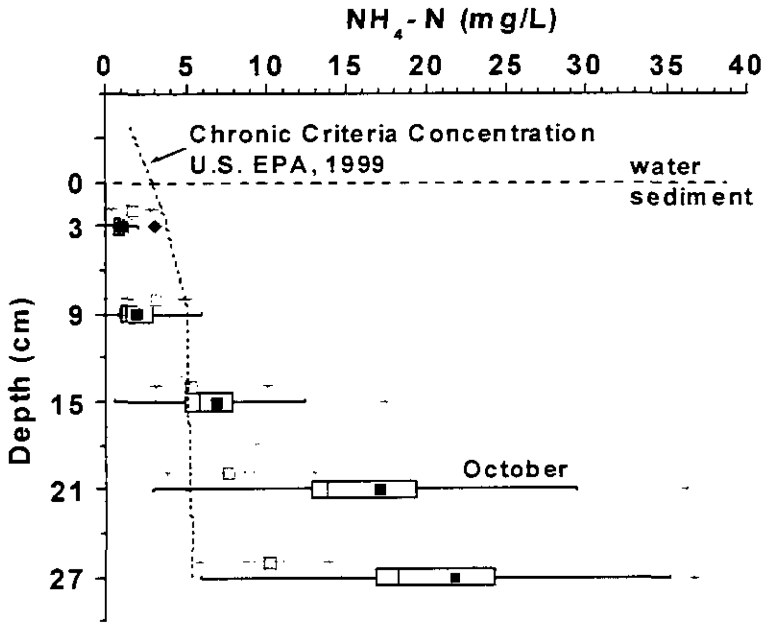

Figure 3. Dissolved ammonia-nitrogen concentrations.

Dissolved calcium concentrations are summarized in Figure 4. Mean and median calcium concentrations increased from 50 to 60 mg/L in the surface water to 120 to 140 mg/L at 27 cm average sediment depth. Pore water concentrations at 3 and 9 cm average sediment depth were somewhat greater in April than October, while the reverse was true at 21 and 27 cm average sediment depth. Dissolved calcium concentrations are probably higher in pore waters because of the increased dissolution of calcite ($CaCO_3$) and/or dolomite ($CaMg(CO_3)_2$) at the lower sediment pH values (Figure 1).

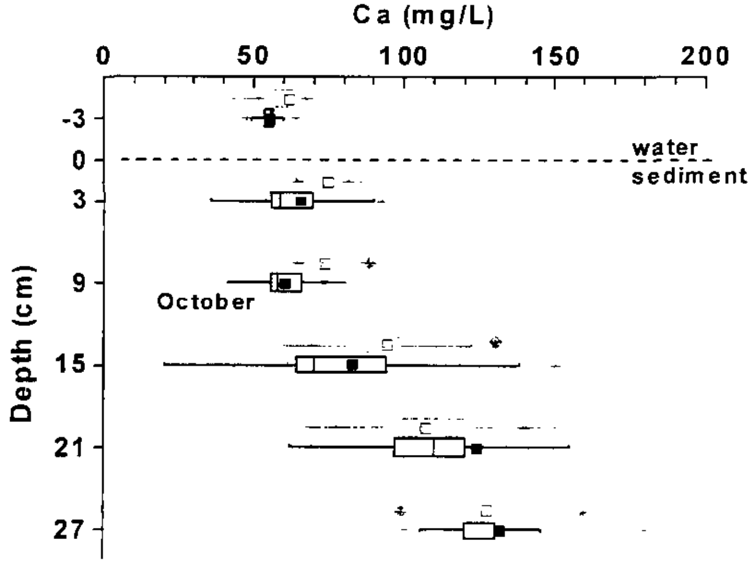

Figure 4. Dissolved calcium concentrations.

Surface and pore water concentrations of dissolved cadmium, copper, lead, nickel and zinc were always less than 15 µg/L. Moreover, of these potentially toxic metals, only nickel was consistently above the analytical detection limits of 0.05 to 0.2 µg/L (depending on the metal). Dissolved nickel concentrations are summarized in Figure 5. Mean and median surface and pore water concentrations ranged from 3 to 6 µg/L, and both surface and especially pore water concentrations were noticeably greater in October than in April. The specific reasons for this difference are unknown, but the higher October concentrations mimic those noted above for NH_4-N.

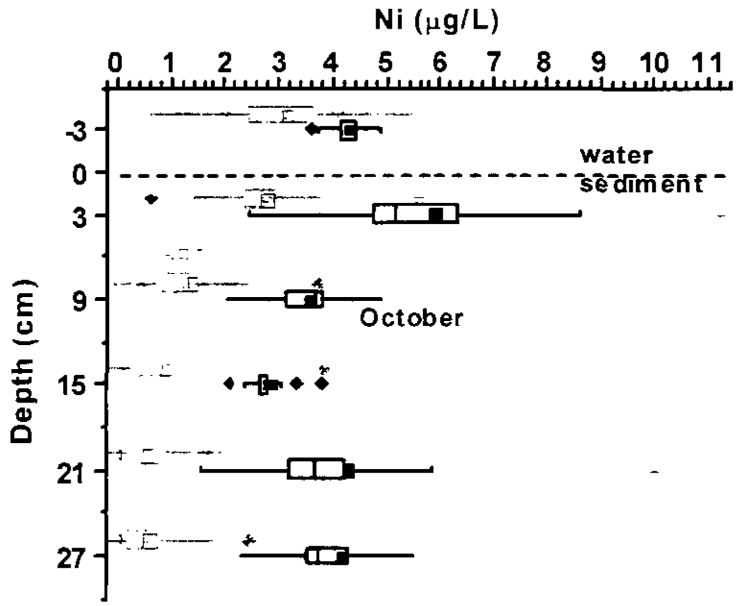

Figure 5. Dissolved nickel concentrations.

In any case, dissolved concentrations of cadmium, copper, lead, nickel, and zinc are too low to be toxic in and by themselves. This can be demonstrated by comparing measured pore water concentrations of these metals with the corresponding Criterion Continuous Concentrations as defined by the U.S. EPA (U.S. EPA, 1999b). These concentrations increase as water hardness increases, and specific formulas incorporating the effect of water hardness are given in Appendices A and B of the U.S. EPA, 1999b document. Water hardness is normally dominated by dissolved calcium and magnesium. Consequently, the mean surface water dissolved calcium concentration of about 60 mg/L represents a minimum water hardness value since mean pore water dissolved calcium concentrations are higher (see Figure 4 above). With this minimum hardness concentration, the Criterion Continuous Concentrations for dissolved cadmium, copper, lead, nickel and zinc are 3, 12.6, 3.9, 73.2, and 166.3 µg/L, respectively. The concentrations are well above measured surface and pore water concentrations of these metals. Therefore, measured concentrations are not likely to be toxic.

Acid volatile sulfide (AVS) and simultaneously extracted metal (SEM) concentrations from our April sediment cores are summarized in Figure 6, with AVS concentrations in gray, and SEM concentrations in black. Extracted cadmium, copper, lead, nickel and zinc concentrations were summed to obtain the SEM values included in this Figure. Acid volatile sulfides were detected in every sediment section analyzed. Consequently, Peoria Lake sediments are strongly reducing below an average sediment depth of about 3 cm since AVS phases are unstable in the presence of oxygen. AVS concentrations are significantly lower at 3 cm than at deeper sediment depths, most likely because this sediment section directly contacts the oxygenated overlying water. AVS concentrations are also highly variable at a given sediment depth, which reflects both the variable concentrations found at the various sampling locations within Peoria Lake, and the experimental variability inherent in the AVS extraction and analysis method itself (Allen et al., 1993).

SEM concentrations were lower than corresponding AVS concentrations in every individual sediment section analyzed. Mean SEM/AVS molar ratios varied from about 0.17 at 9 cm average sediment depth, to about 0.30 at both 3 and 27 cm average sediment depth. These averaged ratios are considerably less than one, which means that none of the individual SEM constituents (cadmium, copper, lead, nickel, or zinc) is probably toxic in the undisturbed sediments. However, suspension of AVS containing sediments has sometimes resulted in short term concentration increases of dissolved forms of these metals due to oxidation of the corresponding solid phase sulfide phases (Zhuang et al., 1994; Van Den Berg et al., 2001). Consequently, this is also a possibility for Peoria Lake sediments, which could result in short-term toxicity of some of the individual SEM constituents. In any case the considerable excess of AVS over SEM is also probably primarily responsible for the low observed dissolved concentrations of these metals in pore waters. That is, excess sulfide leads to the formation of sparingly soluble metal sulfides.

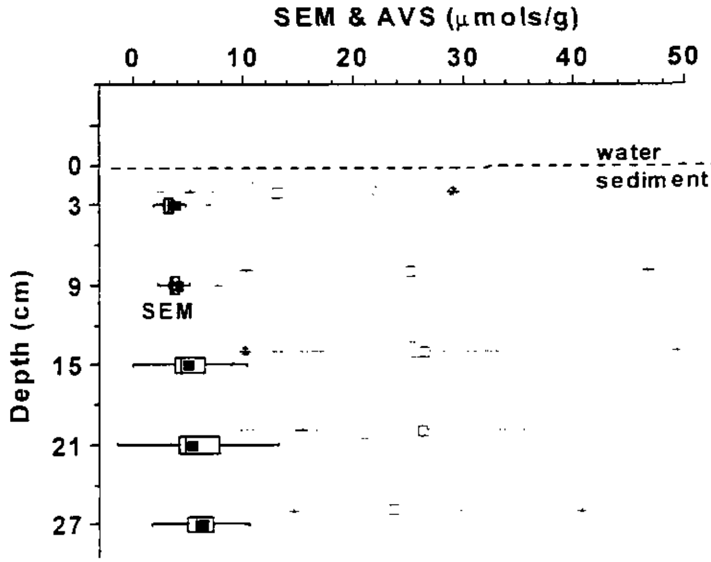

Figure 6. April 2000 AVS (gray) and SEM (black) concentrations.

CONCLUSIONS

The pore waters of recent Peoria Lake sediments have a distinctly different chemistry from that of the overlying water. Sediment microorganisms metabolize available organic matter of the rapidly accumulating sediment, consuming first oxygen and then other electron acceptors. This leads to the development of strongly reducing conditions within 3 cm of the sediment-water interface with a concomitant reduction in pH and increase in dissolved organic carbon and ammonia nitrogen with increasing sediment depth. Pore water ammonia concentrations are high enough to possibly be toxic to indigenous sediment biota such as fingernail clams. Moreover, ammonia concentrations below 15 cm average depth are significantly higher in early fall than in early spring, most probably because warmer sediment temperatures promote increased microbial mineralization of available particulate organic nitrogen.

Pore water concentrations of potentially toxic metals were low and below threshold toxic concentrations primarily because molar concentrations of acid volatile sulfides exceeded those of the potentially toxic metals. Consequently, a large fraction of these metals exist as sparingly soluble metal sulfides. Proposed dredging in Peoria Lake may cause oxidation of these metal sulfides, and this could result in short-term elevated concentrations of dissolved cadmium, copper, lead, nickel, and zinc. However, dissolved ammonia is potentially more toxic than these metal species.

Questions worthy of additional study include conducting similar investigations in other reaches of the Illinois River or other rivers within the State, as well as before, during and after any dredging in Peoria Lake itself. The removal of 2 or more meters of sediment from areas of Peoria Lake would place previously deeply buried sediments near the sediment-water interface. Detailed studies of this new sediment-water interface environment should be an integral part of post-dredging research activities; the reestablishment of desired benthic organisms could be impaired if potentially toxic chemical species exist at elevated concentrations. These studies should include a detailed characterization of potentially toxic dissolved and solid phase organic compounds, which were not part of the present investigation.

ACKNOWLEDGEMENTS

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FROM SEDIMENT TO SOIL

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ABSTRACT

The Peoria Lakes area of the Illinois River has been greatly impacted by sedimentation. and a large dredging project has been proposed to reestablish its wildlife habitat. Placement and potential beneficial reuse of the dredged sediments is an issue. Two research projects were conducted to investigate the feasibility of using sediment as landscaping soil. The first was a retrospective study of sediment disposal operations. Sediments previously dredged from reservoirs in central Illinois were sampled along with adjacent upland soils serving as references. Sediments from the Illinois River above Peoria were sampled from islands, river bottom, and adjacent floodplain. Recently dredged sediments have high water content and low soil strength and are capable of supporting only wetland vegetation. After dewatering, the physical properties of sediments tend to become similar to upland soils and then are able to support conventional agriculture. Sediment organic matter content was similar to local reference surface soils and pH of the sediments was neutral or above. Sediment textures were dominated by silts and clays, with the Lake Peoria samples being most clayey. Calcium was the dominant cation in all the samples and micronutrients measured were in adequate supply. Because the Illinois River watershed includes industrial inputs, river sediments contained elevated levels of some metals, but they were generally below levels of concern.

The second experiment was conducted to determine if plants grown on sediments from the Illinois River suffered adverse impacts. Lettuce, barley, radishes, tomatoes, and snap beans, grown in the greenhouse in pots of sediment and reference topsoil did not show significant or consistent differences in yields. Metal contents of tomatoes grown in sediments were below levels of concern, and generally similar to tomatoes grown in local topsoil.

Results indicate that land placement of the sediments is a beneficial option. Properly managed sediments can make productive soils because of their high natural fertility and water holding capacity. The lack of significant metal uptake indicates that metals may not be a serious obstacle. In addition, sediment placement on poor soils, such as found at eroded areas, surface mines, or brownfields, could improve their productivity and utility.

INTRODUCTION

Sedimentation is a significant problem in reservoirs and other water bodies in watersheds impacted by erosion from farmland, urban areas, and stream banks and beds. Sediment reduces water depth and quality and impacts such uses as water supply, recreational boating, and fish and wildlife habitat. Illinois water supply reservoirs are expected to lose approximately 1.2×10^8 m^3 of useful storage capacity between 1990 and 2030 due to sedimentation (Singh and Durgunoglu, 1990). The adverse impact of sedimentation on the Illinois River was summarized by Talkington, 1991. Demissie (1997) estimated that on average bottomland lakes in the Illinois River valley lost 72 percent of their water storage capacity to sedimentation by 1990.

Dredging is employed to remove sediment from water supply reservoirs and navigation channels. Placement of dredged sediment has traditionally been considered disposal. regardless of sediment quality. Typically sediments removed from reservoirs are deposited in constructed basins where they are allowed to dewater and consolidate. In recent years. the difficulty of placing large amounts of dredged material has lead to a national search for a beneficial use (Landin, 1997).

Previous work in Illinois has demonstrated that dredged sediments may be utilized for agriculture. Material removed from Lake Springfield and from Lake Paradise in central Illinois was shown to have potential for increasing crop yields on eroded soils (Olson and Jones, 1987: Lembke *et al.*, 1983a, b). However. contamination of sediments with industrial and municipal pollutants can occur even in relatively weakly industrialized watersheds, so site-specific assessment is warranted.

The work reported here was done to investigate physical and chemical properties of sediments derived from rivers in Central Illinois. This is in anticipation of dredging of the Peoria Lakes, which are wide, slow-moving portions of the Illinois River. The operation will potentially remove millions of cubic meters of sediment that will have to be dealt with in an environmentally and economically sound manner. The intent of this study was to test the feasibility of using dredged materials in agricultural or similar applications such as landscaping soil for cover for unproductive or highly eroded soils, highway rights-of-ways, brownfields, or abandoned surface mines. Sediments, both natural alluvium and dredged from reservoirs in Central Illinois, served as analogs of the Lake Peoria sediments. Normal agronomic physical and chemical tests, as well as analyses for several metal pollutants, were done on the sediment samples collected. Analyses for potentially harmful organic compounds or other pollutants were not part of the research.

A follow up study investigated metal uptake from plants grown in Peoria Lake sediments.

METHODS AND MATERIALS

Research sites were chosen from reservoirs that were recently dredged; Lake Springfield, Lake Decatur, and Lake Paradise near Matoon, Illinois. These dredging projects were completed at Springfield in 1991, at Decatur in the mid 1990's, and at Matoon in 1981. At each site, local upland soils within 100 m of the sediment sites were collected to serve as reference samples. Additional samples were collected from Woodford County, Illinois, in and near Upper Lake Peoria in the Illinois River where dredging is proposed.

The Decatur sampling site was within a large impoundment with high water content supporting hydrophilic plants. Two adjacent natural upland cultivated soils, formed in loess, a Typic Argiudoll and an Aquic Hapludalf (Soil Survey Staff, 1999), served as references. At Matoon, the sediments were in a small impoundment that was supporting a wheat crop. An adjacent cultivated Typic Hapludalf formed in till served as a reference. At Springfield, the sediments were dewatered and in a large impoundment cultivated to corn and soybeans. An adjacent cropped Typic Argiudoll formed in loess served as the reference. Woodford County sample sites in the Illinois River upstream from Peoria included Typic Fluvaquents on natural islands, an island constructed from dredged sediments, and a grab sample from the river bottom. Three reference sites were from the adjacent floodplain; a Typic Fluvaquent, an Aquic Udifluvent. and a Typic Udifluvent.

Soils were collected as continuous cores to a depth of 122 cm. Soil strength was determined with a hand-powered continuously recording penetrometer. Cores were wrapped in plastic for transport to the lab, then sectioned by horizon and air-dried prior to laboratory analyses. The Lake Peoria bottom grab sample was collected from about 60 cm of water by hand with a bucket auger. A shovel was also used to collect the dredge sediment island samples.

Laboratory analyses followed standard methods (Klute, 1986). Chemical and physical analyses were done on the < 2 mm fraction. Particle size analysis was by sieving for the sand fractions and by hydrometer for the silt and clay fractions. Soil pH was measured 1:1 in distilled water. Organic matter content was determined by weight loss on ignition at 430°C. Extractable nutrients were determined in a Mehlich 3 extracting solution (Mehlich, 1984). Cation exchange capacity (CEC), was determined by summation of the extractable nutrients. Because of the presence of free carbonates in some of the sediments, the CEC values may be exaggerated. Analysis for total recoverable metal content was by USEPA method 3050.

For the plant uptake study, samples were collected from West Woodford, a constructed island near Chillicothe, and from the lake bottom under about 75 cm of water at Spindler Marina. The reference soil used was a mixture of Drummer and Flanagan silty clay loam, which is a common, highly productive topsoil in Illinois. Soils and sediments were ground and mixed with an equal volume of horticultural grade perlite, a conventional greenhouse practice. The mixtures were placed into 15 cm greenhouse clay pots.

Plants grown included: barley, snap beans, radish, lettuce, and tomatoes. A randomized complete block design was used with four replicates in three blocks. The pots were watered as needed and fertilized with 20-10-20 at a rate of 200 ppm of N each week after thinning. Grown plants were dried at 60°C to determine yield. Tomato fruits were used for the metal uptake evaluation, and tomatoes from residential vegetable gardens in Champaign and Peoria Counties, Illinois also served as reference samples.

Dried soil materials used in greenhouse experiments were analyzed for total recoverable metals by Inductively Coupled Plasma Mass Spectrometry (ICPMS). Tomato pulp was acid-digested using a modified version of USEPA Method 3050.

RESULTS AND DISCUSSION

Physical Properties

Sediments tend to have low soil strength that varies little with depth. This is due to the high water content of the sediment, absence of contrasting compacted layers, and lack of coarse fragments. Because of the low strength, trafficability is a problem and may indicate future differential settling as sediments dewater and consolidate. The sediment retention basins at Springfield and Matoon were dewatered and consolidated, and currently support conventional row crop farming. Reference soils have higher soil strength than sediments. They have been farmed continuously with heavy equipment and show evidence of compaction, a problem not seen in the farmed sediments cultivated only a few years. As long as they are strong enough to support equipment, lower soil strength in sediments can be an advantage because compaction in agricultural soils can inhibit plant growth (Dunker *et al.*, 1995).

Due to the nature of sediment transport and deposition, dredge sediments tend to be fine textured and without significant amounts of coarse fragments. Floodplain soils tend to be more coarse textured on natural levees and terraces. At Woodford the soil textures follow these typical sedimentation patterns (Table 1). For example, sand content ranged from 81% at 101 cm to 35% at the surface. The Illinois River island sites, in contrast, acted more like levees. Soils there tended to have more sand toward the surface due to recent deposition; sand content increased from 9% at 111 cm to 88% at the surface. Clay content of these alluvial samples tended to be moderate, ranging from about 2 - 21%. Underwater grab samples from the lake bottom were very clayey at 63 - 73% clay, even more clayey than samples from a dredge sediment island that ranged in clay content from 42 - 52%. The difference in clay content could be due to the method of dredging or the sediment source. Different portions of the river bottom can be expected to vary in texture due to proximity to variable sediment sources and to water depth and velocity.

Table 1a. Soil texture at Springfield research sites.

Sediment Pond						Reference Mollisol					
Horizon	Depth	Class	Sand	Silt	Clay	Horizon	Depth	Class	Sand	Silt	Clay
	cm		%				cm		%		
Ap	8	SiC	1	56	43	Ap	10	SiCL	3	68	30
C1	21	SiL	2	71	27	A	27	SiCL	3	67	31
Cg1	42	SiC	3	48	49	Ab	43	SiCL	2	64	35
Cg2-1	81	SiC	3	54	43	Bt1	61	SiC	1	56	44
Cg2-2	122	SiCL	6	56	39	Bt2	82	SiCL	1	60	40
Cg3	151	SiCL	8	55	38	Bt3	103	SiCL	1	63	37
Cg4	177	SiC	0	50	50						

Table 1b. Soil texture at Woodford research sites.

Floodplain						Natural Island					
Horizon	Depth	Class	Sand	Silt	Clay	Horizon	Depth	Class	Sand	Silt	Clay
	cm		%				cm		%		
Ap	5	SiL	35	50	15	C	9	FS	88	10	2
A	19	SiL	36	50	14	A	29	FSL	68	23	9
Bw1	37	SiL	35	50	14	Bg1	51	L	46	44	10
Bw2	59	L	40	46	15	Cg1	71	SiL	24	66	10
2Bw3	82	FSL	67	23	10	Cg2	92	SiL	16	72	12
2C1	101	LS	81	12	7	Cg3	111	SiL	9	70	21
Spoil Island						River Bottom Grab Samples					
Cg1	5	SiC	6	51	43	Cg1	10	C	25	12	63
Cg2	22	SiC	5	53	42	Cg2	60	C	3	20	77
Cg3	38	SiC	3	45	52						

The soils from the dredging impoundments at Springfield, Decatur, and Matoon were silt loams, silty clay loams, and silty clays with generally 30-50% clay, < 5% sand. There were essentially no coarse fragments. This fine texture reflects the sediment source, the methods of dredging, and the placement of the materials. As expected with hydraulically deposited sediments, the textures varied randomly with depth, unlike the natural reference soils, which show an accumulation of clay in the B horizon. The natural reference soils are primarily developed in loess, which generally has silty textures similar to many dredge sediments. Because the sediment samples were from low-energy bodies of water, they tend to have much less sand and more clay than the natural alluvial samples from better drained floodplains and islands that require higher energy flows before they receive sediments.

Chemical Properties

Illinois soils are naturally fertile as were the samples (Table 2). Calcium was the most abundant nutrient, and in addition, the sediment samples had much higher extractable Ca than the reference samples due to bioaccumulation in the aquatic sedimentary environment. At Decatur, for example, extractable Ca was over 5,000 mg kg^{-1} in the sediments and about 2,000 mg kg^{-1} in the reference soils that presumably have been limed. This Ca trend was followed at the other sediment sites and contributed to the high pH of the sediment relative to the reference soils leached of Ca, particularly in their upper horizons. For P and K, the sediments had an abundance as high or higher than the reference productive agricultural soils. This indicates that the potential for supporting vegetation is good, although most sites tested, particularly the reference sites, had less than optimum levels of P and K for row crop production and like most soils could benefit from fertilizer additions (University of Illinois Extension, 1998).

Table 2a. Soil fertility at Springfield research sites.

Horizon	Depth	TEC	pH	OM	S	P	Ca	Mg	K	Na	B	Fe	Mn	Cu	Zn	Al
	cm	meq/100g		%	----------					ppm						----------
Reference Mollisol Site																
Ap	10	18	5.9	4.0	25	26	2380	341	178	12	0.5	130	64	2.5	2.9	441
A	27	22	5.9	3.6	23	16	2405	434	108	13	0.6	156	44	2.8	1.3	581
Ab	43	22	5.9	3.0	23	10	2081	526	104	17	0.4	137	27	2.4	0.6	660
Bt1	61	26	5.9	2.3	35	8	2546	854	144	27	0.5	118	35	2.1	0.6	760
Bt2	82	21	5.9	1.8	38	9	2129	814	117	22	0.4	94	40	1.7	0.6	752
Bt3	103	19	6.6	1.5	37	11	2204	894	124	28	0.4	93	61	1.7	2.7	712
Sediment Pond Site 1																
Ap	8	29	7.7	3.5	46	44	4497	758	200	20	0.7	271	90	5.4	5.1	422
C1	21	17	7.6	1.7	36	47	2402	509	104	23	0.6	310	80	3.1	2.9	424
C2	29	31	7.5	3.2	69	47	4712	793	170	30	0.7	296	57	4.3	5.4	405
Cg1	42	30	7.5	3.3	103	51	4515	835	188	34	0.7	303	51	4.0	5.1	439
Cg2-1	81	25	7.6	3.0	138	58	3624	712	160	29	0.7	319	55	2.9	4.4	442
Cg2-2	122	23	7.5	3.0	183	63	3399	696	165	35	0.8	325	65	2.5	4.5	445
Cg3	151	33	7.1	3.8	160	58	4480	1160	234	50	0.9	310	193	5.0	4.4	496
Cg4	177	31	7.3	3.1	83	29	4060	1200	203	48	0.7	303	234	3.0	2.7	586
Difference*		-	s	-	s	s	s	s	s	s	s	s	s	s	s	r

* Statistically greater at natural reference sites (r) or at the sediment sites (s) over all samples at location.

Table 2b. Soil fertility at Woodford Co. research sites.

Horizon	Depth	TEC	pH	O.M.	S	P	Ca	Mg	K	Na	B	Fe	Mn	Cu	Zn	Al
	cm	meq/100g		%	----------				Extractable (ppm)					----------		
Reference Floodplain Site																
Ap	5	15.4	7.6	3.5	22	18	2036	568	175	11	1.0	103	153	5.5	5.5	285
A	19	15.3	7.9	2.1	18	12	2216	478	81	11	1.0	130	148	4.3	2.7	335
Bw1	37	23.2	8.2	1.7	19	6	3785	483	86	12	1.1	114	120	4.9	1.5	266
Bw2	59	25.6	8.0	1.4	19	4	4190	526	89	14	0.6	94	83	3.8	0.9	112
2Bw3	82	20.0	7.9	0.6	21	6	3300	393	74	14	0.6	87	49	2.9	1.2	141
2C	101	10.8	8.1	0.4	13	14	1654	286	48	12	0.5	90	45	1.9	1.0	193
Illinois River Island Site 2																
C	9	15.3	8.1	0.8	53	61	2568	259	54	38	0.7	364	84	2.5	77.1	138
A	29	18.1	7.6	3.9	80	81	2671	511	70	79	1.1	404	61	3.4	79.5	217
Bg	51	21.6	7.6	3.1	83	49	3089	655	80	102	1.1	326	122	4.4	145.2	267
Cg1	71	24.9	7.9	1.9	88	25	3807	628	77	104	1.0	284	175	4.6	97.5	216
Cg2	92	28.8	8.1	2.3	120	27	4337	762	86	132	1.1	291	166	4.8	86.0	115
Cg3	111	35.2	7.8	2.6	155	30	5175	998	107	171	1.7	225	125	5.4	164.2	183
Illinois River Dredge Sediment Island Site																
Cg1	5	35.5	7.8	4.3	47	44	5227	1031	154	76	1.4	403	28	5.8	19.4	380
Cg2	22	38.3	7.5	4.7	75	65	6019	886	165	80	1.1	390	30	10.5	67.4	373
Cg3	38	33.5	7.5	4.9	73	62	5226	804	148	65	1.1	421	31	7.7	52.0	400
Illinois River Bottom Sediments																
Cg	2	34.5	7.5	3.4	213	71	5633	665	150	84	1.0	470	107	5.9	63.1	284
Difference *		s, i	f, i	s, i	s, i	s, i	s, i	s, i	s, i	s, i	-	s, i	f, i	s, i	s, i	-

* Statistically greater at natural island sites (i) or at the floodplain sites (f) or the sediment sites (s).

Secondary and minor nutrients including S, Fe, Mg, Mn, and B were also in adequate supply (University of Illinois Extension, 1998), and tended to be in greater concentration in the sediment samples than in the upland reference soils. The reference sites at Decatur and Matoon may have been slightly deficient in B. Potentially problematic elements Al and Na in the sediments tended to be at concentrations lower or equal to those in the upland reference soils. Soil organic matter content tended to be greater in the sediments than in the reference soils due to the sedimentary additions and biogenic accumulation in the aquatic environment.

One striking difference among the samples is the Zn and Cu content of the Illinois River island soils. Extractable Zn ranged from 60-170 kg mg^{-1} on the islands but was closer to 4 kg mg^{-1} on the adjacent floodplain. This is similar to the samples analyzed from the other reference sites. The differences were not as striking with Cu, but it was also more abundant in the island soils than elsewhere. The concentration of Zn and Cu did not systematically decrease with depth in the island soils; therefore there is no indication that they represent recent additions. Given the vigorous vegetation at the island sites, neither Cu nor Zn appeared to be inhibiting plant growth. Copper and Zn tended to be elevated in the other sediment samples tested, as compared to their reference soils, but the concentrations and contrast with their reference samples were not as great. From a micronutrient view, the soils at all the reference sites may be deficient in Zn whereas all the sediments sites had adequate Zn. Again, the Cu and Zn content of the sediments does not appear to be at a level to cause concern. The grab sample from the river bottom and the samples from the sediment islands had chemistry similar to the natural island soils, except their organic matter content tended to be greater than in the reference floodplain samples.

The overall impression given by the fertility data is that the sediments are generally rich in plant nutrients and have potential for agriculture, particularly for crops that are tolerant of relatively high pH, fine textured soils. Although micronutrient levels measured in the sediments were more than adequate, levels of P and K are below optimum (University of Illinois Extension, 1998), as is the case with normal agricultural soils that are routinely fertilized with N, P, and K as part of accepted agricultural practices to maximize crop yields.

Sediment Cd levels tended to run slightly higher than the Illinois EPA statewide mean and background levels (unpublished IEPA data) (Table 3). This should not likely be a concern because they are not statistically different from the reference samples and are below the U.S. EPA 503 pollutant regulation levels. (U.S. Environmental Protection Agency, 1995).

Table 3a. Soil metal content at Springfield research area.

Site/Horizon	Depth	As	Ba	Cd	Cr	Pb	Ni	Se
Reference Mollisol Site	cm	-------------			ppm		---------------	
Ap	10	6	153	2	8	21	10	0.1
A	27	7	157	3	9	22	12	0.1
Ab	43	8	136	3	10	18	12	0.1
Bt1	61	11	136	4	13	26	17	0.1
Bt2	82	12	139	5	14	29	21	0.1
Bt3	103	11	131	5	14	26	21	0.1
Sediment Pond Site 1								
Ap	8	9	147	4	14	28	24	0.2
C1	21	6	101	3	10	19	12	0.1
C2	29	8	142	4	13	26	15	0.2
Cg1	42	9	132	4	13	29	16	0.2
Cg2-1	81	8	135	3	13	24	14	0.2
Cg2-2	122	7	122	3	12	23	14	0.2
Cg3	151	9	161	4	15	28	16	0.2
Cg4	177	18	297	8	30	50	33	0.3
Difference *		-	-	-	-	-	-	s

* Statistically greater at natural reference sites (r) or at the sediment sites (s) over all samples at location.

Table 3b. Soil metal content at Woodford Co. research area.

Horizon	Depth	As	Ba	Cd	Cr	Pb	Ni	Se
Reference Floodplain Site	cm			ppm				
Ap	5	2	33	< 3	5	< 10	9	< 0.2
A	19	2	36	< 3	5	< 10	8	< 0.2
Bw1	37	3	39	< 3	6	13	10	< 0.2
Bw2	59	4	41	< 3	6	11	9	< 0.2
2Bw3	82	3	26	< 3	5	11	6	< 0.2
2C	101	2	14	< 3	4	< 10	5	< 0.2
Illinois River Island Site 2								
C	9	3	30	< 3	6	11	10	< 0.2
A	29	3	41	3	9	20	12	< 0.2
Bg	51	5	56	4	10	26	17	< 0.2
Cg1	71	5	69	4	8	18	15	< 0.2
Cg2	92	4	83	4	10	22	18	0.2
Cg3	111	4	104	6	14	31	22	0.2
Illinois River Dredged Sediment Island								
Cg1	5	6	127	7	26	50	28	0.4
Cg2	22	15	134	7	42	100	28	0.4
Cg3	38	12	141	7	38	90	29	0.3
Illinois River Bottom Sediments								
Cg	2	10	123	8	39	72	28	0.4
Difference *		s	s, i	s, i	s, i	s, i	s, i	s

* Statistically greater at natural island sites (i) or at the floodplain sites (f) or the sediment sites (s).

At Springfield, sediment samples were also similar to the reference samples. All of the elements in the samples were below the Illinois EPA statewide mean with the exception of the deepest sample at the sediment site. These levels are not of a concern because they are below the U.S. EPA 503 levels and are deep below the soil surface and only represent a small volume. Statistically, only Se was higher in the sediments than in the reference soils at Springfield. At the Decatur and Matoon research areas, sediment metal contents were also similar to their reference sites. Again, the Cd levels tended to run slightly higher than the IEPA mean, but they and all the metals are less than the U.S. EPA 503 pollutant levels. Given the comparable values in the reference and sediment sites, metal contamination is not a concern.

Metal levels at Woodford generally ran the highest among the soils tested, and the metal content increased in proximity to the river. The texture of the reference soils tended to be somewhat coarser, consequently the CEC level was somewhat lower than the other soils which accounts, in part, for the low metal content. The Illinois River samples tended to have the highest metal contents in the study. The samples from the natural islands, the sediment island, and the river bottom samples all had higher As, Cd, Cr, Pb, and Ni levels than the IEPA statewide mean. Apparently, the elevated metal levels are associated with geologically recent Illinois river sedimentation, and are possibly anthropogenic in origin. The floodplain represents an older Illinois river sediment deposit that has not received metals, as indicated by the relatively low metal content of the floodplain soils.

The general decrease in metal content toward the surface of the Illinois River island soils indicates that the metal content of the sediment supplied to the islands may have fallen off recently. Given the luxurious vegetative cover on the islands, metals do not seem to be inhibiting plant growth. The metal levels should not be a significant concern solely because they exceed the statewide mean. They do not exceed U.S. EPA 503 pollutant levels.

Greenhouse Soil Metal Content

There are no generally agreed upon standards for metal contamination in sediments. Compared to the Drummer-Flanagan topsoil, the sediments had higher Cr, Ni, Cu, Zn, Pb, and Cd (Table 4). The USEPA has a concept of a critical value for contaminants in its 503 regulations for the land disposal of sewage sludge (USEPA, 1995). Under those regulations, none of the metals approach regulatory pollutant levels.

Table 4. Total recoverable metals in the materials used in the greenhouse experiment.

Material	Cr	Ni	Cu	Zn	As	Se	Ag	Cd	Ba	Pb	Na	Mg	Al	K	Ca
	mg kg^{-1}														
Drummer-Flanagan	29	22	20	60	8	1.1	<1	<1	183	18	134	5500	24600	4600	5000
Spindler	48	38	43	241	7	<1	1.2	3.4	157	40	301	17100	19900	4550	35500
Woodford	61	36	43	293	11	1.4	<1	4.4	200	54	1110	13000	24000	5890	19900
	Fe	Va	Mn	Co	Mo	Ti	Sr	Zr	Cs	La	Ce	Th	Ga	Ru	Yt
Drummer-Flanagan	21300	54	687	9	<1	383	23	14	3	19	40	<1	8	47	12
Spindler	22800	40	637	9	1	210	54	12	3	16	32	8	6	39	11
Woodford	28100	53	569	10	1	343	44	14	3	17	32	8	8	50	12

Plant Yield and Metal Uptake

Plant growth was generally no different on the sediments as compared to the reference soil, plants grew well in all the soil treatments (Table 5). Barley, bean, and radish yields did not differ among the materials. Lettuce grown on Spindler had the highest yield and the two other materials did not different. Tomatoes grew least on the Drummer-Flanagan natural topsoil

Table 5. Yield† of plants grown in dredge sediments and reference materials.

Material	Barley‡	Lettuce	Radish	Bean	Tomato
Drummer-Flanagan	0.7±0.1	1.3±0.4a	2.6±0.4	4.1±0.7	40.1±8.9b
Spindler	0.7±0.2	0.8±0.3b	2.7±0.3	4.6±0.6	48.7±9.9a
Woodford	0.7±0.2	1.4±0.4a	2.9±0.3	4.3±0.6	42.0±8.4ab

† Mean mass (g) per 12 pots. Values followed by a different letter in a column are significantly different.

Metals detected in the tomatoes were all at a very low, and dietetically insignificant levels, values from the sediment-grown plants indicate that metal uptake was reduced, possibly due to the higher pH of the sediments or to the presence of less available forms of the metals (Table 6). There were no statistically significant differences in the contents of Pb, Cr Cu, Mn, Ni, Ti, Zn, St, or Zr among the tomatoes. With Cd, the lowest content was found in the plants grown in Drummer-Flanagan in the greenhouse. However, the Cd content of the tomatoes from the local gardens had about the same amount of Cd as the plants grown on the sediments in the greenhouse. Tomatoes grown on Drummer-Flanagan had the highest content of Co, while Co levels from the growth media were not different. Barium contents were higher for the tomatoes from the Drummer-Flanagan and the garden grown tomatoes and lowest with the Woodford samples. Likewise Mo was highest on the Drummer-Flanagan and lowest on the Woodford tomatoes. Selenium and Ru were highest in the Spindler and lowest in the Drummer-Flanagan tomatoes. Only one sample, from a Drummer-Flanagan pot, had detectable Hg (0.001 mg kg^{-1}), and Cr was only found in one sample of Champaign (3.4 mg kg^{-1}) garden-grown and one Drummer-Flanagan (3.3 mg kg^{-1}) greenhouse-grown tomato.

Table 6. Metal content of tomatoes grown in dredged sediments and reference materials.

Material	Cd†	Pb	Co	Cu	Ba	Mn	Mo	Ni	Se	Ti	Zn	Ru	St	Zr
	Dry Weight Concentration (mg kg^{-1})													
Drummer-Flanagan	0.1b	0.5	0.16a	13	1.6a	9	6a	2	0.1c	18	25	20c	2	0.2
Spindler	0.4ab	0.4	0.08b	12	1.0ab	10	3c	1	0.5a	20	25	41a	2	0.2
Woodford	0.5a	0.3	0.04b	8	0.7b	7	4b	1	0.2b	19	20	31b	1	0.3
Peoria	0.4ab	0.2	0.08b	10	2.4a	10	2d	1	0.5ab	19	20	36ab	2	0.2
Champaign	0.2ab	0.9	0.12b	21	1.4a	11	2d	13	0.2ab	18	21	32ab	2	0.2

†Mean of three combined samples from each material. Values followed by a different letter in a column are significantly different; for statistical purposes, Peoria and Champaign results were combined.

CONCLUSIONS

The physical characteristics of dredged sediments are similar to naturally productive agricultural soils in Illinois. Their potential water storage capacity is high and their coarse fragment content is low. After the sediments dewater and age, they can develop good tilth associated with productive agricultural soils. The trafficability of sediment impoundments should not be a problem after dewatering occurs and natural soil structure develops. There is no indication in the physical data that these sediments should present a problem for agricultural utilization given proper handling, tillage, and fertility treatments.

Metal levels in the Illinois River sediments were somewhat elevated compared to the other sediments and to their reference soils. However, there are no consistent criteria for judging the significance of a soil's metal content. Regulatory agencies have not reached a consensus in this area; what should serve as a reference level is not well defined, and critical values are not universally recognized (U.S. EPA, 1995, 1997; IL EPA 1997). The high pH, fine texture, and high CEC indicate that metals would be tightly held in the sediments and not move.

Sediments from the Peoria Lakes of the Illinois River are essentially equal to highly productive natural topsoils from central Illinois in terms of fertility and plant productivity in the greenhouse. Because of their initially poor soil structure and consistence immediately after dredging, crusting and sealing of the surface may initially be a problem but should become less of an issue after weathering. Addition of materials to improve the tilth, such as compost or similar materials, may be helpful. Plant metal uptake, as indicated by tomatoes grown on sediments in the greenhouse, should not be a problem. Metal levels in the tomatoes grown on the sediments were essentially the same as those grown on natural topsoils in the greenhouse or from local gardens. There is no chemical or physical reason that dredged sediments, properly managed, should not make an excellent plant growth medium.

The beneficial use of sediments should be evaluated as part of dredging projects, particularly when the potential for contaminants is low. The work reported here indicates that the dredged sediments in the study sites may serve useful purposes. These may include use as agricultural or landscaping soil, or as cover for undesirable substrates such as found in brownfields, highly eroded or sandy soils, abandoned surface mines, or scalped highway rights-of-way.

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FEDERAL PERSPECTIVES ON ILLINOIS RIVER RESTORATION EFFORTS

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ABSTRACT

The Illinois River Basin encompasses 30,000 square miles, covering 44 percent of the land area of the State of Illinois. The Illinois River along with the Upper Mississippi River System is designated a nationally significant ecosystem by the Water Resources Development Act of 1986 which mandated that the rivers be managed to balance competing interests in natural resources. The Corps of Engineers and Illinois Department of Natural Resources (DNR) are jointly conducting a number of related feasibility studies (Illinois River Ecosystem Restoration Study, Peoria Riverfront Development Study, Kankakee River Basin Study, and some site specific projects) to address ecosystem degradation within the basin. Similar to other large restoration projects taking place throughout the country, key components of these efforts include using a watershed perspective, ecosystem approach, and partnering with Federal, state, and local entities. The principal problems impeding the restoration of habitat in the Illinois River Basin are sedimentation of backwaters and side channels, degradation of tributary streams, fluctuations in hydrologic regimes and water levels, and other adverse impacts caused by human activity. Ongoing efforts include developing site specific pilot projects and conducting a multi-agency restoration needs assessment to identify desired future conditions. Potential recommendations include activities within the river corridors such as island creation, side channel restoration, protection and creation of wetlands, improved water level management, and floodplain function. In addition, efforts will be focused on restoring the smaller tributaries and watersheds through stream and wetlands restoration, water retention, conservation easements, fish passage, and riparian buffers.

INTRODUCTION

This paper addresses the Corps of Engineers and Illinois Department of Natural Resources ecosystem restoration partnership efforts in the Illinois River Basin. The major focus is on the Illinois River Ecosystem Restoration Study which addresses the entire basin. The paper also briefly addresses the related Peoria Riverfront Development Study, Kankakee River Basin Study, and other ongoing efforts that focus on specific portions of the basin. All these efforts are in the detailed feasibility study phase.

In order to coordinate these efforts, the State of Illinois developed the Illinois Rivers 2020 initiative to provide an overarching framework. The initiative sets out to establish a Federal-State focus on restoration in the basin with a goal of eventually implementing $2.5 billion of restoration over 20 years. The first effort to come out of this initiative involving the Corps of Engineers is Section 519 of the Water Resources Development Act of 2000, which authorized the Corps of Engineers to expend $100 million to complete a comprehensive plan, implement critical restoration projects, evaluate new and innovative technologies, and implement long term resource monitoring. As of the date of the conference, no funds have been appropriated to implement Section 519.

The Corps' ecosystem restoration mission has evolved over the past decade, and now is an essential part of our program. The Corps' Ecosystem Restoration mission provides an opportunity not only to restore valuable environmental resources, but also to carry out projects that more effectively balance economic and environmental needs. Key components of Corps of Engineers restoration efforts include using a watershed perspective, ecosystem approach, and partnering with Federal, state, and local entities. Corps restoration authorities provide opportunities to utilize Corps technical expertise and Federal funding to address critical water resource problems. These efforts add to ongoing Federal investments in watersheds such as Farm Bill Programs administered by the U.S. Department of Agriculture, the Section 319 - non-point pollution program of the U.S. Environmental Protection Agency, and habitat incentive programs of the U.S. Fish and Wildlife Service.

CORPS RESTORATION EXPERIENCE

These efforts to restore an ecosystem are not the first of its kind, but can build upon other existing Federal and State restoration partnership efforts such as the Florida Everglades, Upper Mississippi River – Environmental Management Program (EMP), and proposed efforts on the Ohio and Missouri Rivers. In the Everglades, the Corps of Engineers is looking to start a $1.4 billion first phase effort to initiate restoration to a more natural historic condition, which could eventually reach $7.8 billion and stretch over 30 years. In Florida, the Corps is working in partnership with the Department of Interior, EPA and other Federal agencies, state and regional agencies, and public interest groups. In the Midwest the Corps of Engineers has been working on the Upper Mississippi River - Environmental Management Program (EMP) which seeks to restore and enhance the environment of the Upper Mississippi River System, including the Illinois River. This partnership involves the U.S. Fish and Wildlife Service, U.S. Geological Survey, and State resource agencies. Since 1986, this program has implemented or is evaluating 70 projects that when completed will benefit approximately 125,000 acres of habitat. The Illinois River Restoration efforts proposed under the ongoing efforts have the potential to eventually be a model for the rest of the nation.

STUDY PROCESS

For the Corps of Engineers to get involved in restoration work a local group must request Federal Assistance. The ongoing efforts presented in this paper are a reflection of the strong state and local interest in restoration and the willingness of the Illinois DNR to cost share study efforts. The Corps of Engineers project implementation process includes the steps presented below. As noted previously the ongoing study efforts are in the feasibility phase and must still result in a recommended plan calling for Corps involvement, complete report review and approval, and Congressional authorization and appropriation, prior to any implementation.

- <u>Problem Perception</u> –The non-federal sponsor identifies a problem.
- <u>Request for Federal Assistance</u> – Corps involvement begins with a request, typically a letter, from the non-federal sponsor for assistance.
- <u>Study Problem and Report Preparation</u> – If applicable to Federal authorities a study can be initiated. These studies are conducted in two phases.
  - Reconnaissance – involves limited study effort. The goals are to assesses Federal and Non-Federal interest, scope the Feasibility Study, and ends in the signing of the Feasibility Cost Sharing Agreement. Conducted at 100 percent Federal Cost.

- Feasibility – more detailed study effort to determine feasibility of a project. develops specific alternatives and makes recommendations for eventual implementation. Cost shared 50/50 between the Corps and Sponsor.

- Report Review and Approval – Reports are processed through Corps of Engineers to the Administration and Congress.
- Congressional Authorization & Appropriation – Projects are then authorized by Congress in Water Resource Development Acts and funds appropriated.
- Project Implementation – Construction or management modifications are implemented. Cost shared 65/35 between the Corps and Sponsor.

Study Area and Background

The Illinois River Basin encompasses 30,000 square miles, including 44 percent of the land area of the State of Illinois and 90 percent of the state's population. The Illinois River is a key part of the Mississippi River flyway a globally important route for migratory birds and is also one of the very few large river floodplain ecosystems in North America that still retains a seasonal flood pulse and connections with its floodplain.

A great deal of groundwork has been done on the Illinois River to identify resource problems and potential solutions. In 1997 the State of Illinois' published an Integrated Management Plan for the Illinois River Watershed, which laid out 34 recommendations developed as part of a yearlong effort to address the rivers needs. Some of the problem areas and solutions identified by that effort include:

- Preservation of Critical Habitats for wildlife abundance, distribution, and diversity
- Restoration of degraded streams and reduction in sediment delivery
- Reduction of deviations from the natural hydrograph
- Improvement in water quality
- Reduction in peak flood flows

Illinois River Ecosystem Restoration Study

The Illinois River Ecosystem Restoration effort brings a system wide perspective to potential restoration efforts and provides an organizing framework for other ongoing efforts, including the other two existing studies. In August 2000, the State of Illinois and the Corps of Engineers entered into a Cost-Sharing Agreement to conduct a 3-1/2 year Illinois River Ecosystem Restoration Feasibility Study. Emphasis is being placed on identifying and evaluating restoration activities related to the State of Illinois' Integrated Management Plan for the Illinois River Watershed and Illinois Rivers 2020 Initiative. The principal problems impeding the restoration of habitat in the Illinois River Basin are sedimentation of backwaters and side channels, degradation of tributary streams, fluctuations in hydrologic regimes and water levels, and other adverse impacts caused by human activity. During the study, alternatives such as watershed/tributary restoration, side channel and backwater restoration, water level management and floodplain restoration and protection are being analyzed.

The study involves partnerships with other State and Federal agencies to look for potential restoration projects including such activities as sediment control, protection and creation of wetlands and critical habitats, stream restoration, and improved water level and floodplain management. For simplicity, the tasks are best viewed in major groupings. There are generally two types of efforts: (1) system evaluations focused on assessing the overall watershed needs and general locations for restoration, and (2) site-specific evaluations focused on developing detailed restoration options for possible implementation at specific sites. The system and site-specific evaluations will investigate restoration opportunities falling into four focus areas:

1. Watershed/Tributary Restoration - Many of the tributaries of the Illinois have been destabilized through channelization, land use changes, and removal of riparian buffers resulting in increased sediment contributions to the Illinois River. The study will evaluate options to address tributary degradation and instability looking at stream and wetlands restoration, water retention, conservation easements, and riparian buffers.
2. Side Channel and Backwater Restoration - Many of these side channel and backwater areas have been greatly impacted, losing roughly 70 percent of their 1903 volume due to sedimentation over that past 100 years. Many of these areas are now only one to two feet and provide diminished aquatic habitat value. The study will consider opportunities to restore aquatic habitats in these areas including off-channel deep water habitat, backwater lakes, side channels, islands, etc.
3. Water Level Management - Numerous alterations have been made to the Illinois River including the construction of the Chicago Sanitary and Ship Canal, diversion of Lake Michigan water, Chicago Metropolitan Reclamation District (MWRD) operation, urbanization of the upper watershed, construction of mainstem dams and levees, and large scale land use changes. These changes have resulted in more frequent fluctuations in water levels. The study will evaluate options to reduce rapid fluctuations and naturalize flows.
4. Floodplain Restoration and Protection – Approximately 60 percent of the lower Illinois River floodplain has been isolated behind levees. The study will evaluate floodplain use, potential restoration of floodplain function, and value and potential for acquisition of conservation easements.

The major focus of the system assessment is to conduct a Restoration Needs Assessment (RNA). The Restoration Needs Assessment will evaluate the need for restoration in the entire basin with a focus on the tributaries and sub-watersheds feeding into the mainstem of the Illinois River.

The Restoration Needs Assessment (RNA) will provide a practical and scientific basis for assessing the large study area and identifying potential restoration project types and locations for the Illinois River and its tributaries. The RNA will define those critical assumptions controlling the ability to determine habitat needs and focus the study, planning, and construction efforts on the areas of critical need. Specifically the goals of the RNA include building off of the large volume of existing work to bring together different disciplines and interests to address the following goals.

Restoration Needs Assessment Goals:

1. Demonstrate Federal, State, and local interest in restoration.
2. Provide an organizing framework and understanding of the state and function of the Illinois River Basin as a whole and its sub-basins (Historic, Existing, and Predicted Future Conditions).
3. Develop Consensus regarding desired future conditions.
4. Provide information to allow prioritization of restoration alternatives.
5. Review existing planning and prioritization efforts, existing agency programs, and develop a list of potential Best Management Practices (BMP)/restoration alternatives

A key outcome of the RNA is defining a desired future condition setting the scope for future restoration efforts. This recommendation is likely to set goals that would include recommendations of acres of backwaters and wetlands that should be restored, miles of stream stabilized, tons of sediment reduces, and number of locations with improved fish passage.

SITE SPECIFIC EFFORTS

Site specific efforts are being initiated in conjunction with the system analysis to provide further detail and context to the system analysis. These initial sites represent critical restoration areas identified by the state. As part of the study efforts these sites are being investigated and restoration plans are being developed and evaluated using cost effectiveness and incremental cost evaluations. By concurrently evaluating some site-specific projects during the system evaluation, these projects, if justified, could move to implementations much more quickly than first completing a system evaluation and then initiating site specific evaluations.

The site specific efforts proposed fall into four general categories. Watershed stabilization and sediment reduction projects, such as those being investigated for the Iroquois River, McKee Creek, and the Kankakee River are looking to address the high rate of sediment being delivered to the Illinois River. Habitat Connectivity Projects including those proposed at Blackberry Creek, Waubonsie Creek, and the Des Plaines River would address dams blocking migration of fish and aquatic organisms. Backwater and side channel restoration projects such as the separate Peoria Riverfront Study and the Pekin Lake area would seek to address the deposition that has occurred along the main stem through dredging to increase water depths.

Peoria Riverfront Study

The Peoria Riverfront study was initiated in October 1999 and will be completed in the winter of 2001/2002. This study effort focuses on one reach of the Illinois River, Peoria Lake, the largest bottomland lake on the Illinois River encompassing 14,000 acres. The problems in Peoria Lake are similar to those of other Illinois backwaters and side channels. The focus is on addressing sedimentation of the lake that has resulted in the loss of lake depth, volume, and habitat diversity. In addition, degraded tributary streams, which are delivering high levels of sediment to Peoria Lake, were investigated. Opportunities were explored to address restoration of both the tributaries and lake as they relate to the Peoria Riverfront Development Project, a public and private effort to revitalize downtown Peoria. The restoration alternatives considered in the feasibility study fit into two broad categories:

1. River restoration measures to restore deepwater and side channel aquatic habitats to address sediments deposited in the lakes. These alternatives fall into two general categories:
    a. Dredging to create aquatic habitat and islands, and
    b. Dredging to create aquatic habitat with sediment placement outside of the lake, such as on agricultural fields, brownfields, or former mined lands.

2. Watershed restoration measures on Farm Creek to stabilize the stream to reduce sediment delivery to the lakes and create habitat. These alternatives fall into two general categories:
    a. Restoration to reduce sediment delivery, such as reducing streambed and stream bank erosion, sediment traps, slowing runoff rates, and
    b. Restoration to create and restore habitats degraded in the basin, such wetland restoration, improved riparian corridors, and plantings.

The initial recommendation identified to date includes dredging to create 200 acres of aquatic area with increased depth diversity and 3 islands encompassing roughly 90 acres in Lower Peoria Lake. The recommendation also includes wetland restoration along Farm Creek.

NEXT STEPS

The next step for all these studies includes completion of the feasibility study, to determine Federal interest, and then following the steps outlined previously. However, related to the State of Illinois' Illinois Rivers 2020 initiative, Section 519 of the Water Resources Development Act of 2000. This authority could potentially be utilized to continue project implementation if feasible alternatives are identified. The exact process and timing of implementation is dependent on timely completion of the study efforts and support by the Administration and Congress. The Corps of Engineers looks forward to continuing its partnership with the State of Illinois and others to complete these important restoration efforts.

For additional information on the study and upcoming meetings, see the Corps' Illinois River Ecosystem Restoration website, http://www.mvr.usace.army.mil/ILRiverEco/default.htm or the Rock Island District website, http://www.mvr.usace.army.mil/.

RESTORATION EFFORTS ON THE KANKAKEE RIVER

<u>Richard Schultz</u>, <u>Michael Van Mill</u>, and B. Carl Miller

Kankakee Municipal Utility, 199 S. East Ave., #2, Kankakee, Illinois 60901
Phone: (815) 933-0487

The presentation will provide a brief history of the Kankakee River Basin and a discussion of its current problems. Information will be provided regarding the outstanding diversity of the area in terms of its flora and fauna and its natural habitats. The threat to this unique ecosystem presented by sedimentation, siltation, erosion, agriculture, and urbanization both within Illinois and Indiana will be explained.

Spotlighted will be the Partnership's systematic approach to project selection. This approach, formalized in the Partnership's 1997 River Basin Stewardship Plan, includes developing a Basin-wide database of identified threats, utilizing geo-spatial technology to locate areas of concern, and the formulation of an action strategy to prioritize projects.

The projects already begun and funded through the Conservation 2000 program in the Kankakee River Basin will be described and linked to the Kankakee River Basin Stewardship Plan's goals and objectives. The presentation will illustrate the Partnership's projects and show the Basin-wide relationship between documented environmental threats and individual project benefits.

The Illinois River:
Partnership for Progress;
Restoration and Preservation

Restoration Efforts on the Kankakee River

Kankakee River Basin Partnership

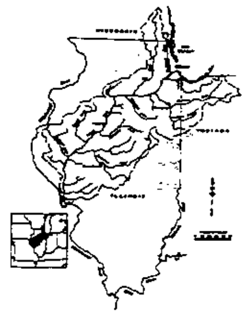
Presenters:

Rich Schultz
Mike Van Mill
Byron Miller

Thank You's

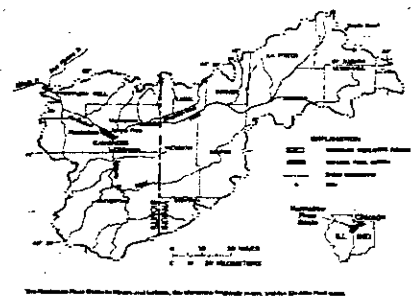
- Delbert Skimerhorn, Kankakee County
- Nani Bhowmik, PhD, PE & The Illinois State Water Survey
- United States Geological Survey

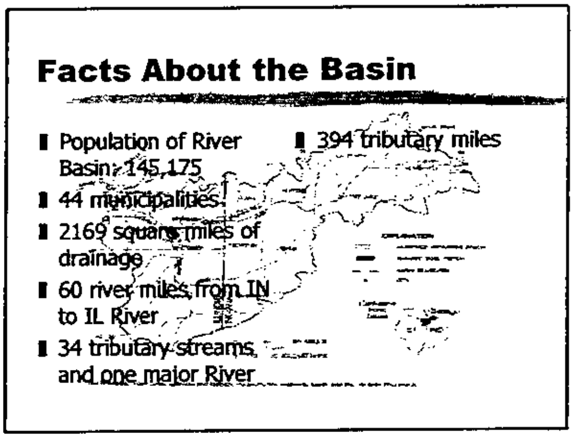
Watershed of the Illinois River

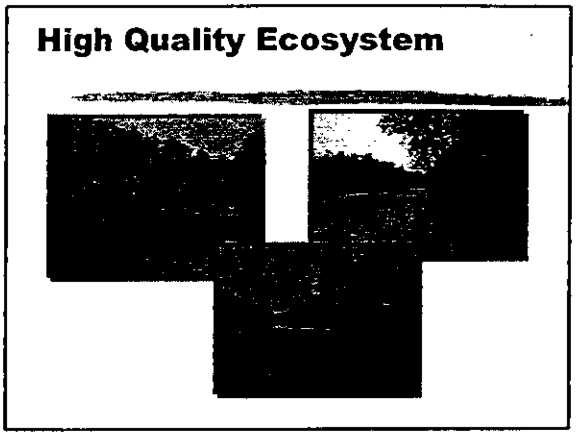


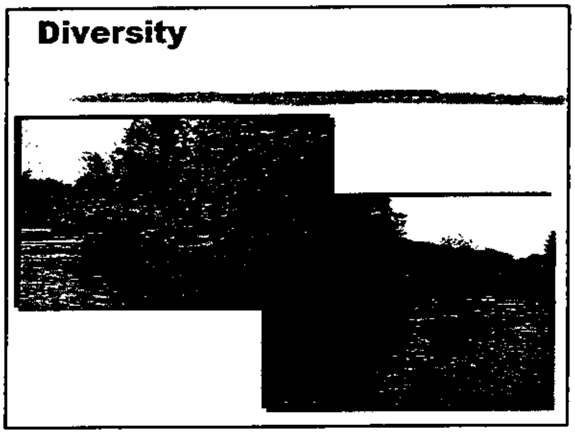
Illinois Partnerships

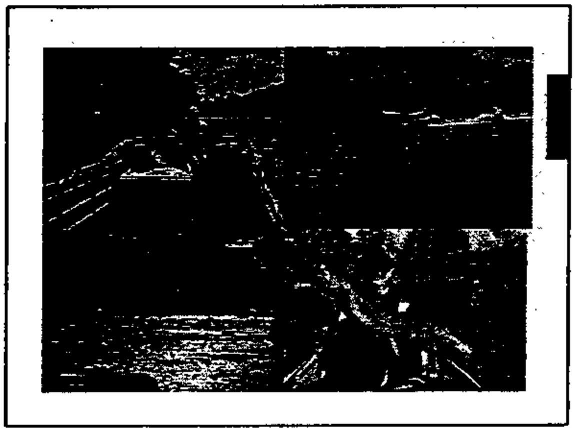
Kankakee/Iroquois River Basin

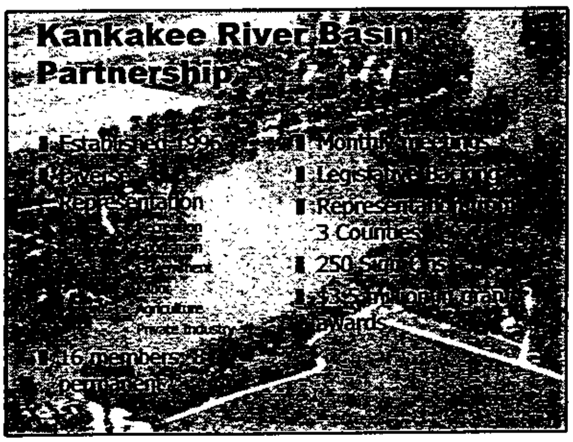



Facts About the Basin
Population of River Basin: 145,175
44 municipalities
2169 square miles of drainage
60 river miles from IN to IL River
34 tributary streams and one major River
394 tributary miles


High Quality Ecosystem


Diversity

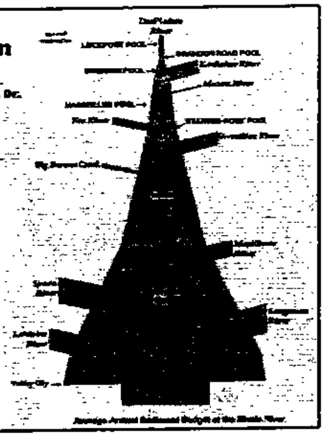



Kankakee River Basin Partnership
Established 1996
Representation
Agriculture
16 members
permanent
Monthly meetings
3 Counties
awards


Kankakee River Basin
Impact upon Illinois River
Basin System

Illinois River Basin Sediment Load

Source: Illinois State Water Survey, Dr. [illegible]



Kankakee RB Impact on IL River Basin

- The Kankakee River provides more than 70% of the flow in the Illinois River at its headwaters.
- The Kankakee River delivers 75% of the sediment load to the Illinois River at its headwaters.
- The Kankakee River is the source of 30% of the sedimentation load entering Peoria Lake from tributaries.

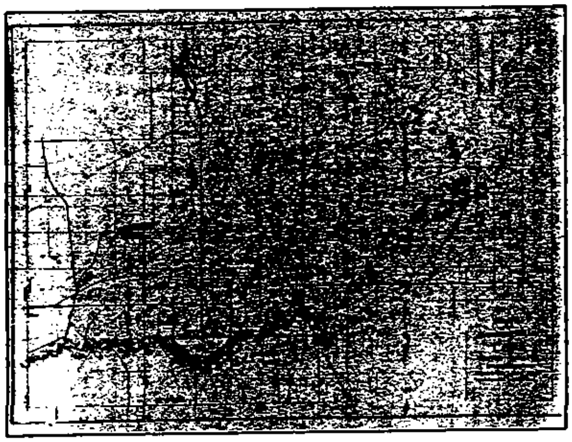
Illinois River Tributary Sediment Inputs Per Year

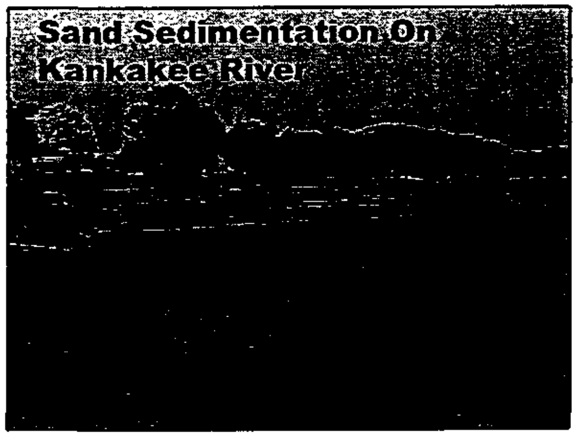
(Name of Tributary & Input in 1000 tons)

Des Plaines River	287
Kankakee River	**872**
Mazon River	42
Fox River	553
Vermilion River	932
Big Bureau Creek	199
Mackinaw River	835
Spoon River	2729
Sangamon River	1552
La Moine River	1372

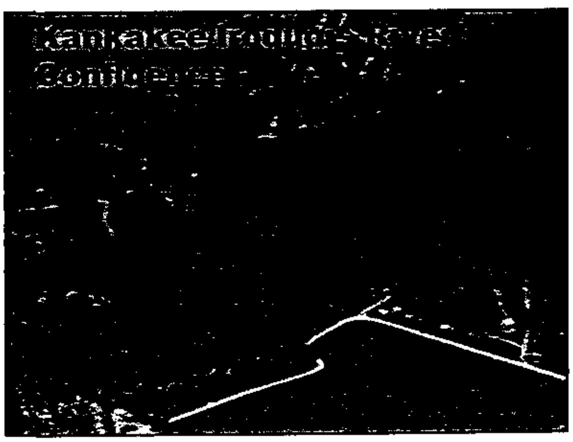
Kankakee River Basin Challenges

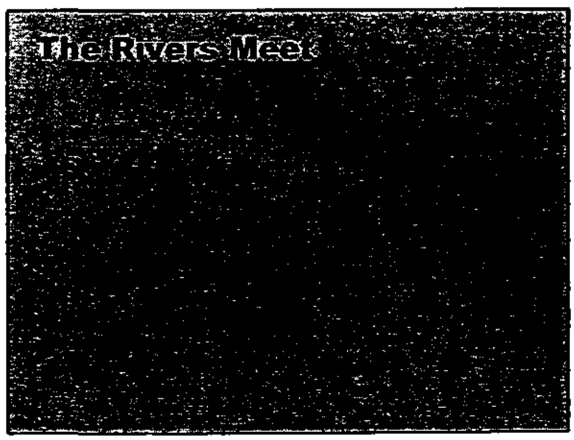
- Indiana Channelization
- Sand Sedimentation
- Iroquois/Kankakee River Confluence
- Erosion
- Flooding
- Increasing Volume/Decreasing Capacity
- Tributary Management/Maintenance

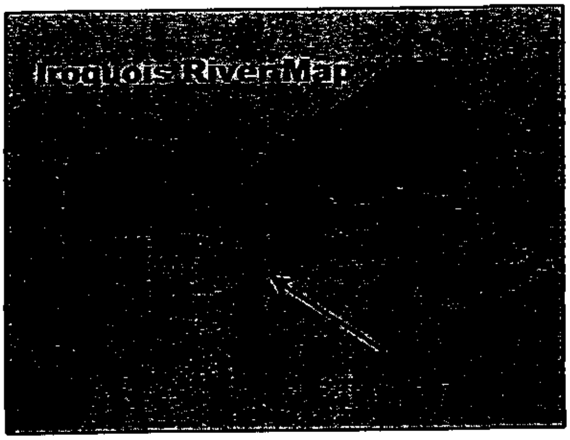


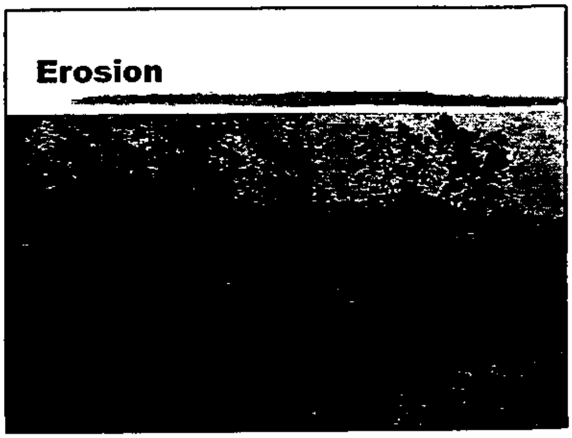

Sand Sedimentation On
Kankakee River

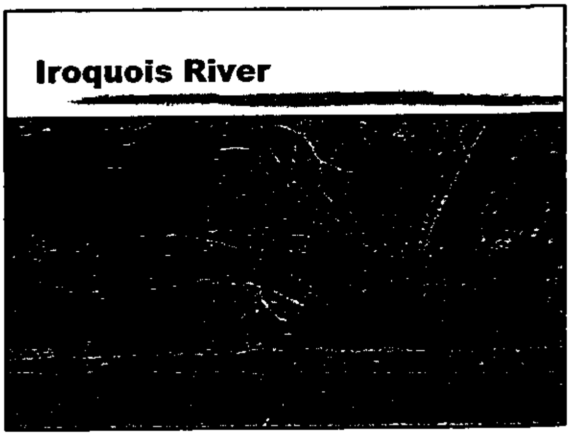

Sedimentation at State
Line


Kankakee


The Rivers Meet



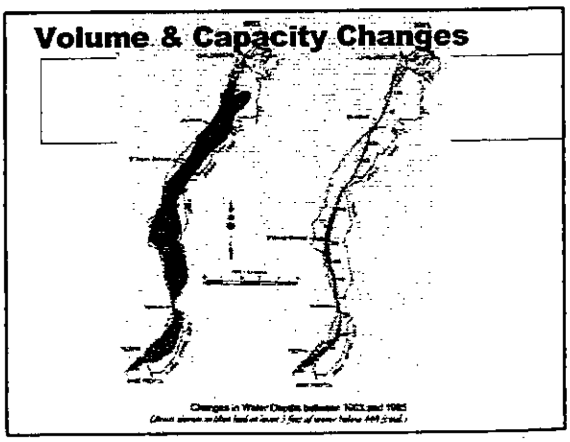




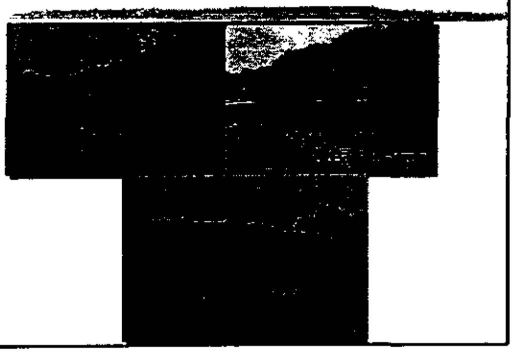
Erosion Findings

Source: Il. State Water Survey, August 2001

Bank Erosion Conditions	*Bank Mile*	*Percent of Total Bank Miles*
Severe	[illegible]	[illegible]
Moderate	39.4	17.6
Minor	[illegible]	[illegible]
Stable or Protected	93.0	41.6
Data Not Available	40.0	[illegible]

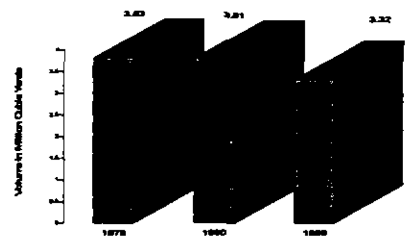


Capacity Analysis



Six Mile Pool - Loss in Capacity

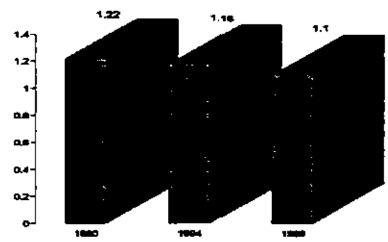
Source: IL State Water Survey, Aug 2001



Momence Wetlands

Capacity Loss (Volume in Million Cubic Yards)

Source: IL State Water Survey, August 2001

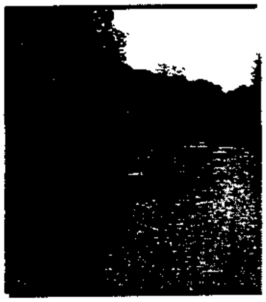


Loss of Capacity

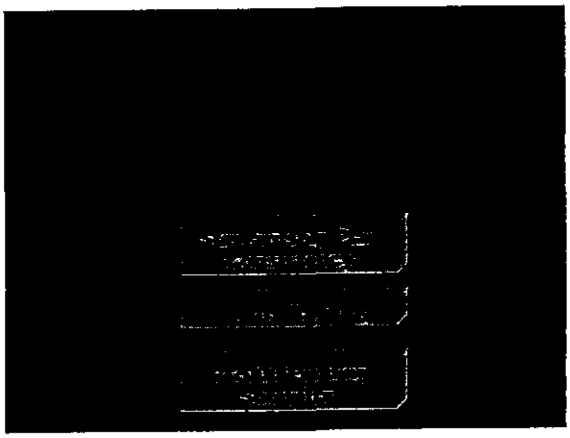
Source: IL State Water Survey, August 2001

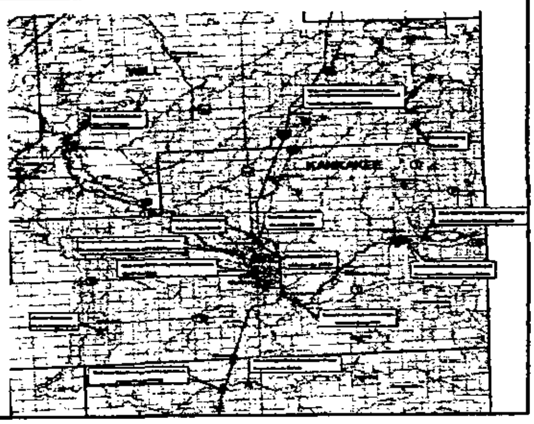
Reach	Year	Capacity	Change in Capacity
Six Mile	1978	[illegible]	100
Pool	1990	[illegible]	[illegible]
	1999	[illegible]	[illegible]
Aroma Park	1966	6.38	100
to Singleton	1997	6.25	97.8
Ditch	1999	6.40	100.3
Momence	1980	1.22	100
Wetland	1994	1.18	96.6
	1999	1.10	[illegible]

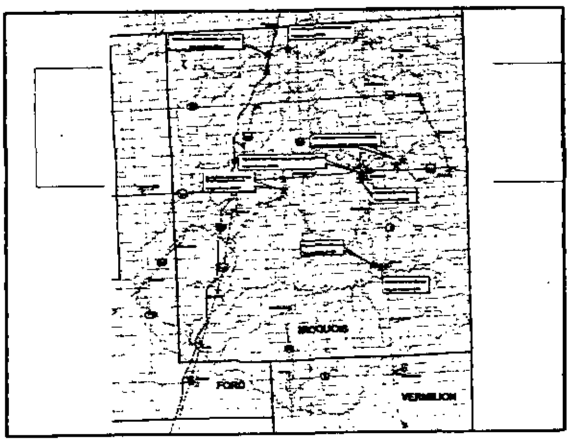
Kankakee River Basin Stewardship Plan



- Water quality Stabilization
- Land Use Stabilization
- Water Quality improvement
- Preservation of high quality natural resources
- Restoration/enhancement of habitats for native species
- Promotion of natural resource educational opportunities
- Protection of prime farmland







Partnership Highlights
1998 - 2001

- 25 Ecosystem Project Grants
- $1,261,130 in C2000 Funds
- $375,864 in outside matching funds
- CREP Program - 525 contracts, 78, 713 acres
  - Iroquois Co. – 457 contracts, 78,034 acres
  - Kankakee Co. – 57 contracts, 590 acres
  - Will Co. – 11 contracts, 90 acres

Funded Projects in Basin

Project	Amount	Problem Solution
Momence Wetland Land Acquisition	$595,350	Sedimentation & Flooding
Compilation of Hydrologic Data	$50,000	Volume Capacity
Sand Bar Survey	$60,000	Capacity & Sedimentation
Channel Geometry Survey	$50,000	Capacity & Sedimentation
Riparian Buffer on Streams	$73,806	Erosion & Sedimentation
Riparian Buffer on Streams	$35,000	Erosion & Sedimentation
Riparian Buffer on Streams	$39,868	Erosion & Sedimentation
Lower Langan Cr. Stream Stabilization	$40,000	Erosion
K3 River-Erosion Repair & Prevention	$4,500	Erosion
Park Island Stabilization	$80,000	Erosion
Flow Obstruction Removal - Iroquois River	$2,500	Maintenance
Watershed Stabilization - Grass Waterways	$7,500	Sedimentation Control
Watershed Stabilization, Construction, Terrace System	$ 3,500	Sedimentation Control
Assessment & Flow Obstruction Removal - Spring Cr	$50,000	Stream Maintenance
Bank Stabilization - No. Branch of Soldier Cr.	$48,555	Erosion & Maintenance
Bank Stabilization - Singleton Ditch.	$21,350	Erosion & Maintenance
Flow Obstruction Removal - Iroquois River	$25,000	Maintenance
Outdoor Classroom	$2,500	Public Awareness
Environmental Education - SWCD	$2,500	Public Awareness & Erosion
Backwater Lake Development - Langan Cr.	$60,000	Stream Maintenance
Erosion Repair & Prevention - K3 River	$4,600	Erosion
Environmental Education Workshops	$3,960	Public Awareness
Water Quality Workshop	$1,500	Public Awareness
Tree Planter Acquisition	$2,500	Erosion

Plans in Process - Feb 2001

Project	Amount	Problem Solution
Storm Sewer Painting	$83,523	Water Quality
Soldier Creek Bank Stabilization	$89,996	Erosion
Adopt A River	$5,487	Public Awareness
River Road Bank Stabilization	$68,464	Erosion
Langham Creek Logjam Removal	$20,000	Stream Maintenance

HABITAT RESTORATION OBJECTIVES ON THE ILLINOIS RIVER

Jim Mick, Mike Cochran, and Ross Adams

Illinois Department of Natural Resources
700 S. 10th Street, Havana, Illinois 62644

The Illinois River Basin encompasses some 30,000 square miles, covering 44% of the land area of the state. The basin (contained in 55 counties) includes 46% of the states agricultural land, 28% of its forests, 37% of its surface waters and streams, and 95% of its urban areas. Over the years, the diversion of water from Lake Michigan, combined with the discharge of domestic and industrial waste into the Illinois River, improved drainage, construction of levees, urbanization, and the introduction of navigation structures , dramatically altered the river's hydraulic characteristics.

Today, the Illinois River, its tributaries, side channels and backwater areas are choked with sediment and in need of environmental restoration. Much of the water in off-main channel areas and backwater areas is less than 1 foot deep at normal pool elevation. Populations of many types of economically important fish, waterfowl, and mussels, as well as numerous other species of flora and fauna are annually declining from the increasing sediment load and deposition of silt in highly productive habitats found in backwater,, side and main channel areas in the Illinois River.

The Illinois Rivers 2020 Program will provide a full toolbox to federal, state, local governments, non-governmental organizations, and the public to implement a sound and successful basin wide restoration effort. This project builds upon and is complementary to the existing Peoria Lake Restoration and Kankakee River Basin Restoration projects with the Corps and numerous farm bill programs implemented through the Farm Services Agency and the Natural Resources Conservation Service. The direct tributaries to Peoria Lake represent about 50% of the annual sediment load. Reducing the sedimentation from the direct tributaries into Peoria Lake and the Kankakee and Vermilion watersheds will significantly reduce the total annual sediment load to Peoria Lake.

The Illinois River Basin project will provide for implementation of ecosystem based watershed management projects within the entire Illinois River Basin in cooperation with the US Army Corps and other federal agencies including the US Department of Agriculture and the State of Illinois under the guidance provided by the Integrated Plan for the Illinois River Basin. The framework for restoration included the following **target areas** on the main stem as well as tributaries of the Illinois River: (a) side channel and backwater areas restoration; (b) floodplain function restoration; (c) more natural water level management; (d) tributary stream basins conservation of land and water resources

HABITAT RESTORATION OBJECTIVES
ILLINOIS RIVER NATIONAL WILDLIFE AND FISH REFUGES

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INTRODUCTION

The National Wildlife Refuge system was born nearly 100 years ago when President Teddy Roosevelt set aside tiny Pelican Island in Florida as a sanctuary for birds. Today the U.S. Fish and Wildlife Service manages a 94 million acre system which encompasses more that 535 refuges in all 50 states. The mission of the system is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations. The largest refuges, Yukon Flats and Arctic National Wildlife Refuge, are 19 million acres each with intact ecosystems. Little restoration is required on these areas but protection is paramount. Most refuges are situated in areas which have been severely impacted by man and require restoration, maintenance, and management as well as protection. Chautauqua Refuge and many others are failed drainage projects.

The Illinois River National Wildlife and Fish Refuges are scattered along 125 miles of the Illinois River floodplain between Meredosia and Henry. The 12,000 acre refuge complex includes:

Chautauqua Refuge 4,488 acres
Cameron/Billsbach Unit 1,709
Emiquon Refuge 2,073
Meredosia Refuge 3,852

REFUGE PURPOSE(S)

Chautauqua Refuge
"...as a refuge and breeding ground for migratory birds and other wildlife" (Executive Order 7524, dated December 23, 1936)

"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (Migratory Bird Conservation Act)

Meredosia Refuge
"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds (Migratory Bird Conservation Act)

"...suitable for 1) incidental fish and wildlife-oriented recreational development, 2) the protection of natural resources, 3) the conservation of endangered species of threatened species..."...the

Secretary...may accept and use...real...property. Such acceptance may be accomplished under the terms and conditions of restrictive covenants imposed by donors..." (Refuge Recreation Act)

Emiquon Refuge
"...the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions..." (Emergency Wetlands Resources Act)

1979 Master Plan Objectives were to 1) provide migrating waterfowl with food, water, and protection during fall and spring months, and 2) to improve and maintain habitat to perpetuate optimum annual production of wood ducks. The plan also discussed other migratory birds and resident species and mentioned restoring "waste" areas to prairie habitat. These objectives were narrowly focused but an indication of the role that waterfowl played in the preservation of habitat along the Illinois River in the 20th Century. The areas that were saved and managed for waterfowl and waterfowl hunting on private, state, and federal land still serve as the foundation for the restoration of biological diversity in the River landscape.

RECENT HABITAT RESTORATION

Management facilities on Lake Chautauqua were rebuilt by the Corps of Engineers as a Habitat Restoration and Enhancement Project. The Corps constructed a pump station and 2 water control structures and rebuilt levees to withstand 10 year flood event on the north pool. The north pool is managed for deep water (2 to 4 feet) habitat for diving birds and fish. The Service rebuilt the south pool levee and moved nearly 2 miles of levee back 1/4 mile from the river's edge to provide relief for this restricted floodplain. Two spillways in the south levee allow high spring flood waters to come and go but keep out the summer fluctuations that can be detrimental to vegetation. The project restored management capability to provide mud flats for shorebirds, moist soil plant growth for foraging habitat for ducks, geese, and swans, and spawning and nursery habitat for fish.

In 1995 refuge staff developed 500 acres of moist soil habitat on Meredosia Refuge supported in part with Ducks Unlimited and State Duck Stamp funds. The project is moderately successful for late winter and spring habitat. Refuge staff restored 10 wetland units totaling 120 acres and a pump site on Meredosia Island in 2000.

HABITAT RESTORATION - PRIVATE LANDS

The refuge in cooperation with the Illinois Department of Natural Resources and Natural Resources Conservation Service provides technical assistance and partial funding to restore approximately 200 acres of habitat on private land annually. The Service and Ducks Unlimited signed a cooperative agreement in 2001 to pool funds and expertise to enhance assistance to private land owners in their restoration efforts.

PLANNED RESTORATION

Excessive sedimentation has nearly destroyed the natural resource values of Weis Lake on the refuge's Cameron Unit near Henry. During normal pool stage, water depth averages about 6 inches and supports no fish and little vegetation. Waterfowl use declined dramatically after 1972. The Service signed a cooperative agreement with Ducks Unlimited this year to restore Weis Lake by building a structure in north end to prevent the flow of bed load material from Crow Creek and Illinois River into the lake. This will be followed by a closing structure at the south end of the lake within a year to keep out summer fluctuations to enhance development of plant communities. The Natural Resources Conservation Service is leading an effort to develop a watershed plan for treatment of the Crow Creek watershed and restoration of floodplain habitat. The Corps of Engineers is considering a restoration project for Weis Lake, Billsbach Lake, and the State's Duck Ranch. These projects could include dredging, stream bank stabilization, stream bed stabilization, sediment basins, dikes and water control structures to reduce sediments and manage water and plant communities.

I mentioned that just this week the Service purchased the south Globe Drainage District from the Nature Conservancy. This 712 acres leveed farm will be restored to wetland habitat and managed as a clear water marsh as part of the Emiquon Refuge. Directly south of the Globe, refuge staff will construct a small low level dike to separate drainage of private lands from refuge lands. This will enable the Service to hold water on approximately 200 acres for winter and spring habitat. Refuge staff will also restore approximately 200 acres of prairie habitat in this area.

THE 15-YEAR COMPREHENSIVE CONSERVATION PLAN

As required by the National Wildlife Refuge Improvement Act of 1997, the Service is in the process of developing a Comprehensive Conservation Plan (Plan) for the Illinois River Refuges. Planners have reviewed legal mandates, authorizing legislation, refuge purposes, ecosystem goals and objectives, regional priorities, and other planning efforts along the Illinois River. The refuge hosted open houses to solicit public comments, met with Illinois DNR staff, with Service staff from various programs, and conducted a facilitated workshop with Illinois River experts to identify issues and opportunities.

HABITAT ISSUES

Altered hydrology and sedimentation in the Illinois River have degraded much habitat. In the past 200 years the prairies were plowed, wetlands drained, and forests cleared for agricultural production. Roughly half of the floodplain has been leveed from the River. Urban sprawl with all of its pollution and hard surfaces has increased run off of surface water and degraded water quality. Lake Michigan water was diverted down the Illinois River to flush Chicago's sewage. These changes in the watershed land uses resulted in substantial loss, degradation, and fragmentation of both terrestrial and aquatic fish and wildlife habitat. Loss of the native grassland habitat has lead to widespread declines in grassland birds. Many native mussels are imperiled because of degraded aquatic habitat. The Plan will identify at the landscape scale new areas for restoration and management to restore lost habitat and provide the most favorable mix possible to reduce fragmentation within the Illinois River Corridor.

The Illinois River System continues to be plagued by exotic species, some of which were introduced intentionally. Common carp, grass carp, purple loosestrife, Eurasian tree sparrow, and zebra mussel are just a few of the exotic species that negatively affect native species and their habitat. Potential impacts from exotic species will be addressed in the planning process and those impacts minimized to the extend practical.

The Refuge lacks a comprehensive strategy to protect and restore Service trust resources in the Illinois River Corridor. This plan will provide a framework for the Refuge to assume a leadership role in developing and implementing a comprehensive and coordinated conservation strategies for the benefit of Service trust resources within the Illinois River Corridor.

DRAFT REFUGE VISION STATEMENT

The Illinois River National Wildlife and Fish Refuges are a wild and thriving places where abundant grasslands and savannas, bottomland forests, backwater lakes, and floodplain wetlands support productive populations of listed species, waterfowl and other migratory birds, fish and mussels, and native biological diversity. The Refuges serve as a regional and national destination for visitors seeking high quality educational and recreational experiences. Through outreach with others, the Refuge has expanded the publics understanding and appreciation of the Illinois Rivers fish and wildlife resources, and in doing so, has perpetuated these resources within the communities surrounding the Refuge. The nation is a better place because of the Illinois River Refuges.

DRAFT REFUGE MISSION STATEMENT

Our mission, in cooperation with others, is to provide leadership and support in protecting, restoring, conserving, enhancing, and managing a large river ecosystem that supplies the biological needs of listed species, waterfowl and other migratory birds, native fish and mussels, and biological diversity. The Refuge and its staff will be leaders in building mutually-beneficial relationships with the public and our partners. These relationships will result in a greater understanding and appreciation of the Refuge and Illinois Rivers fish and wildlife resources, and will lead to an expanded role humankind plays in their stewardship.

DRAFT REFUGE GOALS AND OBJECTIVES

Goal 1 - Wildlife
Through outstanding leadership and support in the conservation and management of diverse and productive populations of listed species, waterfowl and other migratory birds, native fish and mussels, and native biological diversity (Service trust resources), the Illinois River Corridor will have a high degree of biological integrity, diversity, and environmental health.

Objective 1.1 Listed Species
By 2017, in cooperation with Federal and state partners, all known populations of federally listed species (e.g. Bald Eagle, Higgins-eye Mussel, Least Tern, Decurrent False Aster) will be protected consistent with federal and state recovery plans.

Objective 1.1 - Dabbling Ducks
By 2017, increase the breeding pair population of dabbling ducks on Refuge land (e.g., Mallard, Blue-winged Teal, Pintails, Wood Duck, Shoveler) to 200 pairs through habitat restoration and management, in accordance with the North American Waterfowl Management Plan (the Refuge currently supports roughly 50 breeding pairs).

Objective 1.2 - Diving Ducks

By 2017, increase the breeding pair population of diving ducks on Refuge land (e.g., Ring-necked Duck, Hooded Merganser, Lesser Scaup) to 20 pairs through habitat restoration and management, in accordance with the North American Waterfowl Management Plan.

Objective 1.3 - Geese

Maintain current population levels of geese on Refuge land, in accordance with the North American Waterfowl Management Plan (currently the Refuge averages 550,000 goose use days during spring and fall migration) throughout the life of this Plan.

Objective 1.4 - Grassland Birds of Concern

By 2017, increase species diversity and the breeding pair population of grassland bird species of concern on Refuge land (e.g., Henslow's Sparrow, Bobolink, Dickcissels, Loggerhead Shrike, Grasshopper Sparrows) through habitat restoration and management, in accordance with the North American Waterfowl Management Plan and the Partners in Flight Physiographic Area Plan.

Objective 1.5 - Savanna Birds of Concern

By 2017, increase species diversity and the breeding pair population of savanna bird species of concern on Refuge land (e.g. Red-headed Woodpecker, Northern Flicker, Field Sparrow. Baltimore Oriole) through habitat restoration and management, in accordance with the North American Waterfowl Management Plan, Partners in Flight Physiographic Area Plans, and guidelines developed by Sample and Mossman (1994).

Objective 1.6 - Forest Birds of Concern

By 2017, increase species diversity and the breeding pair population of forest bird species of concern on Refuge land (e.g. Cerulean Warbler. Wood Thrush, Veery, Yellow-billed Cuckoo), through habitat restoration and management, in accordance with the Partners in Flight Physiographic Area Plan.

Objective 1.7 - Wetland Birds of Concern

By 2017, increase the breeding pair population of wetland bird species of concern on Refuge land (e.g. Black Tern, American Woodcock, Least Bittern, Sora Rail, King Rail, American Redstart, Pileated woodpecker) through habitat restoration and management, in accordance with the North American Waterfowl Management Plan and the Partners in Flight Physiographic Area Plan.

Objective 1.8 - Native Fish

By 2017, increase native fish species diversity on Refuge land to 85 percent of the fish species historically present in the Illinois River System at the end of the 19th century through additional habitat restoration and management.

Objective 1.9 - Native Mussels

By 2017, increase native mussel species diversity on Refuge land to 50 percent of the mussel species historically present in the Illinois River System at the end of the 19th century through additional habitat restoration and management.

Objective - Native Biological Diversity

By 2017, native biological diversity on Refuge land will represent a high degree of ecological health and integrity characteristic of the historic Illinois River Corridor at the time of European settlement.

Indicators of Progress - Wildlife

- Percent of listed species protected within the conservation estate

- Abundance of Service trust resources (e.g., populations of fish, mussels, waterfowl, etc)

- Indices of biological integrity and environmental health

- Number of Regional Conservation Priority Species protected and maintained (as stable or increasing) within the conservation estate.

Goal 2 - Habitat
Through outstanding leadership and support in the conservation and management of high quality native grasslands and savannas, forests, and wetland ecosystems characteristic of the historic Illinois River Corridor, populations of listed species, waterfowl and other migratory birds, native fish and mussels, and native biological diversity will be healthy, resilient, and capable of producing a variety of outdoor recreation benefits over the long term.

Objective 2.1 - Native Grasslands
By 2017, protect, restore, and manage 1,000 acres of high quality native grasslands (e.g., upland prairies, hill prairies, wet prairie meadows) characteristic of the Central Tallgrass Prairie ecoregion within the Illinois River Corridor and capable of providing breeding habitat for listed species (e.g., Henslow's Sparrow), waterfowl (Mallard, Blue-winged Teal, Pintail) and other migratory birds (e.g. , Bobolink, Dickcissels, Loggerhead Shrike, Grasshopper Sparrows) and to promote native biological diversity (currently the Refuge has roughly 200 acres).

Objective 2.2 - Native Savannas
By 2017, protect, restore, and manage 200 acres of high quality native savannas (e.g., oak barrens) characteristic of the Central Tallgrass Prairie ecoregion within the Illinois River Corridor and capable of providing breeding habitat for diverse migratory birds (e.g. Red-headed Woodpecker, Northern Flicker, Field Sparrow, Baltimore Oriole, Wild Turkeys) and to promote native biological diversity (currently the Refuge has no savanna).

Objective 2.3 - Native Forests
By 2017, protect, restore, and manage 6,000 acres of high quality forest habitat (e.g., upland hardwood, bottomland hardwood) on Refuge land characteristic of the historic Illinois River Corridor and capable of providing breeding habitat for diverse migratory birds (e.g. Cerulean Warbler, Red-shouldered Hawk, Yellow-billed Cuckoo), forest nesting waterfowl (e.g. Wood Ducks), Indiana Bats, and to promote native biological diversity (currently the Refuge has roughly 4,500 acres).

Objective 2.4 - Wetlands
By 2017, protect, restore, and manage 10,000 acres of high quality wetland habitat characteristic of the historic Illinois River Corridor (e.g., side channels, backwater lakes, shallow and deep water marshes, moist soil habitats) and capable of providing resting, nesting, and feeding habitat for waterfowl and other migratory birds; spawning, nursery, and overwintering habitat for native fish and mussels; and to promote native biological diversity (currently the Refuge has roughly 6,000 acres of wetlands).

Indicators of Progress - Habitat

- Acres of high quality native grassland and savannas, forests, and wetlands restored and protected in the conservation estate

- Indices of biological integrity, diversity, and environmental health (e.g., size of habitat blocks, degree of fragmentation, connectivity, barriers)

- Water quality (e.g., phosphorus content, toxic substances, sediment content, clarity)

- Number of miles of tributary stream banks with permanent vegetative cover

LAND PROTECTION AND RESTORATION

The existing refuge land base will serve as the core of focus areas for additional habitat restoration and protection efforts. Refuge staff will work closely with the Illinois Department of Natural Resources, The Nature Conservancy, Ducks Unlimited, Natural Resources Conservation Service, and private land owners in ensuring that the most critical habitat is protected and restored for the benefit of listed species, migratory birds, native fish and mussels, and native biological diversity.

JUSTIFICATION

Over 99 percent of the original oak savanna in the Midwest has been lost and is one of the rarest ecosystems in the world. The tall grass prairie and wetlands have suffered dramatic losses also. Many remaining wetlands are being degraded from sedimentation and exotic species. This loss of habitat has led to substantial declines in grassland and wetland dependent birds. The aquatic system along the Illinois River has been degraded to the point of being nearly devoid of vegetation and organisms such as the fingernail clam. Objectives to restore portions of these depleted systems are proposed in the Comprehensive Conservation Plan. Refuge infrastructure, funding, and staff required to maintain existing habitat and to protect and restore additional habitat needed to accomplish the refuge objectives will be identified in the Plan.

OPPORTUNITIES

Presently, opportunities abound along the Illinois River for making great strides in natural resource conservation. The Conservation Reserve Enhancement Program has been highly successful with over 80,000 acres enrolled within the watershed. The Wetland Initiative now owns the Hennepin Drainage District and initial restoration efforts look outstanding. The Nature Conservancy has restored Spunky Bottoms with rare species such as Henslow sparrows returning to nest in the restored prairie. The Conservancy also purchased the 7,500 acre Wilder Farm and will restore the highly productive Thompson and Flagg Lakes. The Nature Conservancy's ownership is within the approved acquisition boundary for Emiquon and Meredosia National Wildlife Refuges. Illinois 2020 program will be moving dirt soon for habitat restoration on projects such as Pekin Lake. The Crow Creek planning team is developing a watershed plan to improve habitat and reduce sources of silt and sediments entering Weis and Goose Lake. The

Midwest Natural Resources Group of 12 federal agencies have agreed to cooperate and coordinate their efforts to further the restoration efforts on the Illinois River. The Service signed agreements with Ducks Unlimited to pool resources and cooperate in restoring habitat on private lands and for restoring habitat in Weis Lake.

The challenge for refuge planners is to identify the role of Illinois River Refuges in conservation efforts in the River corridor. Certainly, efforts to maintain, restore, and manage habitat for the Service's trust resources on refuge lands will continue. But more importantly, the refuge will be working hand in hand with all the conservation interests in the watershed to ensure that we are working with maximum effectiveness in protecting and restoring habitat that will sustain these important natural resources for generations yet to come.

You can help! Please be sure to pick up a copy of our planning news letter at Fish and Wildlife Service exhibit and let us know your thoughts on what the role of the Illinois River Refuges should be on the river.

Thank you.

MATHEMATICAL MODELING FOR THE CONSTRUCTION OF ARTIFICIAL ISLANDS WITHIN THE LOWER PEORIA LAKE

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INTRODUCTION

Ecosystem based restoration of any system requires a coordinated effort by a variety of scientists and engineers. Since water is the main driving force behind restoration of aquatic habitats, a thorough understanding of the interactions between a proposed activity and how to predict the future is essential for all implementable projects. The Illinois River drains about 75,000 square kilometers (km^2), is more than 500 kilometers (km) long and flows through a variety of physiographic features. Presently, state, federal and local agencies are actively involved in proposing several projects, which could enhance the ecosystem of this river. Before such projects are implemented, predictive tools are needed to determine what could happen in the future. Mathematical models are being utilized now for several areas to determine the correct course or courses of action. Modeling is done to determine the consequences of site-specific projects. This paper will deal with one specific area.

The project area is the proposed creation of artificial islands with dredged sediments within Peoria Lake, a main stem lake within the Illinois River. Peoria Lake is about 35 km long, 3 to 5 km wide with an average depth of about 0.8 meters (m). The size, location, and orientation of the artificial islands are being determined based on expert knowledge and two-dimensional hydrodynamic models such as SMS. Approximately 20 to 25 scenarios have been tested and four different options within the Lower Peoria Lake have been selected for further evaluation and engineering design. The Peoria Lake project is an integral part of the major activity on the Illinois River entitled *Ecosystem Restoration of the Illinois River*, a state and federal partnership activity.

BACKGROUND

Research conducted by Demissie and Bhowmik (1985), Bhowmik et al. (1993) and Demissie et al. (1992) have shown that the Peoria Lake has experienced significant sediment deposition since 1903 to present time. Moreover, it has also been shown that about 50 percent of the total sediment delivery to the Peoria Lake is from the local tributaries, which comprises only about 4 percent of the total drainage area of the Peoria Lake.

Management of this excessive sediment load must be done at two geographical locations: a) at the watershed level, and b) within the lake environment. Just controlling the sediment input from the watershed will not show any substantial sediment reduction to the lake for many years to come. At the same time, trying to manage the sediment within the lake environment without controlling the input of the sediments from the watershed will also not be a very successful operation.

As part of the Peoria Lakefront Development project of the State of Illinois and the U.S. Army Corps of Engineers, it was agreed that one option for sediment placement would be to build artificial island or islands within the Lower Peoria Lake by utilizing the sediment that have already been deposited within the lake environment. However, before such island or islands could be built, a thorough hydrodynamic modeling work must be completed to estimate the size, shape, orientation, and location of such island(s). This modeling work will also enable the managers to estimate the location or locations where additional high or low velocities may be expected due to the island construction.

The Peoria Lake is located between River Mile (RM) 157.8 and about RM 181. The Peoria Lake is located upstream of the Peoria Lock and Dam. A series of locks were built on the Illinois River to facilitate the navigation with 2.78m deep draft barges. The sedimentation problems of the Peoria Lake can be illustrated with the four cross sections of the Illinois River within the Peoria Lake (Figure 1). The cross sections show the sediment deposition between 1903 and 1985. By 1999 to 2000, the lake has lost more capacity due to sediment deposition, especially within the Lower Peoria Lake.

Hydrodynamic Modeling

The model used for this project is the Surface Water Modeling System (SMS), which is a two-dimensional finite element model in plane coordinates. It was developed by the Engineering Computer Graphics Laboratory at the Brigham Young University in close cooperation with the U.S. Army Waterways Experiment Station (WES) and the U.S. Federal Highway Administration (FHWA).

For the Peoria Lake, the hydrographic data collected by the U.S. Army Corps of Engineers from the Rock Island District were used in the creation of the finite element grid. Where overbank elevation data were not collected, those gaps were filled by utilizing the contour elevations from the U.S. Geological Survey 1:24,000 Quad maps. The Manning roughness values were assigned for six different zones along the cross section which included main channel, channel border, shallow areas and areas near the one percent flood elevations. Other parameters were assigned based on hydrodynamic properties of an alluvial river. The model was calibrated utilizing measured stages at two locations and verified with a third stage value located at another location. Calibration and verification was also done for three flow events, one high flow event in February 1997, two medium flow events one each in February-March of 1997, and another one in May-June of 1996, and two low flow events one each in August 1996, and November 1995.

It was decided by the Interagency Committee that all the testing would be done for a flow having a 2-year frequency of occurrence. Flow data were analyzed from the Henry Station and the 2-year flow was determined to be 1,275 cubic meters per second (cms). All subsequent plots and analyses are based on this 2-year flow.

Island Options

The SMS model was run for 20 to 25 options to test the ideal location or locations of the island(s) within the Lower Peoria Lake. Results from those options will not be discussed here. Results from the two (2) options are discussed here.

No Island

SMS was initially run for the entire Peoria Lake without any island at any location to determine the undisturbed flow conditions. Results from this modeling work was used to determine the initial boundary conditions for that segment of the river from the constriction at about RM 166.3 through RM 165.2 This spatial extent of the model covered the areal extent of the four island options that have been selected for further analyses.

The spatial velocity distribution for this selected area without any island for a flow of 1,275 cm is shown in Figure 2. This illustration shows that the high velocities are concentrated within the main channel and that the core of high flow stays within the restricted area near the constriction between the Upper and Lower Peoria Lake.

Option 1

Figure 3 shows the flow patterns for Option 1 with a discharge of 1,275 cms. The top elevation of the island is 137.25 m-msl. The normal pool elevation of the Peoria Lake is 134.2 m-msl. The flow in this figure is from top to bottom. The main channel is on the right side or west side of the river. Left and right sides are determined based on an observer standing on the middle of the river and looking downstream. The lateral depth integrated velocities thus obtained are depicted in Figure 3. Some general observations from this figure are:

- As suspected, because of the semicircular shape of the island at the leading and tail ends, flows do not stay attached within the island at these locations.
- The velocity at this zone is either negligible or very low.
- At the upper top right hand edge (looking downstream), it is quite possible that additional sediments will be deposited in the future making this end of the island elongated. A portion of this elongated stretch will stay below normal pool level and a portion very close to the proposed island may extend above normal pool level in the future.
- The middle portion of the tail end of the island may also experience similar fate in the future because of the existence of extremely low velocities. It is suspected that ultimately and also in the long run, the tail end of the island may be elongated assuming a shape similar to an air foil.

The velocity structure has further been analyzed by constructing lateral velocity profiles at three cross sections (Figure 4) and results from two cross sections are shown in Figures 4 and 5. The locations of these cross sections are given in Figure 3. At all the cross sections, the depth integrated average velocities at the verticals at the dredged channel next to the main channel and on the west side of the island do increase as a result of the construction of this deep channel. Similarly, an increase in velocities is also observed on the east side of the island along the deep dredged channel. This is true at all three cross sections.

This increase in velocities at the deep channel next to the island is obviously desirable for the future maintenance of these newly created deep water channels. The maximum increase is for cross-section 2, on the main channel side, i.e. right side (looking downstream) of the island where the velocities increased from about 0.15 to 0.3 ms.

Option 3

Figure 5 shows Option 3 with a pair of islands below the McClugge Bridge. This illustration also shows the velocity structure for a flow of 1,275 cms. This illustration also shows the locations of three cross sections where lateral velocity data have been determined with and without islands. Areas shaded very dark are the areas where the velocities are computed to be very low. An examination of this illustration will show:

- Velocities are very low at the tips and tail ends of both the islands.
- These low velocities may enhance the sediment deposition at these locations.
- However, the extension of the island due to sediment deposition next to the navigation channel will be smaller compared to the larger island.
- The tail end of the larger island may extend in the downstream direction within the areas shown in dark.
- The velocities along the right side (next to the navigation channel) of the smaller island will be relatively higher.

- The velocities between both the islands are expected to be higher than the ambient flow condition.
- There is an area on the left side of the larger island near the upstream zones where velocities are also going to be relatively high.
- Higher velocities on both sides of both the islands indicate that the newly created deep water channel may last relatively longer time.

The two plots for cross sections are given in Figure 6. Examination of these two illustrations will substantiate the observations made previously. In all locations, the velocities within the navigation channel increase with the islands in place compared to the ambient conditions.

CONCLUDING REMARKS

This ongoing research has shown that mathematical hydrodynamic modeling work could serve as a powerful tool to make appropriate decisions in the alteration of a stream environment. Sedimentation has been a major problem for the Illinois River, especially for the Peoria Lake. Present management alternatives call for the utilization of deposited sediments to create artificial islands. A two-dimensional unsteady hydrodynamic model called SMS was used to identify the size, location, and orientation of several islands. Results from this research and also for two specific island configurations have been included in this paper.

ACKNOWLEDGMENTS

The author acknowledges the contributions made by a number of professional staff from the Illinois State Water Survey. A special thank you goes to Jim Mick, the coordinator of the Illinois River projects for the Illinois Department of Natural Resources (IDNR) and to John Marlin of the Waste Management Research Center, who served as the Project Director for IDNR for this specific project.

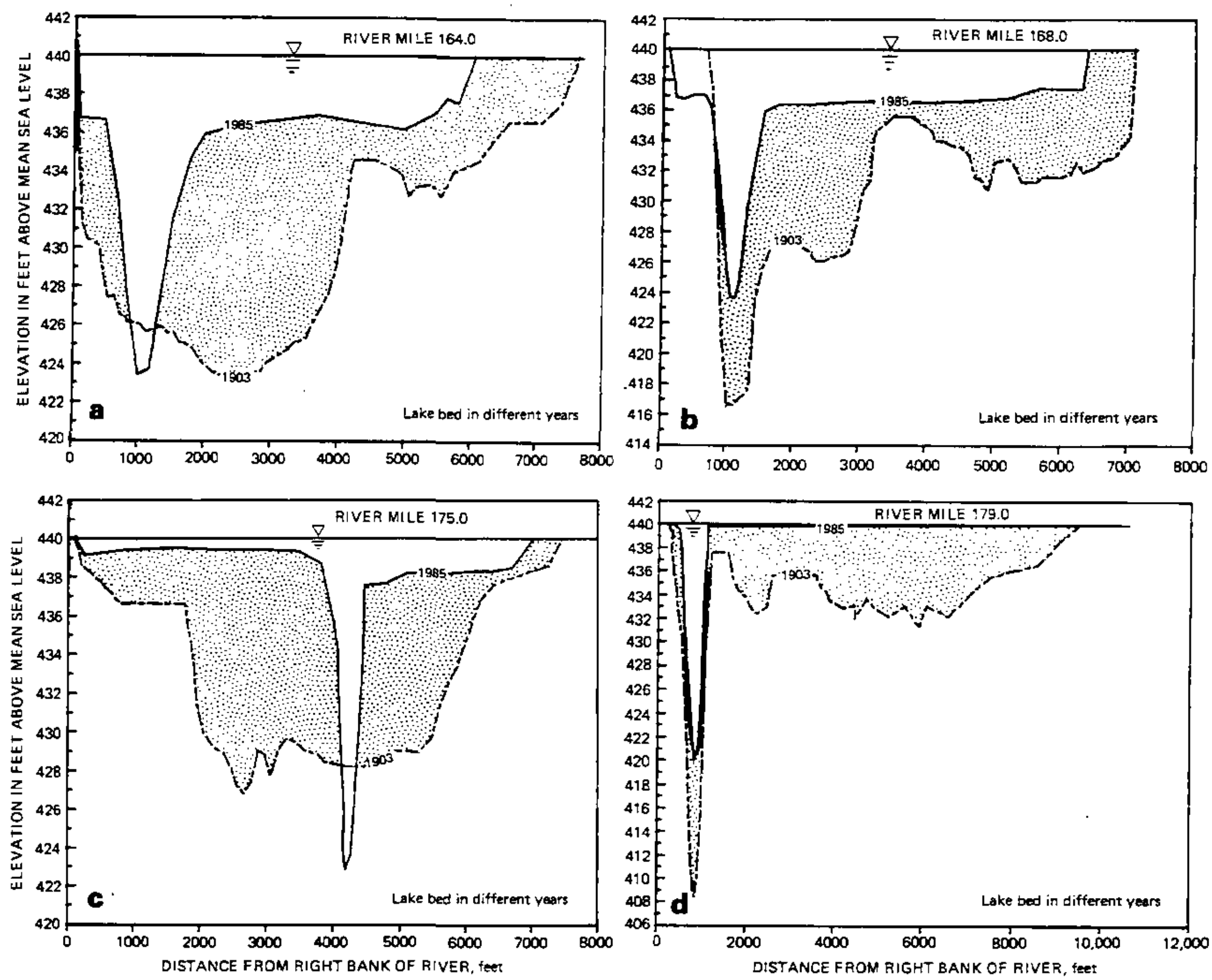

Figure 1. Historical sediment accumulations within Peoria Lake.

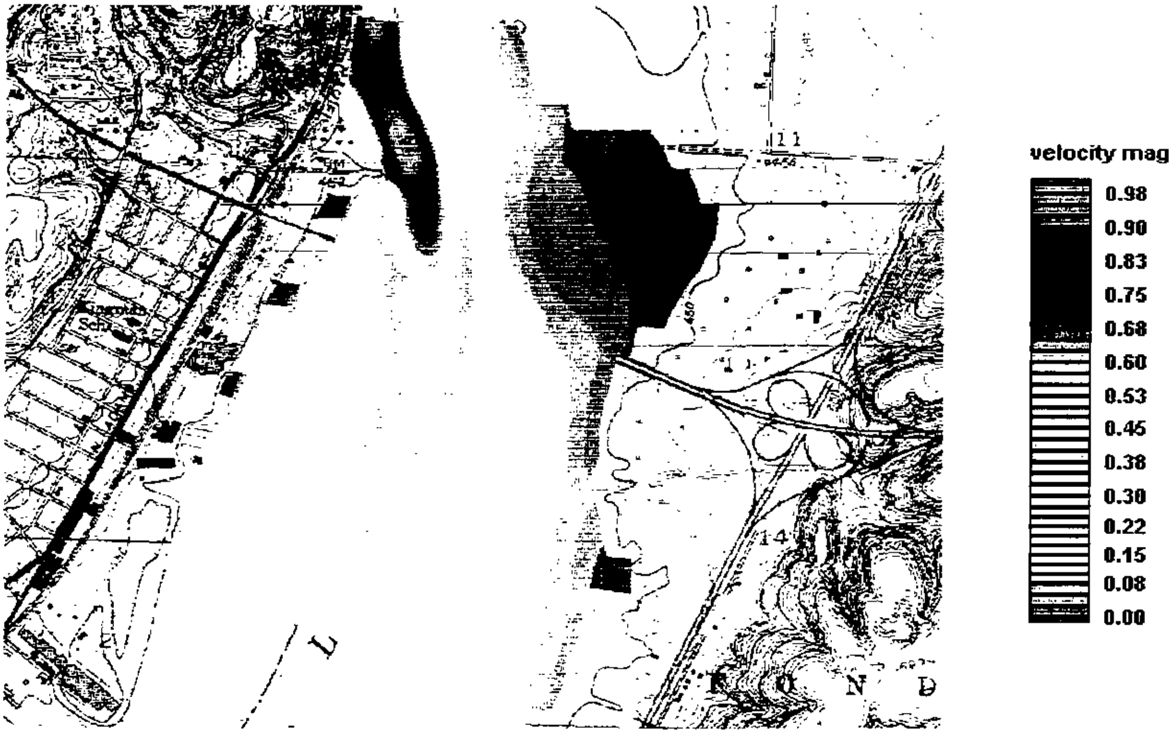

Figure 2. Velocity distributions for the ambient flow condition.

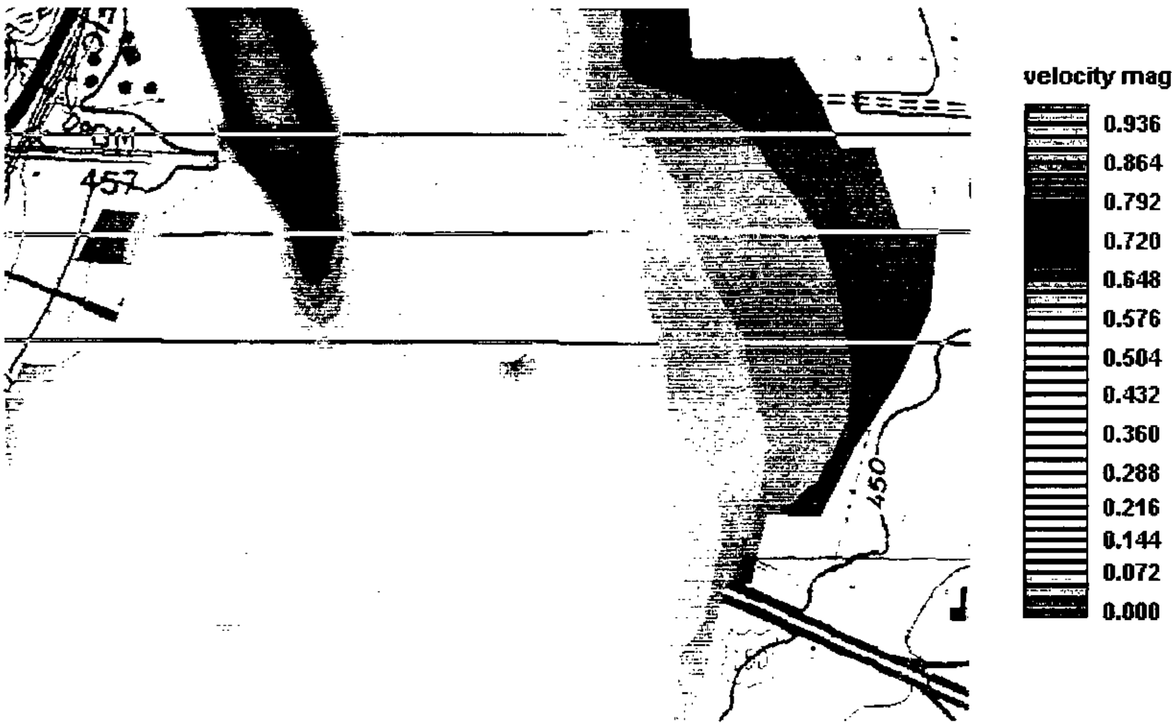

Figure 3. Velocity distributions for Option 1.

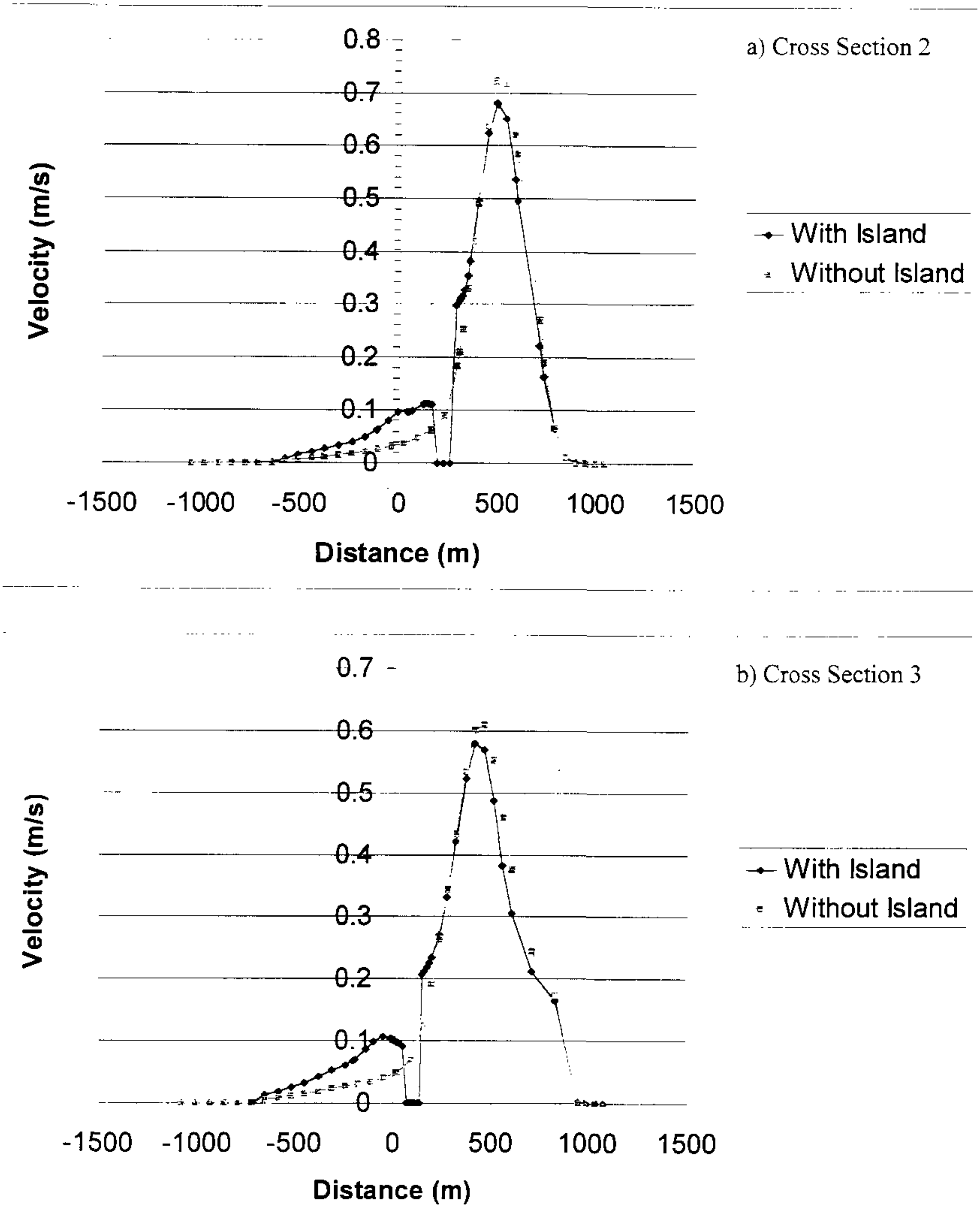

Figure 4. Lateral velocity distribution at cross sections 2 and 3 for Option 1.

Figure 5. Spatial velocity distributions for Option 3 for a flow of 1,275 cms.

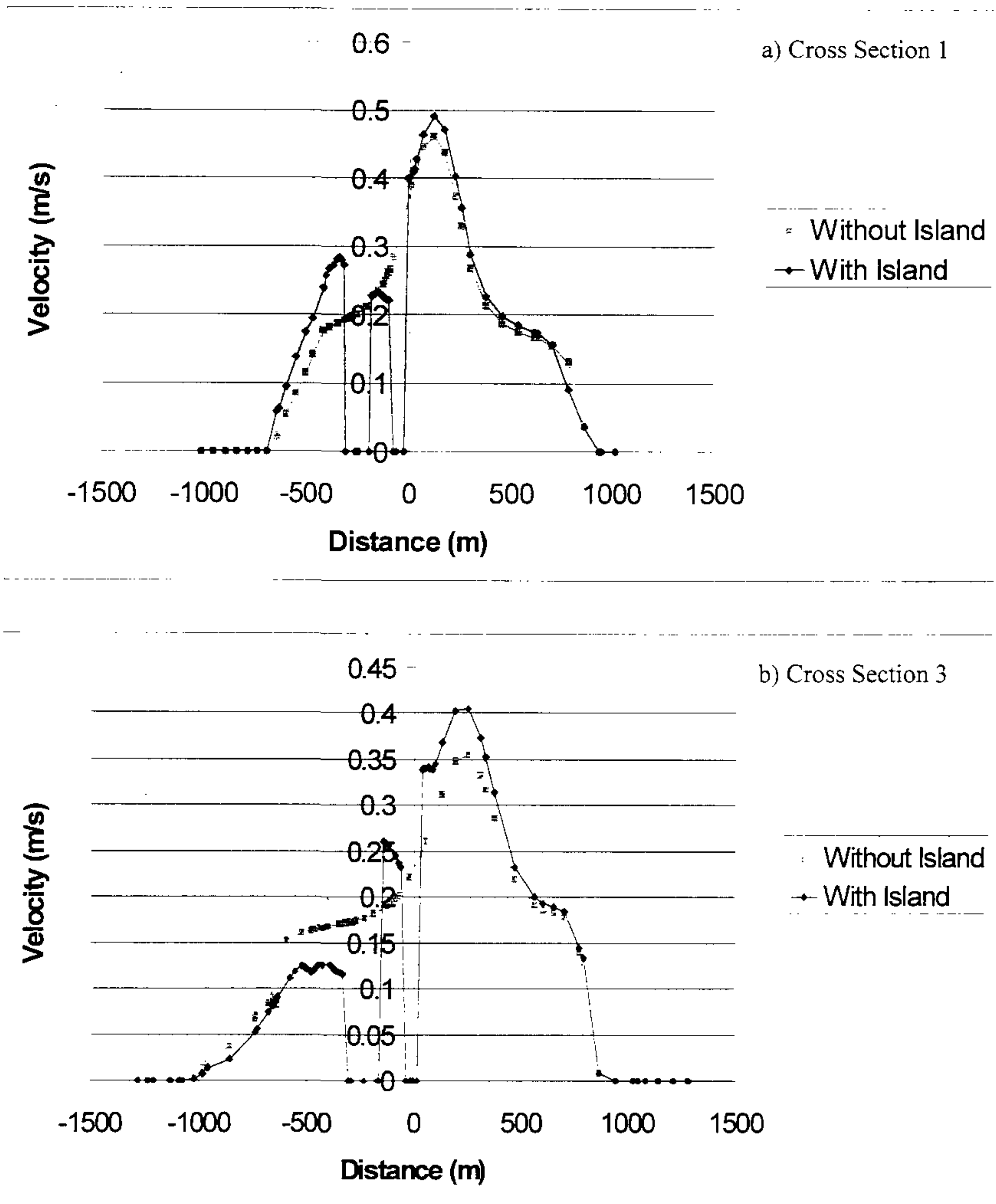

Figure 6. Lateral depth integrated velocities at two cross sections for Option 3.

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ILLINOIS BUFFER PARTNERSHIP

Tom Miller

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The mission of the Illinois Buffer Partnership is to promote and showcase, through a private/public partnership, the voluntary efforts of farmers and landowners in the planting, maintenance, and enhancement of Riparian Management Systems (RiMS) in watersheds throughout Illinois. The program was initiated by the Illinois Council on Best Management Practices (C-BMP) and Trees Forever in 2000.

Twenty demonstrations sites are selected each year over the next four years to demonstrate to landowners how living filters consisting of trees, grasses, and shrubs improve water quality, reduce soil erosion, increase wildlife habitat, and improve air quality. Field days are held on sites to illustrate the importance of buffers and the partnership efforts by local, state, and federal agencies as well as private conservation organizations.

TYPES OF LANDOWNER DEMONSTRATION PROJECTS

- Stream side buffer plantings of trees, shrubs and grasses
- Streambank stabilization demonstrations
- Stream channel enhancements
- Constructed wetlands
- Plantings around livestock facilities

PROGRAM STRATEGIES

- Bring together private sector agricultural organizations, financial sponsors, government agencies, researchers, conservation organizations, farmers and landowners involved with conservation buffers working toward common goals.
- Strengthen and increase awareness among farmers and landowners about the need for stewardship projects, including buffers, riparian management systems and streambank restoration as a part of overall best management practices.
- Enhance the resources and the statewide network of technical assistance partners, cooperating farmers and landowners.
- Recognize farmers, landowners and land managers currently protecting streams and rivers.
- Integrate watershed level approaches into the program.
- Augment training for natural resource professionals including riparian management designs and buffer practices.

- Identify and integrate research opportunities where appropriate to validate the effectiveness of conservation buffers.
- Provide outreach to and involve urban and community stakeholder

The *Illinois Buffer Partnership* was initiated in the fall of 2000 and will run through 2005. A site nomination process is being used to select at least 20 landowners to participate in the program each year. Site nomination forms are sent out to each NRCS field office, Soil and Water Conservation District, county Farm Bureau office, RC&D office, District foresters, Private contractors, County Extension Service offices and others. Landowners can work with any of these agencies or the Trees Forever Headquarters to fill out the nomination forms.

Once selected, Trees Forever field coordinators work directly with the landowner and interested partners to determine the landowner's objective, who can help the landowner achieve those objectives, and what design will best work for the site. The field coordinator also helps the landowner identify available cost-share programs. Once these cost-shares are located, the *Illinois Buffer Partnership* offers the landowner additional cost share of up to $2,000 for participating in the Initiative.

Working with a number of agriculture and conservation organizations at local state and national levels, this partnership provides a successful network to increasing public awareness of buffers in urban and rural areas. Each organization involves members/producers across the state, providing a network of local conservation leaders and many statewide communication and educational opportunities. Field days involve guest speakers from different agencies/organizations, a presentation from the landowner about their practice, and involving FFA, 4-H, and Scouts in the planting of the trees, grasses, and shrubs. Key sponsoring partners for this program include: Archer Daniels Midland Company, Illinois Council on Best Management Practices, Illinois Department of Agriculture, Illinois Environmental Protection Agency, Syngenta Crop Protection, Inc., and the USDA Natural Resources Conservation Service

Trees Forever coordinates each field day to actively involve landowners, youth and neighbors in hands-on learning. Through active involvement in the field day, everyone takes home more than just another brochure. They receive an experience they will remember for a long, long time.

The transfer of the riparian buffer technology occurs through one-on-one contact, training workshops and field days. The *Illinois Buffer Partnership* recognizes that technology transfer occurs on several planes including: research scientists to technical specialists, to farmers, to neighboring farmers, to local natural resource professionals, to students, to concerned citizens - and back again.

Trees Forever is a 501(c)3 nonprofit organization. A 23-member Board of Directors and staff of 21 conduct the day-to-day work of the organization. Trees Forever has succeeded with a number of programs through collaborative frameworks that include and actively involve a diverse array of organizations and individuals working together for a common goal. More information regarding our organization can be viewed at www.treesforever.org.

800-369-1269 ♦ 319-373-0650
www.treesforever.org

Illinois Council on Best Management Practices

USDA/NRCS PROGRAMS: WORKING IN ILLINOIS WATERSHEDS

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NRCS offers a wide variety of conservation programs that can help with planing in addition to the on-going technical assistance they have always provided. Some of these programs are as follows:

EQIP - Environmental Quality Incentives Program
WHIP - Wildlife Habitat Incentives Program
WRP - Wetland Reserve Program
CRP - Conservation Reserve Program

As local work groups complete their planning, these programs are available to help them implement their plans. The EQIP Program fits into watershed planning especially well because 90% of the EQIP financial assistance is spent in areas that have watershed plans in place. The remaining 10% of EQIP is spent throughout the State of Illinois on livestock related concerns.

EQIP is a voluntary program designed to provide technical, financial and educational assistance to landowners with serious threats to the natural resources. EQIP provides up to 75% cost share potentially for any practice in the NRCS Technical Guide. Landowners compete against each other for approval and those with contracts environmental benefits for the cost of the project, rank the best.

NRCS also offers a program for improving wildlife habitat. The program is titled the Wildlife Habitat Incentives Program. The voluntary program provides financial assistance to landowners to improve wildlife habitat on private land. The program provides up to 75% cost share to improve fish and wildlife habitat and to restore prairies, wetlands and woodlands. Landowners within an area with a local work group and a resource plan can receive extra points to help them compete for the WHIP cost share money.

The Wetland Reserve Program (WRP) is another voluntary program offered by NRCS to landowners wanting to restore and protect wetlands on private land. WRP offers a financial incentive for enhancing wetlands in exchange for retiring marginal agriculture land. Interested landowners compete for WRP money on a statewide basis and they are put on a funding/waiting list based on their rank. WRP offers several options for restoring wetlands to landowners from cost sharing on restoration only to cost share for restoration plus an incentive to retire the land permanently.

One other program available to landowners that offers important conservation practices is the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The Farm Services Agency administers these programs; however, NRCS provides the technical assistance to the landowners that enroll in the program to help them put practices on the land. The CRP offers an opportunity for environmentally sensitive land to be enrolled in return for 50% cost share money to establish the practice as well as provide landowners an annual CRP payment for up to 15 years. CRP also offers an opportunity to enroll HEL land periodically. The program also provides some special incentives when producers are located in the Illinois River Basin.

Local work groups that have gotten together and identified problems and alternative solutions for their watersheds need to know these programs are available to address their resource concerns.

FUNDING TOOLS

Steve Frank

Illinois Department of Agriculture, Bureau of Land and Water Resources, State Fairgrounds
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The Illinois Department of Agriculture's Bureau of Land and Water Resources administers three C-2000 programs that are helping landowners control erosion, improve water quality, and maximize agricultural economic returns in the Illinois River Basin.

Conservation Practices Program

The Conservation Practices Program, administered locally through Illinois' 98 Soil and Water Conservation Districts, provides cost-share assistance to eligible landowners with sheet and rill erosion or ephemeral/gully erosion on cropland, for constructing conservation practices that conserve soil and protect other natural resources.

Streambank Stabilization and Restoration Program

The Streambank Stabilization and Restoration Program, carried out in partnership with Illinois' Soil and Water Conservation Districts and the USDA Natural Resources Conservation Service, provides cost-share funding assistance to Illinois landowners to install effective, low-cost vegetative and other bio-engineered practices to stabilize or restore severely eroding streambanks.

Sustainable Agriculture Program

Sustainable Agriculture Program grant funds are awarded on a competitive basis to SWCDs, universities, and sustainable agriculture organizations for on-farm research, education programs, and studies of integrated farming systems that will positively impact Illinois agriculture and the environment.

Illinois Department of Agriculture
Bureau of Land and Water Resources

Water Quality, Erosion Control, Nutrient Management and Natural Resource Protection Program Activities in the Illinois River Basin

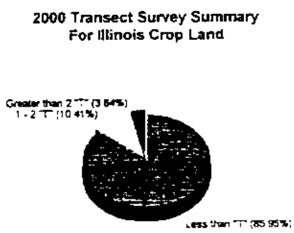
Conservation Practices Program
CPP

ILLINOIS' SOIL CONSERVATION GOAL

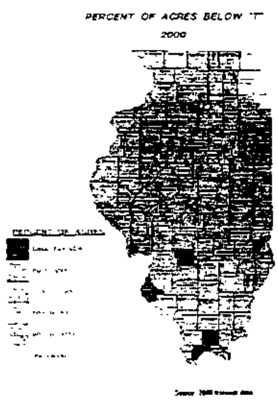
In 1982, the State of Illinois and the 98 county Soil and Water Conservation Districts (SWCDs) initiated the Illinois Erosion and Sediment Control Program, with the goal of reducing soil loss on agricultural land to the "T" or tolerable soil loss level.

Soil conservation reduces sedimentation, protects water quality, reduces flooding and helps maintain soil productivity and farmer profitability.

Currently, nearly 20 million acres (86%) of the state's cropland acres are at or below tolerable soil loss levels.



Although very good progress has been made, approximately 3.2 million cropland acres (14%) are still exceeding tolerable soil loss levels.



In addition, 18% of cropland fields are experiencing either ephemeral or gully erosion. These agricultural lands are the target of the Conservation Practices Program.

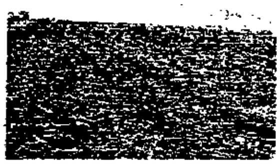
CPP Program Eligible Practices

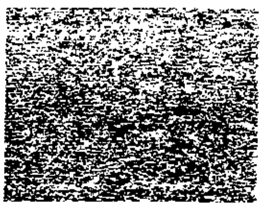
- Contour Farming

- Contour Stripcropping or Buffer Strips

CPP Program Eligible Practices

- No Till and Strip Till





- Cover and Green Manure Crops

CPP Program Eligible Practices

- Filter Strips

- Field Border Strips

CPP Program Eligible Practices

- Pasture and Hayland Planting

- Critical Area Planting

CPP Program Eligible Practices

- Grassed Waterway

- Diversion

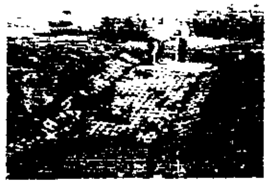
CPP Program Eligible Practices

- Terraces

- Water and Sediment Control Basin

CPP Program Eligible Practices

- Grade Stabilization Structures



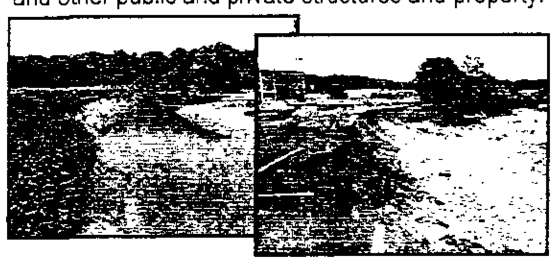
Streambank Stabilization and Restoration Program SSRP

Streambank Stabilization and Restoration Program Goals

- Support a comprehensive and long-term approach to conserving, protecting and managing Illinois' natural resources.
- Emphasize the use of cost-effective streambank stabilization techniques using vegetative materials and other bio-engineering techniques.

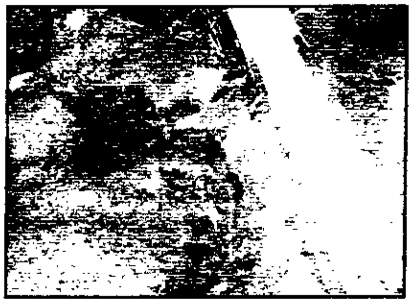
Streambank erosion has become a serious threat to the land, water, plant and animal resources along many streams in Illinois.

Streambank erosion, when left unchecked, can be responsible for the loss or damage to valuable farmland, wildlife habitat, buildings, roads, bridges and other public and private structures and property.



Streambank erosion is also a major source of sediments deposited in Illinois lakes, streams and backwater areas, and may contribute to as much as 30-50% of the downstream sediment load.

Sediment reduces stream channel capacity, which may increase flooding and streambank erosion, or reduce the depth and holding capacity of lakes and reservoirs.



SSRP Eligible Control Methods

• Willow Post Method

• Bendway Weir Method

SSRP Eligible Control Methods

• Rock Vanes (Barbs)

• Pool and Riffle Method

SSRP Eligible Control Methods

• Stone Toe Protection

• Lunkers

Save Our Illinois Soils Project
SOILS

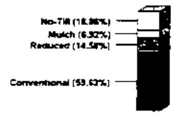
SOILS

CONSERVATION TILLAGE PROJECT

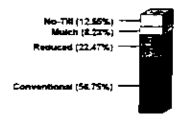
The Save Our Illinois Soils project is a field level research program designed to compare:

Conservation tillage, No-till, and Strip tillage.

Transect Survey data from 1994 and 1998 showed a marked decrease in the acres of No-Till in corn.

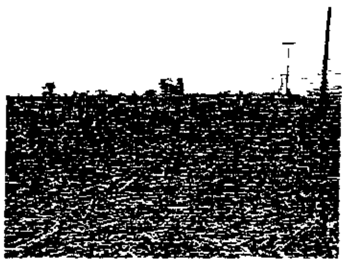


SOILS was conceived as a means to demonstrate a viable alternative to No-Till.



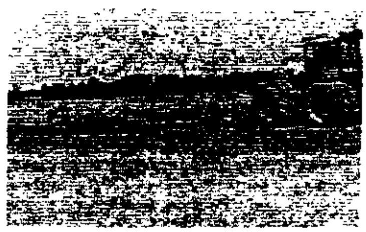
The SOILS Program is a demonstration approach designed to provide field level comparisons of:

- No-Till,



The SOILS Program is a demonstration approach designed to provide field level comparisons of:

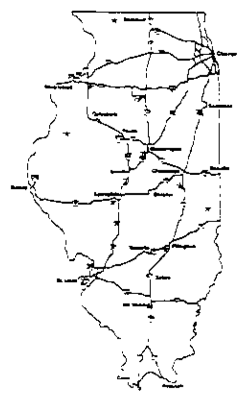
- Conservation Tillage,



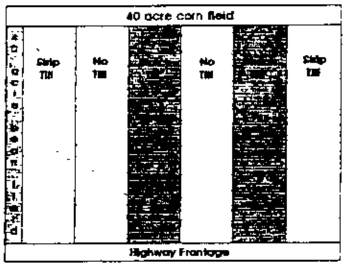
The SOILS Program is a demonstration approach designed to provide field level comparisons of:

- and Strip Tillage.

Eleven farmers and one Junior College have agreed to participate in the program for a minimum of three years. It is hoped that some of the trials will continue beyond the three year period.



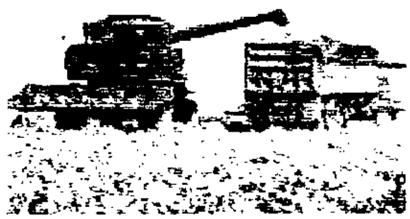
Each of the twelve sites consists of two forty acre fields, side by side, in a corn – bean rotation. The corn field is divided into six plots with two replications for each tillage practice.



Strip Till is begun in the Fall using a toolbar that disturbs a six inch wide area of soil and creates a small 3 – 4 inch mound.

The mound of bare soil warms up and dries out in the Spring more quickly than the surrounding residue covered soil, allowing for earlier planting.

After the first year's harvest of the different plots at each of the twelve sites, Strip Till proved its worth. While yields at most sites were comparable to No-till and Mulch till, Strip till required less labor and machinery cost, making it net profit competitive.



Researchers are utilizing the field level trials to investigate other aspects of Strip Tillage.

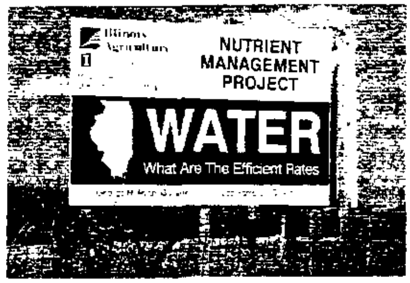
- Soybean Cyst Nematodes
- Nitrogen Utilization
- Carbon Sequestration
- Soil Health

The Soils Program has had an influence on Soil and Water Conservation Districts and landowners state wide. Many SWCDs are offering cost share incentives through CCP for farmers who want to try Strip Till.

What Are The Efficient Rates? Project

WATER

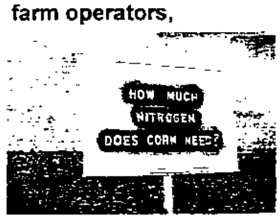
The What Are The Efficient Rates project is a field level research program designed to compare four different Nitrogen application rates.



Excessive Nitrogen is thought to be the primary contributor to the hypoxic zone in the Gulf of Mexico.

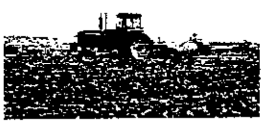
The WATER project was conceived as a means of gathering field level data on the effects of reduced Nitrogen application.

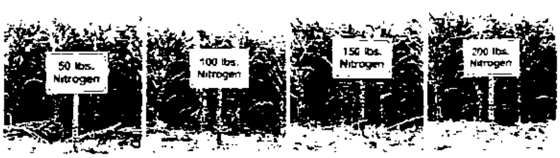
A cooperative effort between the U of I Extension, Illinois Department of Agriculture, Soil and Water Conservation Districts and eleven farm operators,



the project is designed to gather data on efficient Nitrogen application rates.

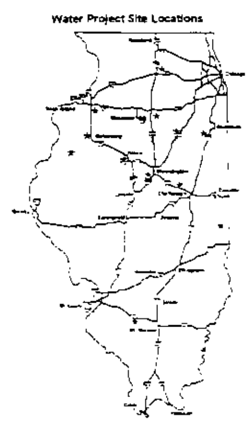
Each plot uses fall applied anhydrous at four different rates. Each plot has a small control area where no Nitrogen is applied.





WATER Project Goals

- Three year on-farm demonstration/research project.
- Sponsors: 11 farmers, SWCDs, U of I, IDA.
- Conduct field scale N rate studies in corn (replicated trials: 50, 100, 150, 200 lbs/ac).
- Assess the usefulness of preplant soil N test.
- Educational forum for the efficient and environmentally responsible use of N.



The WATER project is in its first year and data is currently being analyzed. The Department will schedule a series of public meetings in January to present the first year's findings. Meeting dates and locations are:

Further Support and Information

For more detailed information and assistance on these programs , please contact the Bureau of Land and Water Resources in Springfield or your county Soil and Water Conservation District.

Illinois Department of Agriculture

George H. Ryan, Governor • Joe Hampton, Director

ILLINOIS CONSERVATION RESERVE ENHANCEMENT PROGRAM (CREP)

Richard J. Mollahan

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The Conservation Reserve Enhancement Program (CREP) is a State-federal conservation partnership program targeted to address specific State and nationally significant water quality, soil erosion and wildlife habitat issues related to agricultural use. The program uses financial incentives to encourage farmers and ranchers to voluntarily enroll in contracts of 10 to 15 years in duration to remove lands from agricultural production. As these agricultural lands have been planted in trees, grass and other types of vegetation, the result has been reduced soil erosion, improved air and water quality and establishment of millions of acres of wildlife habitat. The Illinois State Enhancement Program is the result of an agreement between the United States Department of Agriculture (USDA) and the State of Illinois. Both entities will cooperate in implementing the Conservation Reserve Enhancement Program (CREP) to protect water quality in the Illinois River Basin.

There are four important ways in which CREP differs from CRP. First, CREP is targeted to specific geographic areas. It is designed to focus conservation practices on addressing specific environmental concerns of a high priority. Second, CREP is a joint undertaking among States, the Federal government and other stakeholders who have an interest in addressing particular environmental issues. Third, it is results-oriented, and requires states to establish measurable objectives and conduct annual monitoring to measure progress toward implementation of those objectives. Fourth, it is flexible, within existing legal constraints, and can be adapted to meet local conditions on the ground.

Illinois Conservation Reserve Enhancement Program (CREP)

Goals of Illinois CREP

- Reduce Sedimentation in Illinois River 20%
- Reduce Nutrients in the Illinois River by 10%
- Increase Populations of Waterfowl, Shorebirds, and Nongame Grassland Birds by 15%
- Increase Native Fish and Mussel Stocks in the Lower Reaches of River by 10%

Illinois CREP Components

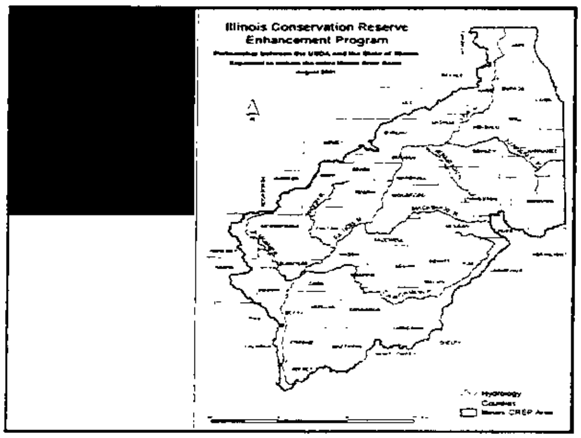
- Targets Riparian Areas defined as the 100 Year Floodplain
- Targets HEL land with an EI ≥ 12 and is immediately adjacent to the floodplain
- Targets Wetland Restorations throughout the eligible area
- Focuses on Native Vegetation

Eligible CREP Land

- CREP eligible lands must be located in the Illinois River Watershed.
- CREP eligible land does not have a time of ownership constraint.
- CREP eligible land must have been planted in commodity crops 2 of the last 5 years.

CREP Eligible Area

- The Governor has signed the Amendment increasing the 100,000-acre cap by 32,000 acres and opening the eligible CREP area to include the entire Illinois River Basin
- Ultimately, the State wants to expand to 232,000 acres for the entire River Basin



Federal Incentives for CREP

- 15 years of annual CRP payments
  - 30% bonus for riparian land and wetland enrollments
  - 20% bonus for erodible land (HEL $\geq$ 12)
- 50% of cost-share from USDA
- Sign-up incentive payment for riparian buffers and filter strips
- Practice incentive payment from USDA for riparian buffers, filter strips, and shallow water areas for wildlife
- Annual Maintenance Rate

State Incentives for CREP

- Lump Sum Payment after Permanent Easement or Contract Extension is recorded against the deed
- Permanent Easement Enrollments Receive Reimbursement for 50% of the Cost to Establish Approved Practices
- Contract Extensions in Riparian Areas and for Wetland Restorations Receive Reimbursement for 40% of Cost Share

Additional Acreage

- Non-cropped acreage or acreage in another CRP sign-up can be offered for a permanent easement at the same time cropped ground in Federal side of CREP is offered for a permanent easement

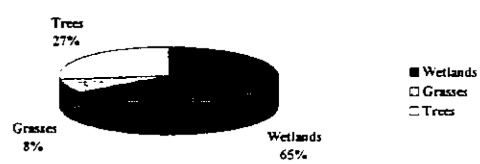
CREP ENROLLMENT

CREP RESTORATIONS BY TYPE

FEDERAL ACRES

CREP RESTORATIONS BY TYPE

STATE ACRES



Other benefits

- Retains ownership
- Could reduce property taxes
- Can do selective timber harvest
- No agricultural production costs
- Use for hunting, recreation
- Improved fish & wildlife habitat
- Stream bank protection- decreased erosion
- Improved water quality

Agencies Implementing CREP

- Farm Services Agency
- Natural Resources Conservation Service
- Illinois Department of Natural Resources
- Soil and Water Conservation Districts
- Illinois Department of Agriculture
- Illinois Environmental Protection Agency

CREP Advisory Committee

- Subcommittee of the State Technical Committee
- Provides guidance to implementing agencies
- Helps review and develop procedures
- Develop program outreach and marketing
- Reviews monitoring results
- Reviews annual report

CREP Advisory Committee Members

- Implementing Agencies
- U.S. Fish and Wildlife Service
- Illinois Farm Bureau
- University of Illinois – Extension
- Association of Illinois SWCDs
- The Nature Conservancy
- Pheasants Forever
- Ducks Unlimited
- Illinois SWCD Employees Association

ILLINOIS CREP is extremely successful

- Leads the CREP Programs in the Nation
- Most number of total acres enrolled
- Most number of permanent easements
- Greatest number of wetland restorations
- Tremendous local support

Why is Illinois CREP Successful?

- Easements are held at the local level by Soil and Water Conservation Districts
- Number of Options Available
- Tremendous local support because money flows to local level for implementation
- Commodity Prices
- High soil rental rates and relatively low land prices

What's Next?

- Additional Assistance to SWCDs for Marketing
- Development of promotional materials
- Targeting marketing efforts to specific areas
- Developing complimentary programs - Illinois Rivers 2020, C2000

ECOLOGICAL RESTORATION IN MULTIPLE-OWNERSHIP WATERSHEDS: THE CASE OF THE CACHE RIVER IN ILLINOIS – SOCIAL AND ECONOMIC ISSUES

Jane Adams, Jeffrey Beaulieu, David Bennett, Leslie Duram, Steven Kraft, Christopher Lant, Tim Loftus, John Nicklow, and J.B. Ruhl (Senior Authorship Is Not Assigned)

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INTRODUCTION

Driven by ongoing problems of non-point source pollution and decline of aquatic ecosystems, the 1990's witnessed a rapid development of watershed-scale planning initiatives. Variously called "place-based," "community-led," "locally-led," "integrated watershed management," or other similar terms, these initiatives now number over 1000 and are growing rapidly throughout the nation. Nevertheless, these initiatives face numerous obstacles, more social than hydrologic, in achieving improved water quality and aquatic ecosystems, or other natural resource goals that planning groups or the Environmental Protection Agency's (EPA) Total Maximum Daily Load (TMDL) program may identify (Wescoat, 1997). In particular, water resources and land-use planning in multiple-owner, largely private watersheds has been fragmented and subject to a variety of forces originating both within and outside the watershed (see for example Viessman, 1990; Rogers, 1993). Watersheds do not normally constitute formal, organized political jurisdictions; hence resource planning groups face the challenge of acquiring political legitimacy and legal authority. Deyle (1995) observes that the fragmented decision making that is typical of watershed management constitutes an "organized anarchy" where the involvement of stakeholders is fluid and goals and the means of achieving them are poorly specified, thus too often producing the "pet" solutions of agents who are only temporarily cooperating to address a particular water resources problem. Our work focuses on the watershed planning process.

The purpose of this multi-disciplinary research is to improve our understanding of how the socioeconomic driving forces external and internal to multiple-ownership watersheds influence and restrict the decision making processes of land-use managers and local watershed management institutions. Further, we are building a spatial decision support system (SDSS) to trace the ramifications of these decisions through the watershed ecosystem. This modeling tool will be able to target those positions within the watershed where land-use change is most likely to occur, as well as those where it would have the greatest positive or negative effect on water quality and aquatic ecosystems. The product will be a generalizable framework for watershed management in private-land watersheds. The research focuses on the Cache River of southernmost Illinois as a case study.

Study Area

The Cache River watershed encompasses 1,944 km^2 of southern Illinois near the confluence of the Mississippi and Ohio Rivers. The watershed has diverse ecological resources and unique natural communities, including bald cypress (<u>Taxodium</u> <u>distichum</u> L. Rich.) – water tupelo (<u>Nyssa</u> <u>aquatica</u> L.) swamps at the northern edge of their range and other forested wetlands. At least 100 state threatened or endangered plant and animal species are known within the watershed (USFWS 1990). The Cache River region also supports unique ecological communities and 10 globally rare or endangered species. For these reasons, the Cache River Bioreserve was designated by The Nature Conservancy (TNC) and parts of the Cache River watershed were incorporated in the Cypress Creek National Wildlife Refuge.

The ecological integrity of the Cache River ecosystem is threatened by: (1) loss and fragmentation of natural habitats as a result of agricultural activities and timber harvest; (2) dramatically altered hydrologic systems caused by drainage, channelization, and other modifications; (3) sediment deposition in wetlands causing deterioration of water quality and alteration of habitat conditions in Buttonland Swamp; and (4) land use and economic activities that are incompatible with long-term maintenance of ecological functions. Moreover, the predominantly rural 5-county area has an impoverished economy with minimal infrastructure and weak linkages to the surrounding region which make it sensitive to the cost and benefits of habitat restoration and protection in the Cache River region.

In addition to its scientific importance, the findings and conclusions of this research can be used by watershed planning groups in the watershed, (e.g., the Cache River Watershed Resource Planning Committee (RPC), Local Partnership Councils through C2000) as a basis for developing integrated resource management plans. The RPC was an EPA-funded initiative, sponsored by TNC and the Natural Resources Conservation Service (NRCS), involving twenty-five citizens who developed a long range plan for the use of land and water resources in the watershed (Illinois Dept. of Conservation, 1992). In addition to the citizen-based planning committee, there was a 20-member technical committee comprised of representatives from public and private agencies (e.g., Illinois EPA, US Fish and Wildlife Service (FWS), US Forest Service, NRCS, Illinois Dept. of Natural Resources (IDNR), US Army Corps of Engineers, and Southern Illinois University Carbondale that functioned as a "research arm" of the RPC.

To be successful, such a planning process requires information that merges ecological constraints with economic data in a framework relevant for farm level and regional analysis and decision making. Over a period of almost 24 months, the RPC identified a number of paramount natural resource concerns for the watershed and the technical committee developed a range of alternatives for dealing with each concern (RPC, 1995). These alternatives were not without controversy, reflecting the diversity of the RPC membership. For watershed planning to be successful, strategies must be developed that permit the recommending of a set of alternatives acceptable to land owners/managers and residents of the watershed, while providing the necessary ecological benefits to maintain the viability of the endangered ecosystem. Thus the Cache River watershed represents a unique opportunity to study the social dynamics of watershed management in a multiple-owner watershed that is undergoing substantial ecological restoration.

Methodologies, Results, and Discussion–A Work in Progress

Through a coordinated process, the research team working as individual members, as small working groups, and as a group of the whole has been exploring a number of areas related to watershed planning. For this paper, we will briefly summarize the ongoing work related to the legal framework informing watershed planning in Illinois, the factors related to the legitimacy of the planning process and the resulting plan, and the development of tools for integrated watershed planning integrating socio-economic and ecological factors. Since the research is still very much ongoing, the material presented here should be seen as preliminary and indicative of what we are learning and might well be relevant to watershed planning in the Illinois River basin.

As part of the research, a thorough review was made of federal and state statutes "informing" or structuring watershed planning. We have a plethora of federal and Illinois laws that impact agriculture and by extension planning activity within watersheds. We have identified 25 different laws that potentially have a role, (e.g., water and air quality, solid and hazardous waste, pesticide and fertilizer application, soil conservation and farm bill legislation, etc). The multi-jurisdictional nature of these laws and their attendant regulations and rules result in a fractured system of media specific laws on one hand, (e.g., water, air, and soil/land) and action specific laws, (e.g. pesticide and fertilizer application) on the other, producing overlap and complexity. In addition, there are no laws specific to the processes of watershed planning and the implementation of resulting plans.

The fractured nature of the regulatory environment may well explain why the local population apparently does not have a grasp on the laws that affect them. Secondly, this inconsistent and complex legal environment will make the sort of reform necessary to facilitate watershed planning more difficult. Thirdly, the present system leaves us without a holistic law governing watershed management and informing the planning process. We hypothesize that this lack of a unified watershed law compromises legitimacy of the planning process, the resulting plans, and the results achieved on the landscape.

As part of the research, the research team identified 30 individuals who were significant players in the recently completed watershed planning process in the Cache River watershed. We conducted open-ended interviews with 27 of these key people. They were drawn from the three major groups involved in the planning process: 14 personnel from the Technical Committee (TC) and associated governmental agencies, 11 members of the RPC who were landowners in the watershed, and two local activists who were not members of the RPC but who had been involved in watershed issues for many years.

The interview questions covered aspects of their personal lives, their recollections and assessments of the functioning of the RPC, their knowledge of the roles of various groups and regulations relevant to the Cache watershed, their recommendations to other watershed planning groups, and their judgment of the major problems currently facing the Cache River region. The 1-2 hour interviews were transcribed and coded. The coding was used both as a discovery mechanism and as an analytic tool. We used a set of pre-defined categories to code for personal data and data concerning group processes. We used a more open-ended set of analytic categories to permit interpretation of the specific data collected in the interviews. These categories included legitimacy, judgments concerning specific aspects of the data (e.g., group processes, roles of different personnel and agencies, land acquisition by agencies), recommendations, articulation of interests, social resource flows, gender and other implicit divisions or distinctions in perceptions, perceptions of salience of insider/outsider distinctions, and other categories that were discovered through the coding process. From this we derived a streamlined set of seven categories that were used to guide the development of focus group questions.

Based on the interviews and literature review, we have developed a set of preliminary findings that will help to guide the remainder of the research. Our primary questions involved how (and if) watershed planning becomes legitimate and thereby capable of shaping the actions of individuals as they interact with each other and with the landscape of the watershed. This involved discovering key actors within the watershed and determining how these actors develop their authority and legitimacy. The preliminary findings, based on initial analysis of the interviews, are:

(1) Outcome of the process: The Watershed Plan coming from the RPC provides local agency personnel with legitimacy in their requests for support from higher levels of their agencies for programs they wish to implement. Virtually all agency (NRCS, FWS, IDNR) personnel noted that the "grassroots" planning process and resultant plan provided them with a powerful basis for arguing for support for programs they initiated locally.

(2) Perceptions of the planning process: The internal dynamics of the planning process were perceived very differently by members of the RPC (all local "stakeholders") and members of the TC (agency personnel and other technical experts). The initial groundrules for the planning process, instituted by the NRCS, established distinct roles for the RPC and the TC: members of the Technical Committee were to provide technical information only and were not to participate in the actual discussions and decision-making processes. TC members were keenly aware of the proscription on their active participation, while the members of the RPC had no practical knowledge of this proscription and perceived the TC members as fully participant. Nonetheless, most members of the RPC felt they had substantially contributed to the final plan, and did not feel overwhelmed by members of the TC.

(3) Resource mobilization: The social resources on which different groups and individuals drew differed considerably. The various agencies, transparently, derived their capacity to act from the financial and organizational capacity of their governmental and nongovernmental organizations (NGOs). There appeared to be a significant difference in the resources mobilized by farmers and by environmentalists as they pursued their often conflicting aims regarding use of watershed lands. They had recourse to different agencies (farmers: Illinois and US Departments of Agriculture, especially the NRCS; environmentalists: EPA, FWS, IDNR); different NGOs (farmers: Farm Bureau; environmentalists: TNC, Sierra Club, Audubon Society); and different branches of government (farmers: local drainage districts, perhaps other local governing bodies, including Soil and Water Conservation Districts; environmentalists, especially through the agency of TNC, federal and state executive personnel.) Both groups sought support from elected officials, and lobbied them directly and through their representative organizations. The Corps of Engineers seemed to operate in an arena in which local actors could only indirectly influence their decision-making.

(4) Local power structures: The environmental or resource use issues that created political divisions within the Cache River watershed exposed significant aspects of the structuring of local power. Despite the watershed's relatively small size, it embraces five counties and

three discrete orderings of power: In the uplands, political, economic, and social power appear quite diffuse, based on relatively small landholdings and relatively diversified economies. In the eastern regions, opened to cultivation in the twentieth century by the building of the Post Creek Cut Off, relatively large-scale farmers operate in a relatively decentralized political system. In the southwestern counties, a history of cotton production and association with the Mississippi River appears to have promoted a political and economic system dominated by a few powerful families. These regional differences mitigate against coherent regional planning, and create the conditions in which farmers and other actors make highly localized judgments about the costs and benefits of specific policies for watershed management. That is, watersheds do not necessarily define socially meaningful regions.

(5) The planning process, which restricted its membership to "stakeholders" defined as property-owners within the watershed, may have defined its constituency too narrowly. The degree to which the plan attains broader legitimacy, and has the ability to influence local governing policies, may have been limited by the nature of the representatives. This tentative finding was suggested by the interviews with key informants and has been supported by findings from the focus groups.

Building on information gained through the key informant interviews, focus groups were organized to investigate local knowledge and perceptions within the Cache River region. Focus groups were held with three groups: elected officials, rural and small town residents, and farmers (not on the RPC). Our approach followed the suggested focus group format (see The Focus Group Kit, Morgan and Krueger, 1998, Sage Publications). Groups consisted of 3 to 11 people with similar backgrounds (identified by residence or occupation as noted). For each focus group, it was necessary to identify participants through specific methods. Public officials were identified through public documents. Rural and small town residents were identified through a random sample of telephone numbers, listed in the telephone book by identified towns within the watershed. Farmers were identified by NRCS District Conservationists, and represented the counties in the watershed.

Once these samples were identified, potential participants were contacted by telephone and asked to attend a specific focus group session. Participants received $20 for taking part in a session. Focus group meetings lasted 2 hours, during which participants were asked a set of 12 questions that were carefully worded to illicit discussion on natural resource topics. During the focus group sessions, key points were written on a large flip chart; this allowed participants to refer back to and elaborate on important topics. The sessions were also tape-recorded and transcribed by a professional stenographer. The full text provides researchers with rich contextual information from each group, while the flip chart provides a concise overview of each focus groups' important discussion points.

The purpose of these social focus groups was to investigate peoples' opinions on natural resource and watershed issues in the Cache River watershed. Thus we sought to learn participants' views on what issues are important, how they gain information, and what they know about the existing planning process. Further, we investigated local awareness of watershed concepts and issues of trust and legitimacy. The questions asked of each groups are listed below:

1. *opening:* Please tell us your name, where you live, and what you like best about living and working in southern Illinois.

2a. *introductory:* I'd like you to take a moment and make a list of the environmental or natural resource issues in the Cache River area that are important to you. (Make a list on a flip-chart.)

> 2b. *follow-up:* Where do you get information about any of these issues?
>
> 2c. *follow-up:* When making decisions about how to manage your land or whether to support a particular proposal, what information would you use and trust?
>
> 2d. *follow-up:* When referring to these issues, I used both the term "environmental" and "natural resource." Do you see a difference between the two?

3. *transition:* Now, let's turn our attention to the term "watershed." How would you describe a "watershed"?

4. *key:* What activities dealing with environmental or natural resources are you aware of in the Cache River watershed and who is involved?

5a. *key:* When developing an action plan for dealing with the issues listed here (point to our flip chart) for the Cache River watershed, what would it take for you to feel comfortable with that plan?

5b. *follow-up:* Who should participate in that planning process?

6. *key:* Does an area like a watershed require an administrative or political structure?

7a. *key:* What rules or regulations that pertain to water and land use management are you aware of?

7b. *follow-up:* Do you think these are useful regulations?

7c. *follow-up:* How do you stay informed about these legal matters?

Offer a short (2-3 minute) oral summary of the focus group session.

8. *summary:* How well does that capture what was said here?
9. *final:* Is there anything that we should have talked about but didn't?
10. *(for first group only):* This is the first in a series of groups that we are doing. Do you have any advice on how we can improve a session like this?

The following key findings were discovered through the focus group sessions. First, important similarities were found among the three groups that indicate some common general perceptions within the watershed. There was little public awareness of the two years of public meetings held by the Resource Planning Committee in 1993-94. A handful of people who did know of the meetings expressed mostly negative opinions, as they doubted whether anything had really been accomplished. But the majority of focus group participants indicated that they were not familiar with any citizen-based groups in the watershed. In addition to this void in terms of citizen involvement, many focus group participants were unaware of the various government agencies and NGOs active in the Cache watershed. Notably, the FWS, the IDNR, and TNC have been key players in Cache wetland and regional land management for more than 20 years. Some participants, particularly the farmers, knew there were government agencies active in land acquisition, but did not know which agencies and for what purpose. Another interesting similarity, and one that will have an impact on the wording of the future telephone survey, is how people perceive "environmental" versus "natural resources." Although a few people said the terms were interchangeable, most participants noted that "environment" indicates more preservationist goals, "treehuggers" and even a negative control over resources. The term "natural resources," on the other hand, is perceived as specific resources such as water, trees, coal, oil, etc. and the <u>use</u> of these resources.

Second, findings from the three focus groups indicate how different perceptions are held by the three types of Cache residents. For example the groups have very different ideas about regional environmental concerns. When asked to identify the key environmental issues in the region, public officials mentioned water contamination, pollution, and federal mandates; rural residents noted hunting, fishing, tourism, and preservation; while farmers stated that property rights, drainage, and the decline of agriculture were key issues among others.

Similarly, the groups varied in their ability to define a watershed, which indicates very different levels of understanding about their local environment. While the public officials and residents had vague notions about what a watershed is, (i.e., water supply or water flow), the farmers had a clear understanding of a watershed. The farmer focus group provided a very clear and accurate definition: the area of land that drains to a single point or stream. Perhaps this indicates that farmers have greater understanding of the interconnected nature of water quality and use throughout the region. As a follow up question, we investigated whether these local people felt there was a need to have some type of watershed-level administration. The public officials believe that yes, this could be helpful in joining together all the various groups and regulations. The residents believe that a watershed administration might be useful, but only if it was based on local input. The farmers felt that such administration was not necessary; that the region did not need "more government."

Related to watershed administration, the groups were questioned about their knowledge of current regulations in the area. Public officials noted that there were many water quality regulations; residents knew about pollution regulations and use rules (for fishing, parks, hunting, etc.); and farmers noted there is substantial regulation of wetland drainage, land clearing and agricultural chemical applications.

Finally, the groups varied in terms of their use of information sources and their perceptions of what makes resource planning acceptable. Public officials tend to rely on government agencies and job experience; residents rely on friends and park rangers; while farmers turn to Farm Bureau and agricultural agencies, such as NRCS, for their information. In terms of accepting any watershed-based plan, the three groups indicated various justifications: officials stated that such a plan must clearly describe why it is necessary; residents noted that the planning process must include public meetings; and farmers stated that planning must include farmer input and allow "zero land acquisition." This indicates that previous planning activities in the watershed, although not clearly articulated in other questions, are viewed negatively by the farmers. This includes the creation of the Cypress Creek National Wildlife Refuge and land purchases by TNC.

At the conclusion of each focus group, the participants were asked to provide additional comments. The three groups each elaborated on unique and varying points. First, the public officials noted that federal mandates often cost local people a great deal, but do not allow local input. Second, the rural and small town residents felt that southern Illinois needs more recreational opportunities, particularly camping sites; and that the government should do a better job of land management in the region. Third, the farmers believe that the public should be educated about agriculture; that people blame farmers for environmental problems and do not understand that farmers are "good environmentalists."

In conclusion, findings from these focus groups indicate that local people in the Cache watershed are unaware of the previous and on-going planning efforts in the region. People generally do not know about the agencies and groups active in the region. There is variation, however, among public officials, residents, and farmers as to their knowledge and perceptions of environmental issues, watershed concepts, need for watershed administration, knowledge of environmental regulations, sources of information used, and reasons for accepting watershed planning.

The development and refinement of an SDSS has continued as part of the project. The goal is to have an SDSS that will show the economic and environmental consequences of different policy scenarios designed to enhance environmental quality. Watershed planners would then be able to develop a number of scenarios and see their economic consequences and the implications for the watershed's landscape. Two approaches have been pursued in this effort:

(1) spatially distributed linear programming designed to find the land uses maximizing the returns to management and fixed resources while meeting environmental constraints. The resulting land uses are then used as input in programs designed to simulate nonpoint-source pollution (e.g., AGNPS).

(2) genetic algorithm (GA) based analytical tools to handle the multiple objectives involved in watershed planning.

Spatial decision support systems are designed to help decision-makers explore the bounds of geographical problems through the generation and evaluation of alternative solutions. An SDSS links several spatially explicit models together so that the economic context of farm management decisions and practices can be combined with the ecologic and hydrologic repercussions of farm management practices. That is, farmers strive to maximize their goals (e.g., profit) within the constraints of available technology and public policy (e.g., US Dept. of Agriculture (USDA) programs) that express both social and environmental objectives. Thus, land use decisions manifest across the landscape in particular patterns of land use/land cover and affect ecosystem processes and outputs. Put another way, farmer managers' decisions have consequences beyond those that are socioeconomic. Landscape structure, function, and change, fundamental characteristics that are relevant to landscape ecology (Turner 1989), are affected. An SDSS provides a means for combining economic and geomorphic/hydrologic modeling to assess both the social and ecologic impacts of land management practices.

Here we have developed SDSS tools to help in the analysis of the Cache River watershed. The first of these tools is designed to help decision-makers understand the economic impact of alternative environmental regulations designed to reduce nonpoint source pollution. At the heart of this system is a linear programming optimization model that constructs a landscape to maximize economic return from agricultural production subject to user specified environmental and economic constraints. This model operates at the farm level. The basin wide environmental implications of these constraints are evaluated using the Agricultural Nonpoint Source (AGNPS) pollution model. We constructed a link between a spatially-distributed version of a linear programming farm management model (referred to here as GEOLP) to the AGNPS pollution model via a commonly available geographic information system (GIS) software package (ArcView GIS 3.1 produced by the ESRI (1996)).

GEOLP is linked to GIS software via Avenue scripts and allows the user to model a set of farms in a watershed as an economic system comprised of independent decision-makers. An Avenue script sequentially selects individual farms from a digital map of all farms in a watershed and develops the linear programming input file for each farm using associated spatial (e.g., watershed-level digital soil maps that record productivity and erodibility by crop, tillage practice and soil type) and aspatial data relevant to specific farms and the agricultural economy (e.g., labor and machinery costs and availability constraints). Each GEOLP output file produced through this process captures the optimal tillage and cropping land cover pattern for a particular farm, the income generated from the land cover, and the estimated soil loss by soil type based on the Universal Soil Loss Equation (Wischmeier and Smith 1978). This information is generated given user-defined constraints. Aggregating across farms provides data for the entire watershed.

AGNPS is an event based, distributed parameter model developed by the USDA Agricultural Research Service in cooperation with the Minnesota Pollution Control Agency and the Natural Resource Conservation Service (Young et al., 1989, 1994). AGNPS models hydrology, erosion, and the transport of sediment and chemicals through a watershed. AGNPS is also capable of simulating sediment yield from gullies, input of water-soluble nutrients, and the impact of runoff from animal feedlots on in-stream chemical oxygen demand. In the hydrology module of the program, runoff volume and peak flow at the outlet of the watershed are calculated. The erosion module calculates total upland erosion and total channel erosion. Chemical transport is measured in terms of soluble and sediment-attached pollutants. A grid-based data structure is used to capture spatial heterogeneity. AGNPS input files are generated using the land-cover maps produced by GEOLP and other GIS datasets (e.g., digital elevation model (for topography) and soil coverage), see Figure 1.

The Big Creek (part of the IDNR Pilot Watershed Program) and Cypress Creek watersheds, tributaries of the Cache River, were used to implement the SDSS. Special tabulations of returns from the 1987 and 1992 Censuses of Agriculture for farms in the Cache River, resulted in land-use statistics required as part of the necessary economic input. In particular, farm size frequency distributions (e.g., acres operated). guided the development of farms modeled to maximize economic returns, defined as gross margin (i.e., the return to the farmer's management and the capital invested in the business). Utilizing a clustering routine available in ARC/INFO, the Big Creek landscape was allocated into 96 farming units, and the Cypress Creek landscape was allocated into 93 farms. That is, continuous blocks of land were grouped to create farms whose boundaries differ from the boundaries of actual farms. The average acreage of these farms was 245 acres (range of 56 to 716 acres). In 1992, the actual average Cache farm size was 256 acres.

Crop type, tillage practice, and timing of farm activities are among the economic decision variables considered by GEOLP. Crop types include corn, soybean, wheat, double crop soybean/wheat and alfalfa. A livestock (calf-cow) operation was also allowed. Conventional, conservation, and no-till farming practices comprise the set of alternative tillage practices. The Conservation Reserve Program (CRP), a USDA program that pays rent to farmers to set aside their arable but highly erodible land, was also considered as an "activity". In addition some of the land was forced into idle use activities to reflect the approximate 20% of non-forested idle Cache lands.

For this analysis we focused our investigation on the different levels of T required by the "T by 2000" mandate, and the incorporation of filter strips into the landscape. One benefit of using a GIS is the ability to locate spatially explicit watershed activities and characteristics. For example, in Figure 2, the left-hand side of the figure presents the spatial distribution of land cover for Big Creek assuming farmers face ten-year average commodity prices, no CRP, and no constraints on soil loss. The right-hand side presents the implications for sediment yield at various points along the Big Creek drainage network and at the mouth of Big Creek assuming the land cover on the left and a 1.5 inch rain event. The figure also indicates what happens to sediment yield assuming farmers face a soil loss constraint of "T" per acre and there is a CRP. Figure 3 shows how the land cover changes as farmers respond to the new soil loss constraint of "T" and the availability of the CRP. However, the implications of the change in land cover in terms of farm income are not evenly distributed across the watershed. Figure 4, illustrates how the impacts on farm income are unevenly distributed across the landscape as well as demonstrating how the SDSS can be used to identify areas in the watershed that might bear a significant portion of the costs associated with policies designed to achieve environmental goals.

To enhance the SDSS, a genetic algorithm (GA) (see Figure 5) has been developed and integrated with USDA's comprehensive watershed simulation model known as Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998). This single objective evaluation model is capable of evaluating the optimal land use distribution across a watershed to minimize sediment yield. Ultimately, however, land use management decisions should not only account for environmental impacts of erosion, but should also integrate the feasibility of the designed policy from the socioeconomic perspective.

With regard to an agricultural watershed with multiple landowners, a likely stakeholder concern may be the economic benefit that s/he may generate from her/his farm. A systematic method of including this individual owner's perspective into a decision support system is very crucial for successful implementation of the policy. To address this critical socioeconomic factor, a multiobjective evaluation technique that operates on a farm scale and that integrates both economic and environmental objectives has been developed. In this way, all stakeholders in the watershed contribute to the common goal of reducing adverse impacts of erosion from their commonly owned watershed, while preserving their private goals of maximizing farm income. The multiobjective model is designed to yield the land use patterns that simultaneously minimize sediment yield and maximize net farm-level profits from a watershed.

The particular approach used here interfaces SWAT with a genetic algorithm based multiobjective global search strategy known as Strength Pareto Evolutionary Algorithm (SPEA) (Zitzler and Thiele, 1999) to locate non-dominated Pareto optimal solutions (see Figure 6). Both the single objective and multiobjective models have been tested using the Big Creek watershed and have demonstrated a capability to address their respective objectives. However, both models were found to be computationally intensive, primarily as a result of required, repeated application of the hydrologic model (SWAT). In efforts to resolve this problem, which ultimately may hamper practical utility of these important watershed decision support tools, the capability of Artificial Neural Networks (ANNs) in replacing and mimicking SWAT has been explored. A multilayer feed-forward ANN was trained to approximate estimates of sediment yield and net economic profit that SWAT provides as a result of implementing various land use types and management combinations over a decision horizon. The training was accomplished by using a hybrid of evolutionary programming and a back propagation algorithm to alleviate shortcomings of traditional ANN training approaches. The training technique was found to be highly effective in reproducing SWAT's estimates. The ANN was then used to replace SWAT in the multiobjective decision support tool. The replacement has significantly reduced the CPU time required for generation of optimal landscapes by approximately 75 percent.

SUMMARY AND CONCLUSIONS

Our ongoing research in the Cache River watershed suggests that there are a number of concerns of which individuals and agencies involved with watershed planning in the Illinois River watershed need to be aware. First, the lack of legislation informing watershed planning and the resulting plans can result in those activities lacking legitimacy in the eyes of the residents of the watershed. Nor can agency personnel assume that an apparently open, public process will result in a plan that residents of the watershed are aware of or assent to. How watershed planning activities and resulting plans acquire legitimacy in the eyes of landowners and managers as well as nonfarm residents is an issue that needs to understood and addressed. A corollary is the need to understand how the mosaic of existing laws, rules, and regulations structures the watershed planning process and the implementation of resulting plans. Second, in the minds of the residents, the concept of "watershed" is not well defined nor does it necessarily correspond to the understanding that agency personnel have. This lack of knowledge and agreement as to what a watershed is can hinder the whole policy thrust of using locally led watershed planning as the primary tool for correcting nonpoint source pollution and ecological restoration. Third, even when planning processes involve public participation and hearings–the RPC held hearings regarding the identification of watershed problems and for presenting the resulting plan, there is no guarantee that the wider community in the watershed will be aware of the results. Fourth, the development of SDSSs to incorporate multiple objectives along with the spatial presentation of results are powerful tools for assessing the distribution of "benefits" and "costs" resulting from alternative options designed to address the needs of the watershed.

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Figure 1: Development of GEOLP and AGNPS through Farm Based Land Cover

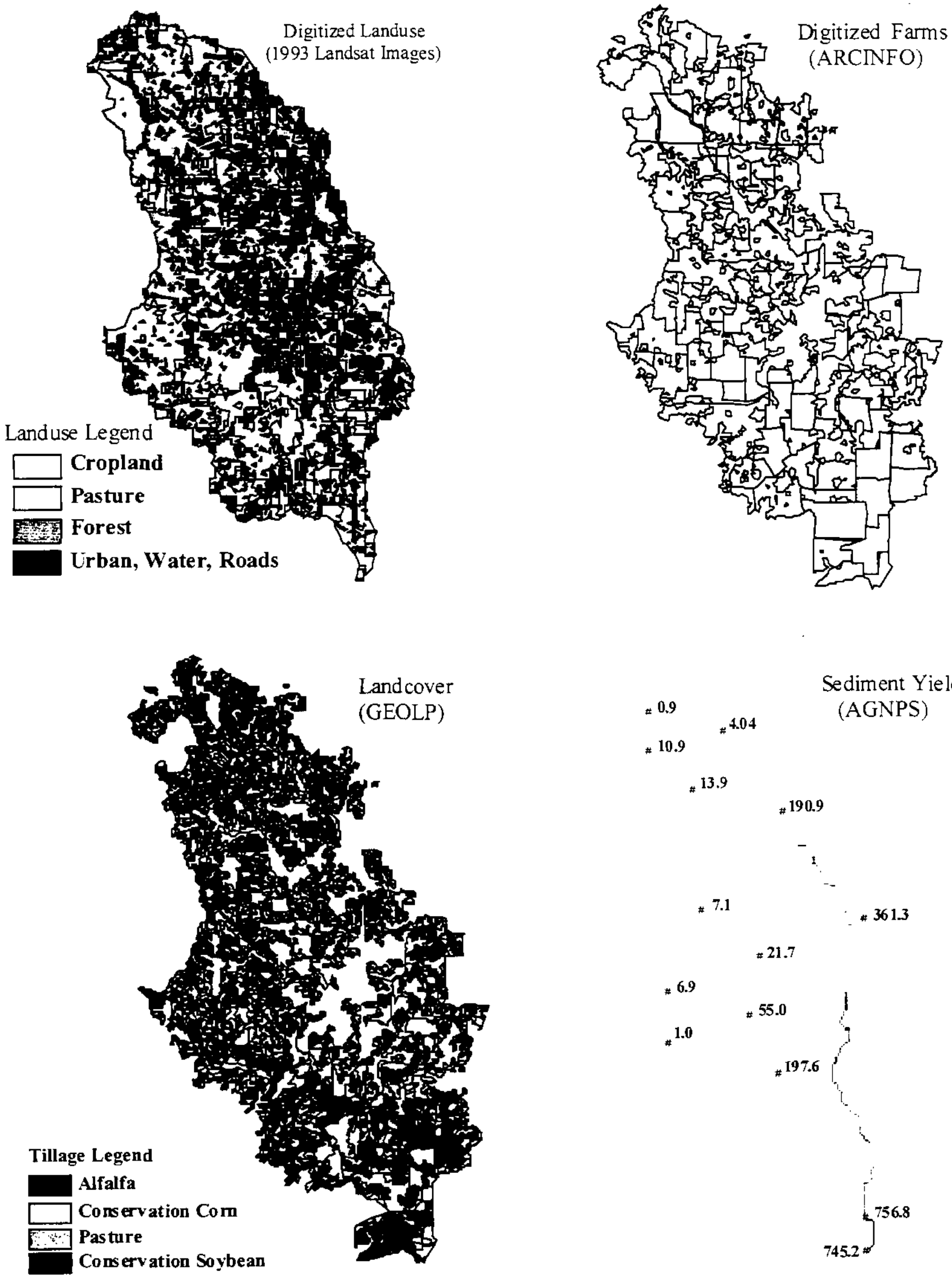
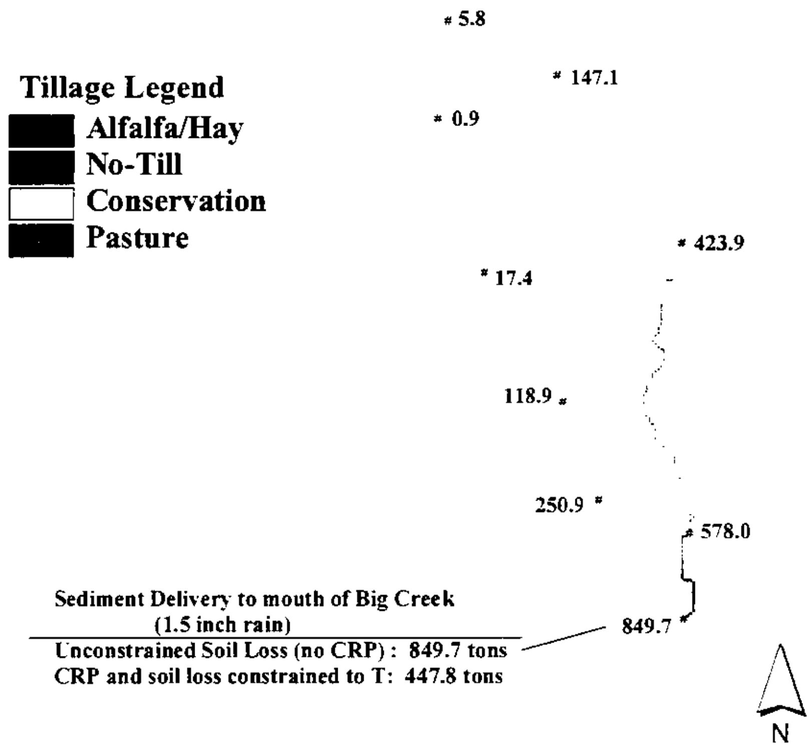


Figure 2: Land use and resulting sediment yield: Big Creek Watershed

Unconstrained Soil Loss
(no Conservation Reserve (CRP))



Sediment Delivery to mouth of Big Creek
(1.5 inch rain)
Unconstrained Soil Loss (no CRP): 849.7 tons
CRP and soil loss constrained to T: 447.8 tons

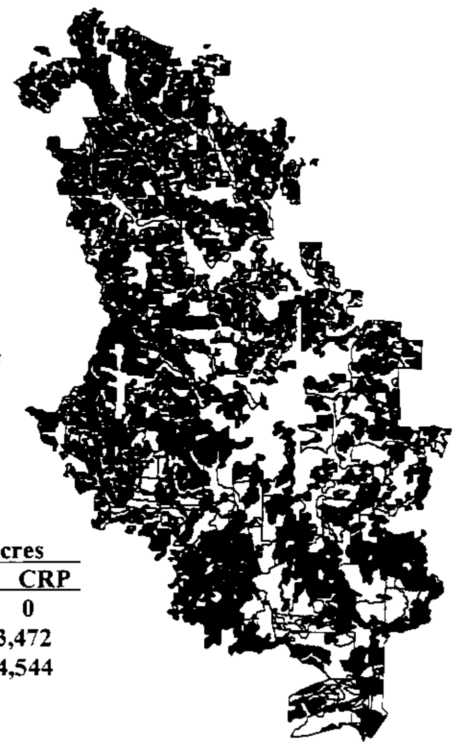
Figure 3: Policy effect on land use: Big Creek Watershed

Unconstrained Soil Loss
(no Conservation Reserve (CRP))

Tillage Legend

- Alfalfa/Hay
- No-Till
- Conservation
- Pasture
- Conservation Reserve

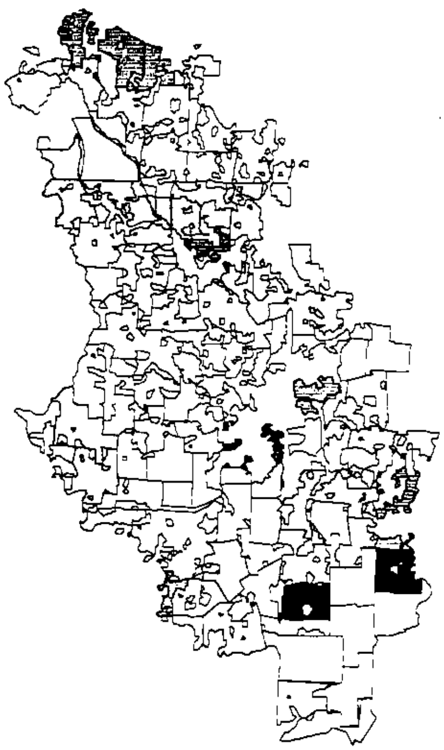
	Cash crop tillage acres		
	Cons. Till	No-Till	CRP
Unconstrained	17,228	200	0
CRP	14,797	0	3,472
CRP & 1T	8,461	4,343	4,544



Conservation Reserve (CRP)
(Soil Loss constrained at T)

N

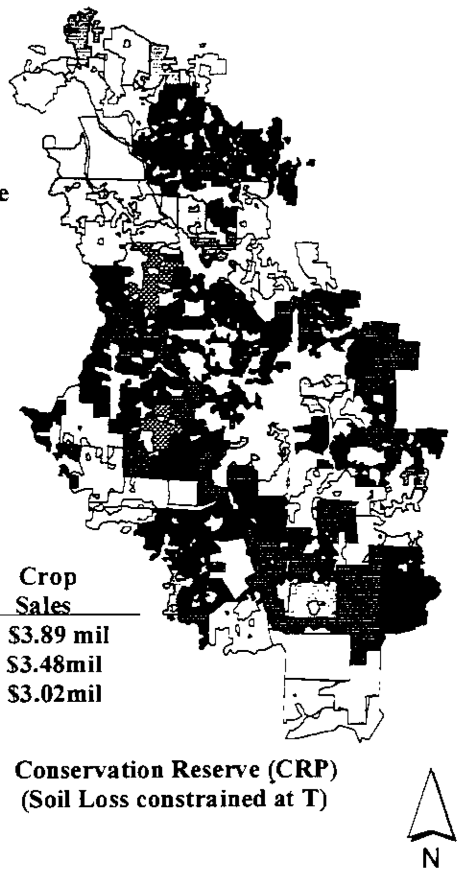
Figure 4: Policy effect on farm income: Big Creek Watershed



Conservation Reserve (CRP)
(unconstrained soil loss)

Percent change in income
< -20
-10% to -20%
-5% to -10%
-1 to 1%
+1 to +5%
+5% to +10%
+10% to +20%
> +30%

	Average Income	Crop Sales
Unconstrained	$22,064	$3.89 mil
CRP	$23,160	$3.48mil
CRP & 1T	$22,142	$3.02mil



Conservation Reserve (CRP)
(Soil Loss constrained at T)

Figure 5: Logic of the GA

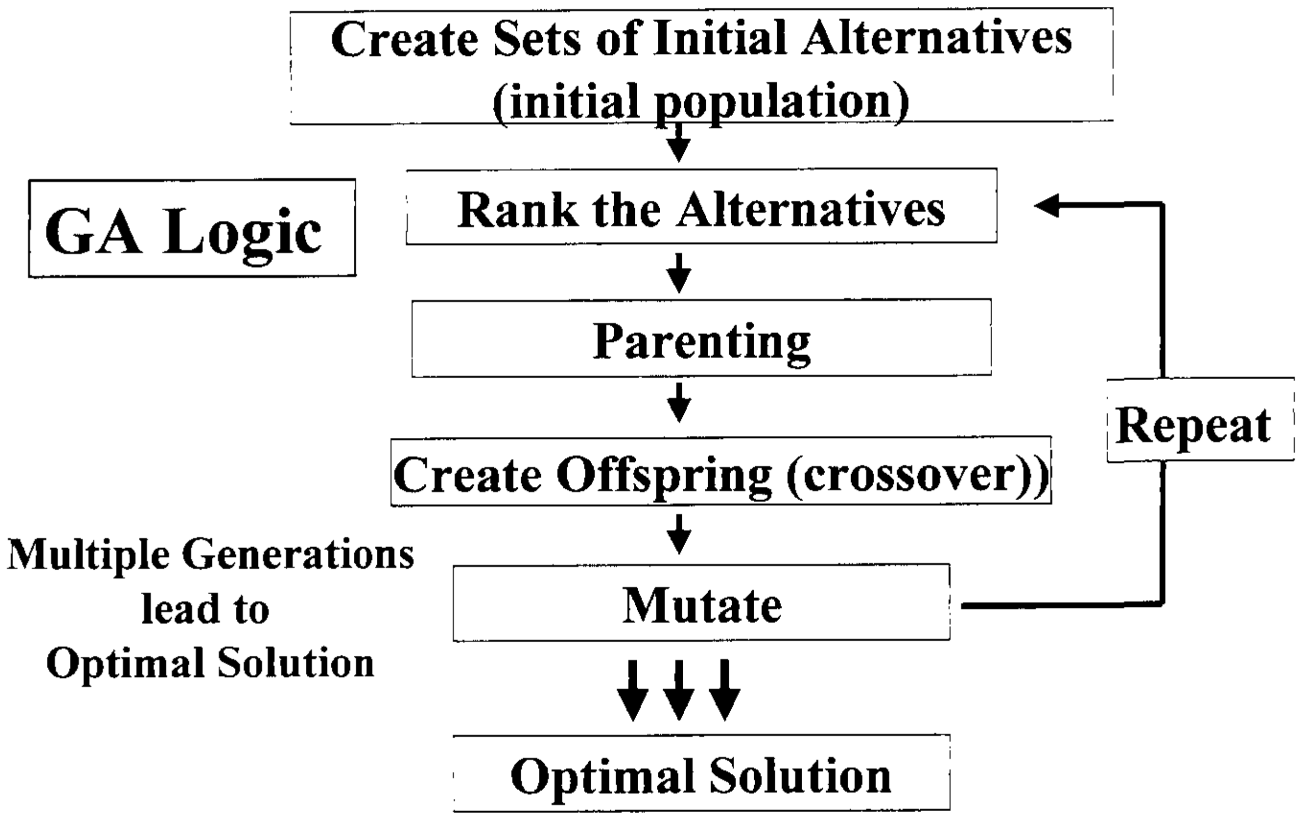
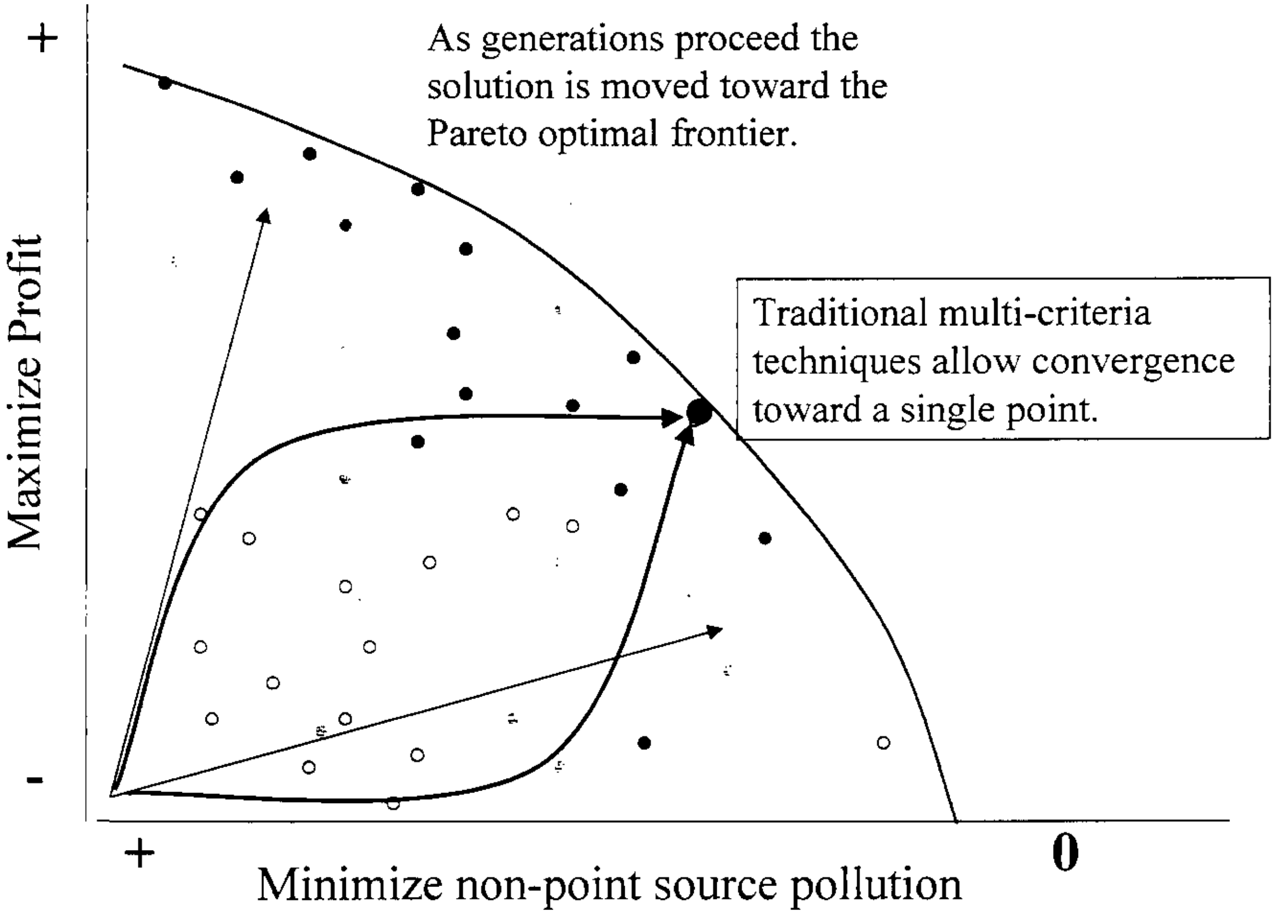


Figure 6: Trade-off between non-point source pollution and farm profitability



THE INFLUENCE OF FORESTED RIPARIAN BUFFERS ON WATER QUALITY AND STREAM INVERTEBRATES IN SUGAR CREEK DRAINAGE, ILLINOIS

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Forested riparian buffers can influence in-stream habitats and biological communities by influencing the quality and quantity of organic matter inputs, sunlight penetration into stream channels, sediment processes, and water quality. In agricultural areas, forested riparian buffers can regulate the movement of nutrients such as nitrogen and phosphorus into streams through uptake by plants, immobilization by soil microbes, supply of carbon to soils that can enhance microbial denitrification, and increased soil porosity that promotes deposition of sediment and sediment-bound nutrients. As a result, forested riparian buffers indirectly influence stream invertebrate communities, which can change predictably with changes in habitat and water quality in streams.

The Sugar Creek drainage in southern Illinois is an area of intense agricultural activity. As a result, many of the streams in this basin experience nutrient additions, degradation of in-stream habitat, and loss of riparian forest cover. Our primary objective is to examine the importance of riparian forest buffers to water quality and overall stream health in this region by examining a cross section of streams with riparian forest cover ranging from poor (e.g., <10%) to good (e.g., >60%). During spring 2001, we began intensively monitoring stream hydrology, water chemistry, in-stream habitat quality, and invertebrate communities in 3 low order streams with ~10%, ~30%, and ~70% riparian forest cover. To supplement information gathered from the 3 intensively monitored sites, we also initiated a similar, less intensive sampling regime on other streams in the same drainage basin.

We anticipate that nutrient concentrations and export from these streams will be negatively correlated with the amount of riparian forest. In addition, because of links between water quality, in-stream habitat, and invertebrate communities, we hypothesize that invertebrate diversity and biological assessment scores will improve with increasing riparian forest cover. Results of this research will further our understanding of the role of riparian forests in regulating water quality in Illinois streams draining agricultural landscapes, and provide important insight into the direct and indirect relationships between riparian vegetation and biological communities in streams.

REDUCING SEDIMENTATION IN LAKE PITTSFIELD

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Lake Pittsfield was constructed in 1961 to serve as a flood control structure and as a public water supply for the city of Pittsfield, a western Illinois community of approximately 4,000 people. The 7,000-acre watershed (Blue Creek Watershed) that drains into Lake Pittsfield is agricultural, consisting primarily in Lake Pittsfield. Sediment from farming operations, gullies, and shoreline erosion has decreased the capacity of Lake Pittsfield by 25 percent in the last 33 years.

Based on a thorough analysis of lake problems and pollution control needs conducted under the Clean Lakes Program, project coordinators developed a strategy to reduce sediment transport into Lake Pittsfield. The keystone of the land management strategy was the construction of settling basins throughout the watershed, including a large basin at the upper end of Lake Pittsfield. USDA Environmental Quality Incentive Project and Illinois Conservation Practices Program funds have provided for installation of additional sediment-reducing practices such as conservation tillage, integrated crop management, livestock exclusion, filter strips, terraces, WASCOBs, and wildlife habitat management. Land-based data and a geographical information system (GIS) are being used to develop watershed maps of sediment sources and sediment yields.

The objective of the Lake Pittsfield Section 319 National Monitoring Program project is to evaluate the effectiveness of the settling basins in reducing sedimentation into the lake. Water quality monitoring consists of tributary sampling after rainstorms (to determine sediment loads); monthly water quality monitoring at three lake sites (to determine trends in water quality); and lake sedimentation rate monitoring (to determine changes in sediment deposition rates and patterns).

The following were keys to the success of Lake Pittsfield Section 319 NMP:

- In the Lake Pittsfield NMP project in the Midwestern United States the large (147 ac-ft) sediment basin removed over 90% of the sediment loading. The effectiveness of 29 smaller upland basins was dependent upon watershed geology and basin position.
- Stream stabilization on Blue Creek was an important component in the overall program to reduce sediment loading to the lake. Installation of low stone weirs prevented further channel incision and mass wasting of stream banks.
- Strong local partnerships along with the interagency corporation have combined to help in the success of this project.

HYDROLOGIC AND SEDIMENT TRANSPORT MODELING IN THE COURT CREEK WATERSHED

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ABSTRACT

The Court Creek watershed located in Knox County, Illinois and draining a 97-square-mile rural basin into the Spoon River is part of Illinois Pilot Watershed and Conservation Reserve Enhancement Programs (PWP and CREP). Under these government incentive programs, the watershed has a local citizen based group called the Court Creek Pilot Watershed Planning Committee (CCPWPC) for watershed restoration planning and management. The watershed was modeled using the Illinois State Water Survey's (ISWS) Dynamic Watershed Simulation Model (DWSM) and rainfall driven surface and subsurface runoff; propagation of flood waves, soil erosion, and entrainment and transport of sediment from single rainfall events were simulated. The model was calibrated and validated using historical storm water stream flow and sediment discharge records. The calibrated and validated model was then used to identify high, moderate, and low runoff and soil erosion/sediment potential areas within the watershed and rank them along with the stream channels. These rankings have been useful to the CCPWPC to prioritize areas within the watershed for restoration projects and utilization of CREP funds where they may reap the greatest benefits. Few water and sediment management scenarios using detention basins or reservoirs were analyzed in controlling high water and sediment discharges.

INTRODUCTION

Flooding, upland soil and streambank erosion, sedimentation, and contamination of water from agricultural chemicals are critical environmental, social, and economic problems in Illinois and other states of the U.S., and throughout the world. The Court Creek watershed located in Knox County, Illinois and draining a 97-square-mile rural basin into the Spoon River has been experiencing problems with flooding and excessive streambank erosion (Roseboom et al., 1982). Several fish kills, including an extensive fish kill in 1981, reported in the streams of this watershed were due to agricultural pollution.

Understanding and evaluating the watershed processes and problems are continued challenges for scientists and engineers. Mathematical models simulating these processes are useful tools to analyze these complex processes, to understand the problems, and to find solutions through land-use changes and best management practices (BMP). The models help in evaluating and selecting from alternative land-use and BMP scenarios. Implementation of these practices can help reduce the damaging effects of storm water runoff on water bodies and the landscape. Developing reliable watershed simulation models and validating them on real world watersheds with measured and monitored data is also challenging.

A number of watershed simulation models exist today. Most of the models were developed in the 1970s and 1980s and since the early 1990s, most modeling research focussed on development of the graphical user interfaces (GUI) and integration with geographic information systems (GIS) and remote sensing data. While enormous progress has been made in developing and refining interfaces, greater efforts are now needed to focus on model formulations – conceptualization and description of hydrologic and water quality processes, efficient algorithms and computational techniques, including both new developments and enhancement of existing codes (Chen, 2001; Committee on Watershed Management, 1999).

Some of the well-known watershed-scale nonpoint source pollution models are Soil and Water Assessment Tool or SWAT (Arnold et al., 1998), Hydrological Simulation Program – Fortran or HSPF (Bicknell et al., 1993), Agricultural NonPoint Source pollution or AGNPS model (Young et al., 1987), Areal Nonpoint Source Watershed Environment Response Simulation or ANSWERS (Beasley et al., 1980), Precipitation-Runoff Modeling System or PRMS (Leavesley et al., 1983), KINematic runoff and EROSion or KINEROS model (Woolhiser et al., 1990), Dynamic Watershed Simulation Model or DWSM (Borah et al., 1999, 2000), and a European Hydrological System or MIKE SHE model (Abbott et al., 1986). SWAT and HSPF are long-term continuous simulation models useful for analyzing long term effects of hydrological changes and watershed management practices, specially, agricultural practices. AGNPS, ANSWERS, KINEROS, and DWSM are single-event models useful for analyzing severe single-event storms and evaluating watershed management practices, specially, structural practices. PRMS and MIKE SHE have both long-term and single-event simulation capabilities. Theoretical (mathematical) bases, the most important elements of mathematical models, of these models are different. Based on mathematical formulations and efficient algorithms, DWSM was found to be the most dynamic and promising watershed-scale single-event model for rural basins having all the three nonpoint-source pollution model components – hydrology, sediment, and chemicals.

The Illinois State Water Survey (ISWS) has been developing the DWSM through improving and expanding a model developed earlier by Borah (1989a,b), and Ashraf and Borah (1992). The DWSM uses physically based governing equations to simulate surface and subsurface storm water runoff, propagation of flood waves, soil erosion, and entrainment and transport of sediment and agricultural chemicals in agricultural watersheds. The model has three major components: (1) DWSM-Hydrology (Hydro) simulating watershed hydrology, (2) DWSM-Sediment (Sed) simulating soil erosion and sediment transport, and (3) DWSM-Agricultural chemical (Agchem) simulating agricultural chemical (nutrients and pesticides) transport. Each component has routing schemes developed using approximate analytical solutions of the physically based equations preserving the dynamic behaviors of water, sediment, and the accompanying chemical movements within a watershed. Different components of the DWSM have been applied and tested on watersheds in Illinois (Borah et al., 1999, 2000, 2001; Borah and Bera, 2000).

In this paper and presentation, applications of the DWSM-Hydro and Sed to the Court Creek watershed in Illinois are presented. This 97-square-mile watershed is part of the Illinois multi-agency Pilot Watershed and Conservation Reserve Enhancement Programs (PWP & CREP). The Court Creek Pilot Watershed Planning Committee (CCPWPC), a local citizen based group, is responsible for making the watershed restoration and management planning and utilizing appropriated resources under these government incentive programs. The DWSM-Hydro and Sed were calibrated and validated on the watershed using storm data monitored and reported earlier by the ISWS (Roseboom et al., 1982, 1986). The calibrated and validated DWSM-Hydro was run for design storms and high, moderate, and low runoff potential areas of the watershed were identified and ranked (Borah and Bera, 2000). It was realized that the design storms with Soil Conservation Service's (SCS) rainfall distributions generated unrealistically high flows for BMP design purposes (Borah et al., 2001). Therefore, rankings of overland elements and channel segments were revised using a historical storm occurred in the springtime and were based on unit-width peak flows and unit-width sediment yields for the overland elements and on peak flows and sediment yields for the channel segments. Few water and sediment management scenarios using detention basins or reservoirs were analyzed for controlling high water and sediment discharges through incorporating these structures into the model.

The Court Creek watershed, the DWSM-Hydro and Sed components, model results and their interpretations are briefly presented and discussed here. The study is being conducted in partnerships with the ISWS, Illinois Department of Natural Resources – Watershed Management Section, CCPWPC, and the Illinois Council on Food and Agricultural Research (C-FAR) Water Quality Strategic Research Initiative (WQ-SRI) program. The CCPWPC has been using some of the model results to plan their initial restoration programs within the watershed.

THE DWSM SCHEME AND HYDRO-SED COMPONENTS

The watershed is divided into subwatersheds, specifically, into one-dimensional overland elements, channel segments, and reservoir units. An overland element is represented as a rectangular area with the same area as in the field, width equal to the adjacent (receiving) channel length, length equal to area divided by the width, and representative slope, soil, cover, and roughness based on physical observations of these characteristics in the element. A channel segment is represented with a straight channel having the same length as in the field and having a representative cross-sectional shape, slope, and roughness based on physical observations and measurements. A reservoir unit is represented with a stage-storage-discharge relation (table) developed based on topographic data and discharge calculations using outlet measurements and established relations. Each of the components of the DWSM uses the same watershed subdivisions - overland elements, channel segments, and reservoir units.

The DWSM-Hydro: Hydrologic Simulations

The overland elements are the primary sources of runoff in which rainfall turns into surface runoff after losing first to interception at canopies and ground covers, then to infiltration through the ground surface and depression storage above it. The rainfall available for surface runoff is the rainfall excess. A portion of the infiltrated water flows laterally towards downstream as subsurface flow sometimes in accelerated mode in the presence of tile drains. Two overland elements contribute surface and subsurface flows into one channel segment laterally from each side of the channel. The excess rainfall is routed over the overland elements beginning at their upstream edges (ridges), at which flows are zeros, to their downstream edges, coinciding with the receiving channel banks. Similarly, subsurface water from infiltration is routed through the soil matrix underneath the overland elements beginning at their upstream edges (ridges), at which flows are assumed zeros, to their downstream edges, coinciding with the receiving channel banks. Currently, the tile drain flows from overland elements having tile drains are lumped with the subsurface flow through the soil matrix using an effective lateral saturated hydraulic conductivity concept. The channel segments carry the receiving waters from overland elements and upstream channel segments towards the downstream side of the watershed and ultimately to the watershed outlet. During its journey, the runoff water may be intercepted by reservoirs, which release it again to downstream channels at reduced rates after temporary storage.

The procedures, and their original sources, used in computations of infiltration and rainfall excess rates and routing these over and under the overland surfaces, and routing their contributions through the channels and reservoirs are described in Borah (1989a) and Borah et al. (1999, 2000).

The DWSM-Sed: Soil Erosion and Sediment Transport Simulations

Similar to the hydrologic component, soil erosion and sediment transport are simulated along with water through the overland elements and stream segments. The eroded soil or sediment is divided into number of particle size groups. Agricultural watersheds having extensive aggregates, the sediment is divided into five size groups: sand, silt, clay, small aggregate, and large aggregate. Each size group is dealt individually during the simulation of each of the processes, and total response, in the form of sediment concentration and discharge is obtained by integrating the responses from all the size groups.

The model computes soil erosion due to raindrop impact. The eroded (detached) soil is added to an existing detached (loose) soil depth from where entrainment to runoff takes place with sufficient velocity and shear (capacity). Erosion due to flow shear stress and deposition depends on sediment transport capacity of the flow and the sediment load (amount of sediment already carried by the flow). Sediment transport capacity is computed using established formulas. If the capacity is higher than the sediment load, erosion takes place and the flow picks up more materials from the bed. If the loose soil volume at the bed is sufficient, sediment entrainment takes place from the detached soil depth. Otherwise, the flow erodes additional soil from the parent bed material. If the sediment transport capacity is lower than the sediment load, the flow is in a deposition mode and the potential rate of deposition is equal to the difference of the two. The actual rate of deposition is computed by taking into account particle fall velocities. Deposited sediment is added to the loose soil volume. If the sediment transport capacity and the sediment load are equal, an equilibrium condition is assumed where there is neither erosion nor deposition. All the processes are interrelated and must satisfy locally the conservation of sediment mass expressed by the sediment continuity equation. The continuity equation is solved to keep track of erosion, deposition, and sediment discharges along the flow segments. Descriptions of these procedures and references to their sources are given in Borah (1989b) and Borah et al. (1999).

At present, the model does not route sediment through a lake, reservoir, or detention pond and assumes deposition of all the sediment carried by the flow. Therefore, the model is applicable to large detention ponds, lakes, and reservoirs where most of the sediment is trapped and sediment bypassed is negligible.

THE DWSM-HYDRO & SED APPLIED TO THE COURT CREEK WATERSHED

The Court Creek watershed (Figure 1) having a drainage area of 97-square-mile is located in Knox County, Illinois. The Court Creek flows along the southern boundary of the watershed for 14.5 miles before discharging into the Spoon River, a western tributary of the Illinois River, at Dahinda. Three major tributaries, Middle Creek, North Creek, and Sugar Creek, enter Court Creek from the north. Strip mining created numerous small lakes in the upper Sugar Creek basin. Directly below these lands, a 512-acre Spoon Valley Lake impounds the waters of Sugar Creek. The only other major lake in the watershed is the Rice Lake, a 30-acre impoundment on the upper Court Creek.

The DWSM-Hydro & Sed were applied to the Court Creek watershed to help the CCPWPC in making their watershed restoration and management plans. The watershed was divided into 78 overland, 39 channel and 2 reservoir segments. Model input data and parameters were taken mostly from an earlier study by Roseboom et al. (1982) and were described in Borah and Bera (2000). The SCS runoff curve number procedure (Soil Conservation Service, 1972) as described

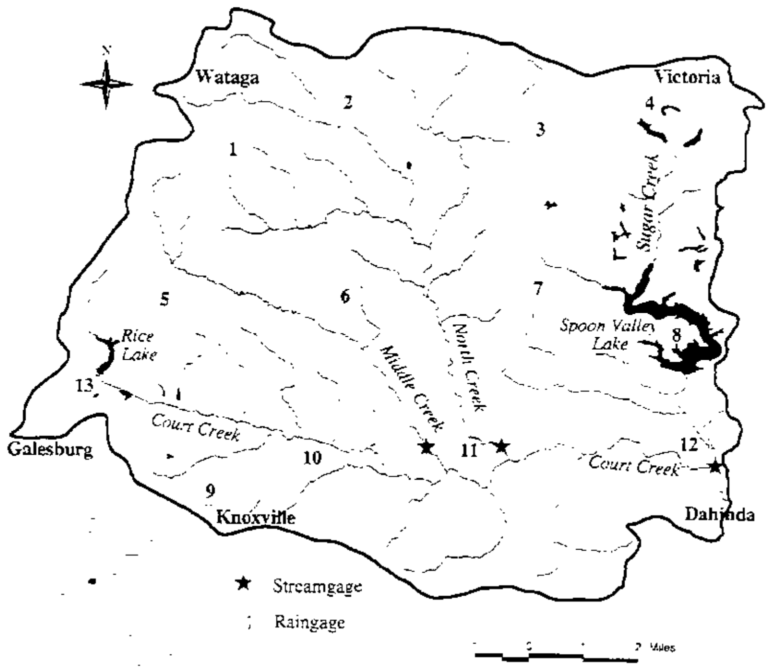

Figure 1. The Court Creek watershed in Illinois (after Roseboom et al., 1982).

in Borah et al. (1999) was used to compute rainfall excess. Roseboom et al. (1986) recorded three storms, which occurred on December 2 and 24, 1982, and April 1, 1983. Continuous rainfalls were recorded at 13 raingage stations shown in Figure 1. The model was calibrated using the April 1, 1983 storm and was validated using the December 24, 1982 storm, and the simulated water and sediment discharges were compared with the available observed data as shown in Figures 2 and 3, respectively. The flow and sediment data at all the stations for all the storms were not available. All the available observed data are shown in these figures. As shown in these figures, although there are some discrepancies, the model was able to generate comparable results considering complexities of the physical processes being simulated and size of the watershed.

Runoff and Sediment Potentials and Rankings of Overland and Stream Segments

Using the calibrated and validated parameters, the model was run again for the April 1, 1983 storm. This time, the average rainfall intensities assumed uniformly distributed throughout the watershed were used for consistencies and relative comparisons of flows and sediment yields in spatial scale. The overland elements were ranked twice – first based on unit-width peak flows, which dynamically accounts for time of concentration, secondly based on unit-width sediment yields, which dynamically accounts for sediment delivery. The first ranking indicates overland units having potentials to produce flows in the order of highest to the lowest. Similarly, the second ranking indicates overland units having potentials to generate sediment in the order of highest to the lowest. Such rankings may be useful to watershed restoration and management

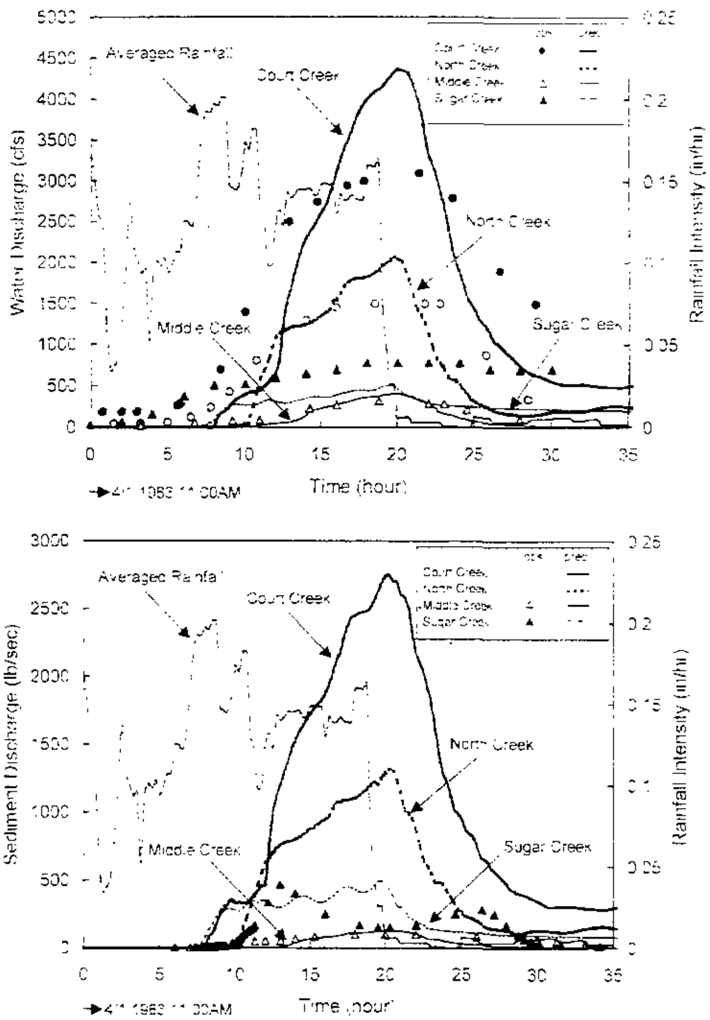

Figure 2. Comparisons of observed and predicted water and sediment discharges in the Court Creek watershed resulting from the April 1, 1983 storm: Model calibration.

planners to prioritize areas needing attention for reducing flooding and/or soil erosion and sedimentation. These numerical rankings are not shown here. However, the upper; middle and lower one thirds of the rankings are isolated as high, moderate, and low potentials and are shown in Figures 4 and 5 – Figure 4 showing the runoff potentials and Figure 5 sediment potentials. Similarly, stream segments were ranked based on peak flows and sediment yields. These rankings may be useful to indicate severity of flooding and sediment delivery at any stream section throughout the watershed and prioritize those for restoration. The overland and stream rankings may be used simultaneously to prioritize stream sections and isolate severe overland elements above those stream sections for implementations of effective BMPs and other restoration measures.

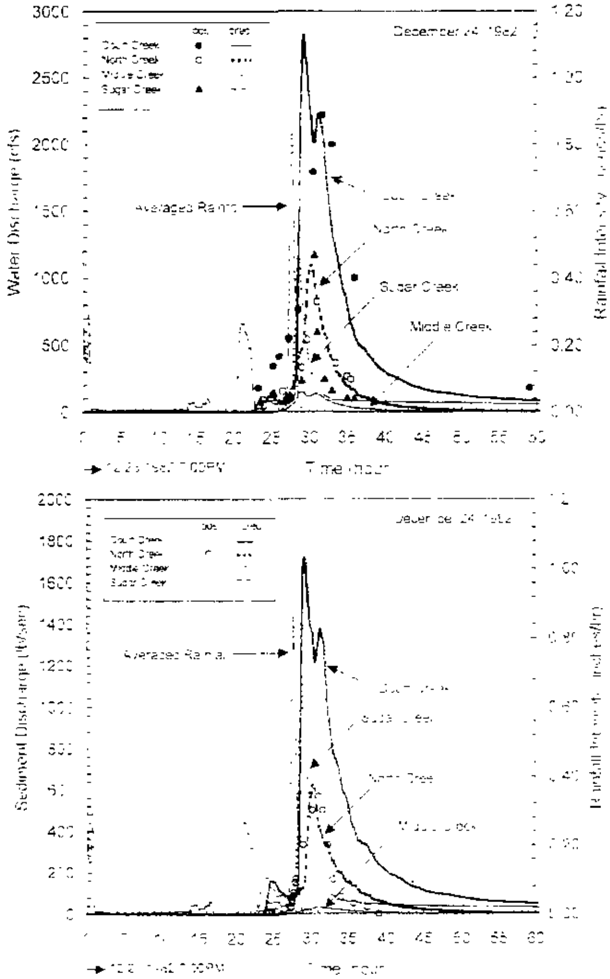

Figure 3. Comparisons of observed and predicted water and sediment discharges in the Court Creek watershed resulting from the December 24, 1982 storm: Model validation.

Water and Sediment Control Scenarios

Using the calibrated and validated model, alternative watershed management scenarios are being analyzed. Results from one of these scenarios are shown here for demonstration. Assuming two Rice Lake sized reservoirs installed at the two major branches of the North Creek (Figure 1), the model was run again for the April 1, 1983 storm using spatially uniform average rainfall intensities for the storm. Impacts of these two reservoirs on the water and sediment discharges at the North and Court Creek outlets are shown in Figure 6. As shown in this figure, impacts on water discharges are minimal, 7 and 3 percent peak-flow reductions, respectively, at North and Court Creek outlets. As expected, hydrographs at both locations are delayed, more in North Creek than Court Creek. Dramatic impact on sediment discharges is shown – 70 and 26 percent reductions of sediment yields, respectively, at North and Court Creek outlets.

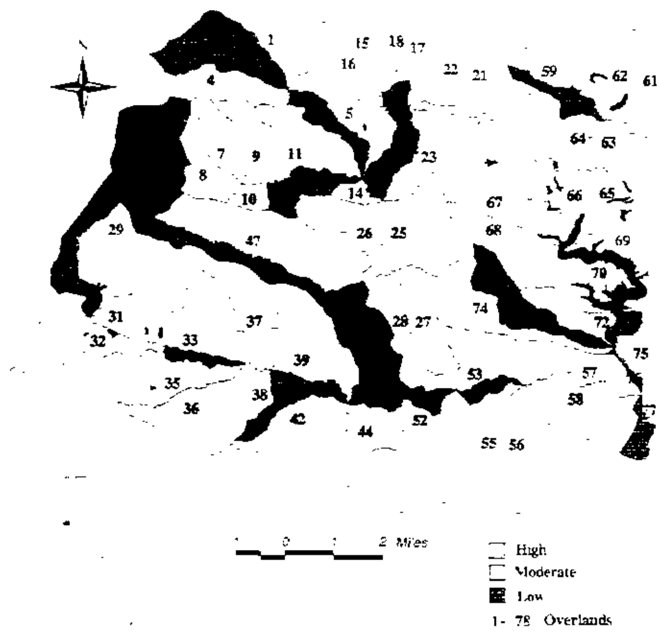

Figure 4. Runoff potentials of overland areas in Court Creek Watershed based on unit-width peak flows.

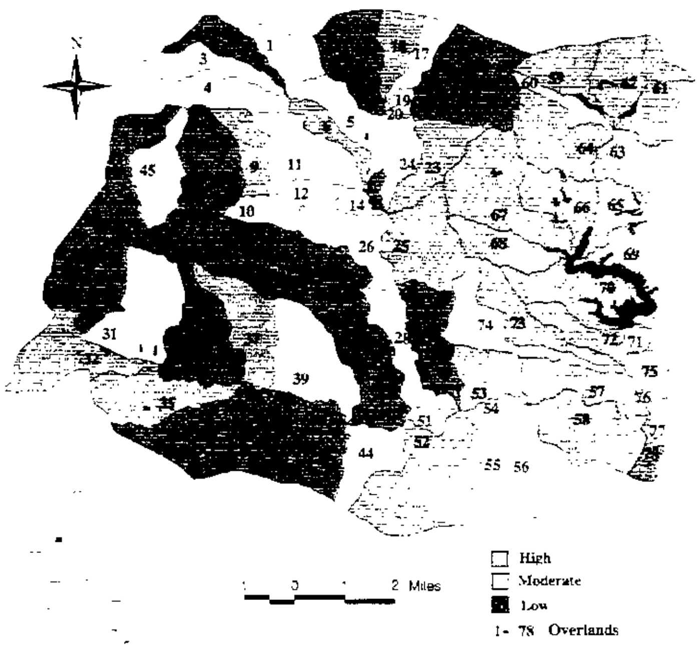

Figure 5. Sediment potentials of overland areas in Court Creek watershed based on unit-width sediment yields.

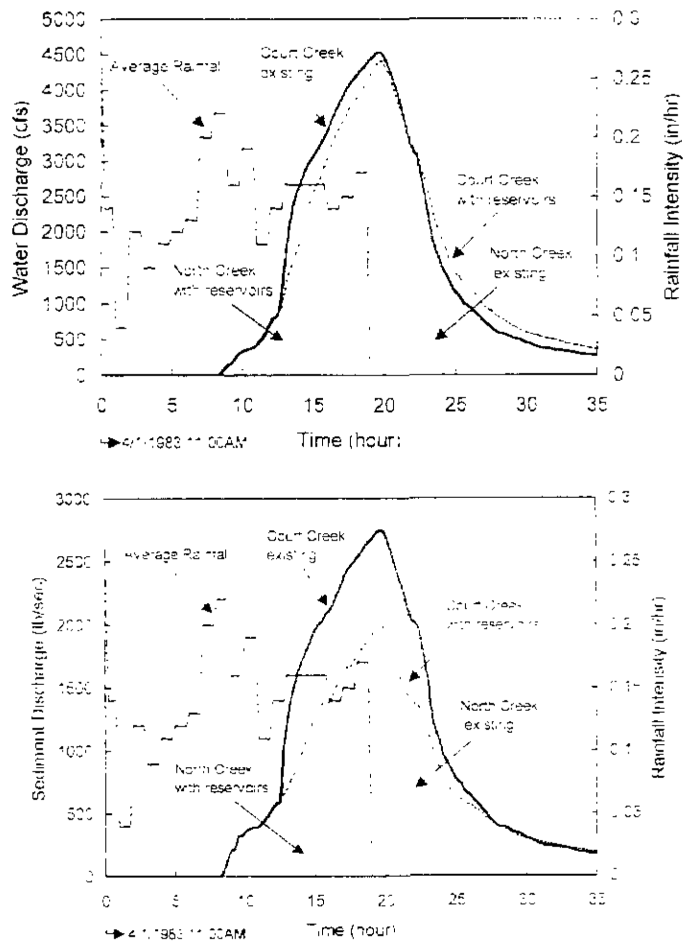

Figure 6. Predicted water and sediment discharges at the North and Court Creek outlets resulting from the April 1, 1983 storm (average rainfall) and assuming two Rice Lake size reservoirs at the two branches of North Creek.

CONCLUSIONS

The DWSM-Hydro & Sed generated useful results on the Court Creek watershed in Illinois, which is part of the Illinois PWP and CREP. The model was calibrated and validated using observed historical storms. Realistic uniform (average) rainfall intensities of one of the historical storms, the April 1, 1983 storm, which is a one-year 24-hour storm, was used to rank overland elements and channel segments and analyze water and sediment management scenarios. Rankings of overland elements were based on unit-width peak flows and unit-width sediment yields and rankings of channel segments were based on peak flows and sediment yields. These new criteria dynamically account for time of concentration and sediment delivery. The model is capable of analyzing impacts of water and sediment management scenarios and showed impacts of two hypothetical reservoirs placed at two branches of the North Creek. Small impacts on peak flows but dramatic impacts on sediment yields were shown. The CCPWPC is currently using some of these results to plan their initial restoration programs within the watershed and prioritize them for implementation of restoration measures and make the best investment of the limited resources.

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STREAMBANK STABILIZATION

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ABSTRACT

The awareness of the need for streambank stabilization along severely eroding banks has never been greater. There is also a growing realization that the total contribution of sediment produced by channel erosion may have been severely underestimated. As a result there have been many attempts to find solutions that are both economically feasible and environmentally acceptable. One of the keys to successfully implementing streambank stabilization techniques that satisfy both issues lies in understanding the fundamental problems associated with a particular stream. Once the stream dynamics are understood a treatment method can be designed to address the cause of the bank erosion rather than the effects. This approach to streambank stabilization will result in a design that works to restore a natural balance while recognizing that bringing a degraded channel back to equilibrium may not be an achievable short-term goal.

INTRODUCTION

The need to develop streambank stabilization techniques that are effective, affordable and environmentally acceptable has brought about a merging of techniques. Using the right combination of hard structure and native plant communities most streambank erosion problems can be addressed in ways that are much less costly than traditional treatments and take on a very natural appearance over time. The use of Stone Toe Protection, Bendway Weirs, Rock Riffle Grade Control Structures and Stream Barbs in combination with vegetation have proven to be effective and affordable. Even more cost savings are realized when natural regeneration can be utilized. Selecting the right combinations of techniques for each site depends on a proper evaluation of stream behavior.

Implementation of lower cost treatments requires a shift of paradigms from the traditional bank stabilization methods. With sufficient funding almost any bank can be protected, the challenge is to accomplish the task by implementing only the minimum protection needed to allow the channel to stabilize naturally. By carefully determining the cause of the failure and applying resources to correct only the root of the problem, costs are held to a minimum. Often the mid and upper bank areas can be left untreated and allowed to fail until they reach a stable grade, where within a very short period of time they will be naturally revegetated. Over time then nature continues to strengthen the project at no cost.

Success using this philosophy requires that an experienced professional or interdisciplinary team make an accurate assessment of the dynamics of the particular stream to be treated, understand the evolutionary stage of the channel plan and profile, and then apply the appropriate treatment strategy at the level required to achieve a balance between risk the sponsor is willing to assume and cost.

ROCK RIFFLE GRADE CONTROLS

Rock Riffles are small stone grade control structures constructed across a stream channel to halt degradation and to dampen the flow through a series of riffles to reduce erosive forces effecting the outer banks of the channel. Degradation of the channel bed is the typical stream response to an increased flow regime or a steepened channel reach. These conditions often are a result of intensified land-use (urbanization) and/or channelization. Degradation is the first phase of channel instability in the Channel Evolution Model. If left untreated the disrupted channel will go through the widening phase of the CEM as well and will not stabilize until a new floodplain is built at a lower elevation.

Ideally, use of rock riffle grade controls would restore the channel to an elevation that re-connects the channel to its floodplain. However in practice many Illinois streams have degraded to the extent that this option is no longer feasible, or acceptable in cases where significant economic damage could occur.

Uses of rock riffle grade controls are still applicable to halt additional downcutting, which would result in additional widening and significant sediment contributions. Rock riffles may also reduce the extent of lateral migration due to energy dissipation in the riffle pool sequence.

Pool spacings have been measured as 5.6 and 6.7 times the bankfull width for alluvial and bedrock streams. (Roy and Abrahams 1980. Discussion of "Rythmic spacing and origin of pools and riffles". Geological Society of America Bulletin, 91:248-250) Therefore rock riffles are designed at approximately 6 bankfull width spacings to ensure passage of bedload material. The crest of each successive structure is set to insure that the pool formed by the riffle extends onto the toe of the upstream riffle. When constructed with a 4:1 frontslope and a 20:1 backslope of properly sized material they are both stable under all flow conditions and allow fish to migrate from pool to pool.

By stabilizing the bed with rock riffle grade control structures future degradation and extensive bank failure can be reduced or eliminated. It is important to realize as well that if left untreated this degradation may well migrate upstream through the entire channel system. Rock Riffle Grade Controls are best suited to channels draining less than 50 sq. miles due to increased cost of installation on larger streams.

STONE TOE PROTECTION

Stone toe protection is a continuous stone dike placed along, or slightly streamward of, the toe of the eroding bank. The cross section is triangular in shape similar to a "windrow". The STP does not necessarily follow the toe exactly, but can be placed to form an improved or "smoothed" alignment through the bend. The normal ratio of the radius of curvature to channel width ranges from about 1.5 to 4.0 with the majority of bends falling within the range of 2 to 3. (Watson, Elliot and Beidenharn, The WES Stream Investigation and Streambank Stabilization Handbook) Therefore a successful design should have a radius/width ratio near 2.0 or greater.

STP protects the bank by resisting the erosive flow of the stream, thereby preventing the toe from being eroded away and allowing the mid and top bank to fail due to oversteepening. The stone in the "windrow" serves as a reservoir of riprap material free to launch into the stream as scour or degradation occurs within the channel. The success of this project depends on correctly determining the extent of scour or degradation that will occur over the design life of the project. Under estimating scour will result in unprotected toe slopes when all the riprap launches and subsequently the project will likely fail. Over estimating the extent of scouring activity will result in increased and unnecessary costs.

Finally STP will capture alluvium and failed upslope bank material on the bank side of the STP forming a bench at the toe. If the STP is properly designed, this bench will be at an elevation that will sustain woody vegetation.

STP is applicable on a wide range of streams in Illinois following these guidelines as long as care is taken to size the riprap to withstand the anticipated maximum local velocities.

BENDWAY WEIRS

Bendway Weirs are low upstream angled rock sills projecting from the outer bank and extending across the deepest portion (thalweg) of the stream. Bendway Weirs act to redirect stream flow away from the eroding bank as flow over the weir crest is redirected at right angles to the downstream face of the weir. By directing flow toward mid-channel the velocities near the outer bank are reduced. Weirs are angled upstream from 5 to 30 degrees from normal flow and built level crested to an elevation of approx. 1 foot above normal low flow.

Bendway Weirs are applicable as a single component to streams with radius of curvature to channel width ratios greater than 4.0. On smaller radius bends the use of STP is recommended to prevent bank scour between the weirs. As with STP, a successful design will have a R/W ratio of greater than 2.0, however the radius of curvature can be measured from the stream ends of the weirs, making the combination of Bendway Weirs and STP very cost effective where STP would normally need to be placed in deeper water. to achieve an acceptable R/W ratio.

Bendway Weirs must also be placed in a stream with a stable bed to prevent undercutting of the weirs, which could cause the practice to fail.

STREAM BARBS

Stream Barbs differ from bendway weirs in that they have a sloping crest and are angled upstream much more acutely. The crest is constructed on a 10:1 slope or flatter with the maximum height being between between bankfull elevation and 50% of bankfull depth. The angle is approx. 60 to 70 degrees upstream from normal flow. (20 to 30 degrees from the bank) The advantage of stream barbs over bendway weirs occurs in three areas.

1. The sloping crest and higher elevation makes them more effective over a wider range of flows.
2. The acute angle upstream creates a zone of greatly reduced velocities upstream of the Stream Barb extending its zone of impact and allowing wider spacings than for bendway weirs.
3. The combination of 1 and 2 above eliminate the need for use STP, even on small radius bendways.

As with Bendway Weirs and STP the use of Stream Barbs is limited to channels with stable beds.

RIVER TRAINING STRUCTURES: NEW WAYS OF DOING OLD BUSINESS

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ABSTRACT

The St. Louis District Corps of Engineers is under congressional mandate to maintain a 9-ft. navigation channel on the Upper Mississippi River from Saverton, Illinois to the river's confluence with the Ohio River. The Corps has traditionally used two river engineering structures to maintain the navigation channel, dikes and revetment. These structures have been used for channel improvement for well over 100 years. A growing realization of the role that channel improvement structures can play in altering and creating habitat can be seen as far back as 1972 when the St. Louis District began notching dikes to increase habitat diversity. In 1996, the St. Louis District implemented the Avoid and Minimize Program. This program was put in place to avoid and minimize the possible effects of increased navigation traffic resulting from the construction of a second lock at Melvin Price Locks and Dam. Measures implemented under the Avoid and Minimize program include the construction and monitoring of innovative river training structures. These innovative structures include bendway weirs, chevron dikes, bullnose dikes, off-bank revetment, multiple roundpoint structures, and notched dikes. Physical monitoring of these structures has shown them to be effective river training structures. Biological monitoring of these structures has found that they have increased habitat diversity in the river, compared to habitat produced by traditional measures. Innovative structures are not only being found to provide valuable aquatic habitat, like over-wintering and nursery areas, but can also be used to create wetland habitat, islands, and side channels. While these new structures will not completely replace the need for traditional dike and revetment work, they have become a normal part of the St. Louis District's channel maintenance program.

Many of these innovative river training structures also have application on the Illinois River. Most of the existing islands on the Illinois are subject to flow and ice scour. Structures like bullnose dikes would protect the heads of islands from erosion, and at the same time create valuable off-channel habitat. Similarly, off-bank revetment can be used to shield islands from tow and recreational boat wave wash while providing off-channel habitat. Selective placement of chevron dikes in commonly dredged reaches could be used to create new islands and also provide over-wintering habitat for fish.

INTRODUCTION

The Corps of Engineers influence on the Middle Mississippi River and it's tributaries dates as far back as the 1820's when snag boats began removing logs from the river to allow safe passage to St. Louis for steamboats. In an effort to keep the Mississippi River from shifting to the Illinois bank, and consequently maintaining a harbor for the city of St. Louis, the Corps of Engineers in 1838, under the direct supervision of Robert E. Lee, built what is believed to be the first dike on the Middle Mississippi River. Though the methodologies have changed dramatically since 1838, the Corps has continued to use river training structures to maintain harbors and provide for safe navigation of the Mississippi River and it's tributaries.

Traditionally, the Corps has relied upon three main tools in their maintenance of the navigation channel, dikes, bankline revetment, and dredging. Through knowledge and experience, the Corps has become proficient at understanding how these tools could be used to create changes in the riverbed and alter water flows to help maintain the navigation channel. Understanding and appreciating how training structures affect habitat for fish and wildlife, however, has taken longer to develop.

A growing realization of the role these structures play (or can play) in altering and creating habitat can be seen as far back as 1972 when the St. Louis District began notching dikes to increase habitat diversity (Neimi and Strauser, 1991). Since 1972, environmental river engineering has become increasingly commonplace within the St. Louis District. In 1996, a major step was taken with the implementation of the St. Louis District's Avoid and Minimize (A&M) Program. This program was put in place to avoid and minimize the possible effects of increased navigation traffic resulting from the construction of a second lock at Melvin Price Locks and Dam. One of the chief measures implemented under the A&M program is the construction and monitoring of innovative river training structures. Six types of innovative structures have been built to date. This mix includes both new structures like bendway weirs, chevron dikes, bullnose dikes, and multiple roundpoint structures and proven structures like off-bank revetment and notched dikes. Physical monitoring of these structures has shown them to be effective river training structures. Meanwhile, biological monitoring of these structures has found that they can be used to increase habitat diversity in the river when compared to the habitat produced by traditional measures. A closer look at each of the six listed innovative structures provides a greater appreciation for the role each play in both river regulation and fish and wildlife habitat creation and preservation.

BENDWAY WEIRS

As the name implies, bendway weirs are a series of submerged dikes placed in the selected river bends of the Middle Mississippi River. The necessity for bendway weirs is a direct result of the need to stabilize and control the lateral or meandering movement of the Mississippi River to protect the property of private landowners and maintain the navigation channel. This is done by controlling erosion on the outside of the bend by placing revetment along the outside bankline. With the river's energy now unable to erode the outside bank, that energy is forced downward and erodes the river bed, while at the same time causing more deposition along the inside bankline, resulting in a deeper and narrower channel through the bend. As conditions continued to degrade, the currents in these areas became to swift, and the river to narrow, for safe navigation. Similarly, flows through the outside of these bends were to swift to provide suitable aquatic habitat for most riverine fishes.

Bendway weirs have provided a solution to this navigation problem and at the same time have improved aquatic habitat within the bendway. By placing a series of upstream slanted underwater dikes in the bend, flow has been redirected back towards the encroaching sandbar on the inside of the bend. This movement, along with the disruption of the lateral flows through the outside of the bend, creates a wider, shallower channel. This redirection of flow has provided for safer navigation conditions and fewer accidents in each bend (Davinroy et al., 1998). Improvements in aquatic habitat are also realized through both the placement of the structures in the bends and through the disruption of the lateral flows. There are 19 bendway weir fields in the Middle Mississippi River, comprising 163 individual weirs. The number of weirs in a field ranges from 3 to 14. All weirs are angled 30° upstream and are placed at least 4 meters below the low water reference plane to avoid interfering with navigation. Physical monitoring of river bends has shown a widening and shallowing of the river channel does occur after placement of bendway weirs.

Figure A. A conceptualized drawing of a bendway weir field. Individual weirs are placed at least 4 meters below the lower water reference plane and are angled 30° upstream.

Post placement studies have found that bendway weirs field provide habitat for both fish and macroinvertebrates. Hydroacoustic work by Kasual and Baker (1996) on a bendway weir field in the Middle Mississippi River showed that placing weirs in river bends does increase the abundance of fish in those bends. Keevin et al. (2001) reported that using high explosives in a bendway weir field resulted in the collection of 217 fish, representing 12 species. Catch was dominated by freshwater drum, gizzard shad, and blue catfish. Also of interest was the collection of two freckled madtoms and two slender madtoms, species likely using the interstitial spaces provided by the rocks forming the weirs. A study assessing macroinvertebrate use of bendway weir rocks (Ecological Specialists, Inc, 1997) found that the community contained 34 taxa, compared to 7 taxa in the sand substrate of a bendway without weirs.

CHEVRON DIKES

Chevron dikes are 'V' or 'U' shaped rock dikes placed in the river to help direct flows in the navigation channel. The dikes are built so that the apex of the structure is upstream, with the wings extending downstream. In the St. Louis District chevron dikes have been used to accomplish three objectives; to help maintain existing flow splits at locations where the river's flow is divided between the main channel and large side channels, as beneficial locations for dredge material placement, and as alternatives to traditional wing dikes in focusing flows in the river channel. There are three chevron dikes fields in the St. Louis District.

At river mile 289, a series of three chevron dikes was constructed in 1993 across the mouth of a major side channel in an effort to maintain the existing flow split at that site between the side channel and the main channel. Traditionally the Corps has attempted to regulate flow into side channels by constructing large closing structures across the mouth of the side channel. In this case, by building chevron dikes instead of a closing structure, continued flow was allowed through the side channel. After construction, dredge material was placed behind all three of the chevron dikes to create island habitat. Through time these islands have not only maintained themselves, but have started to establish vegetation. In addition, during periods of high water, flows have overtopped the structures and created large scour holes directly behind the dikes. These areas, which are protected during normal flows, are known to provide over-wintering, nursery, and rearing habitat for fish. Post-construction monitoring work (Atwood, 2001a) has collected over 48 species in association with the chevron dikes, with the determination that the chevrons were providing useful and valuable habitat for a variety of riverine fishes.

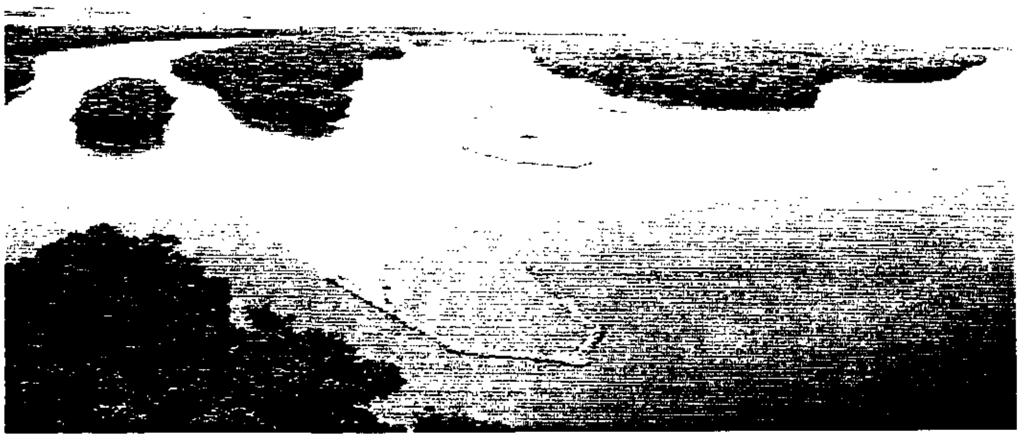

Figure B. Chevron dike field at Mississippi River mile 289. Note the dredge material islands formed behind each chevron.

In 1998 the St. Louis District constructed a set of chevron dikes at river mile 266. The dikes at this location were located along the main channel border to increase flows in the main channel. These three dikes, placed in a downstream line, were constructed instead of traditional wing dikes. Like the dikes at river mile 289, each of these dikes has deep scour holes below them, which provides habitat for fish throughout the year. Hydroacoustic fisheries monitoring work behind these dikes (US Army Corps of Engineers, 2001) has documented fish use of the holes created below the dikes. Sampling during the winter showed fish densities nearly six times those outside of the over-wintering period. Depths in the upper scour holes exceeded 8 meters.

Figure C. Chevron dike field at Mississippi River mile 266. The deep slack water habitat formed behind these structures has been shown to be used extensively by fish in the winter.

MULTIPLE ROUNDPOINT STRUCTURES

In 1998, the St. Louis District constructed a multiple roundpoint structure in Pool 25 (river mile 265). This innovative training structure (Figure D) consists of six separate round rock points, or cones, on 100 ft centers extending from the bank in a fashion similar to a wing dike. The round point structure was developed to function as a wing dike and appears at the water surface to be a heavily notched wing dike. Each of the six points stands alone and is not connected to the other points. Future plans call for the construction of a series of multiple roundpoint structures with the notches offset such that the second row of rock points will be behind the first row of notches. This type of configuration will improve the overall ability of the structures to modify flows patterns and at the same time increase aquatic diversity.

The multiple roundpoint structure has been monitored since construction for both fish use and bathymetric changes. Electro-fish sampling at the site (Atwood, 2001b) has resulted in the collection of 21 species, with gizzard shad, emerald shiners, carp, freshwater drum, and flathead catfish making up the majority of the collected fish. The blue sucker, a species of concern in Illinois, has been collected on four occasions. Bathymetric surveys conducted by the St. Louis District have shown that the multiple roundpoint structures have increased habitat diversity at the site by creating a series of individual scour holes directly downstream of the structures.

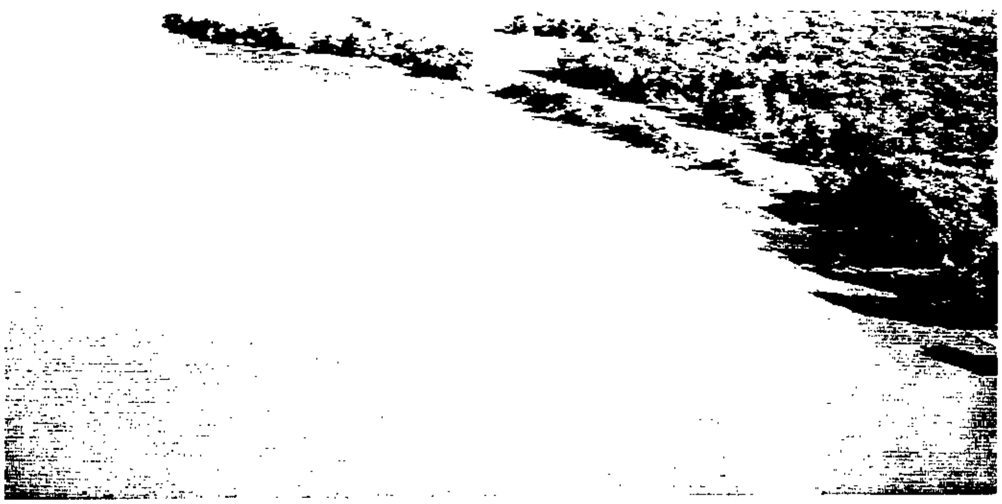

Figure D. Multiple roundpoint structure at Mississippi River mile 266.

OFF-BANKLINE REVETMENT

The St. Louis District has traditionally used bankline revetment to stabilize caving banklines along the Mississippi River. Revetment has proven to be an effective means of stabilizing the navigation channel but often results in the clearing and grading of the bankline. Off-bankline revetment provides an alternative to the traditional bankline revetment techniques. Instead of placing revetment on the bank, a parallel stone structure is built riverward of the bankline. The length and height of the structure is dependent on each situation, but when used on islands, often runs the length of the island. In most cases the upstream end of the structure is tied into the bank. Notches are placed throughout the off-bankline revetment to allow an exchange of water and allow both fish and boat access to the newly created off-channel habitat. There are five sites within the St. Louis District where off-bankline revetment has been used instead of traditional revetment.

From 1991 to 1995 the Illinois Department of Natural Resources conducted fish sampling on the Gosline Island off-bankline revetment in Pool 24 of the Mississippi River (Atwood, 2001c). The results of that work showed that the off-bankline revetment, placed in the mid-1980s, was providing valuable habitat for a variety of fishes. A total of forty-eight species of fish was collected during sampling, with 47 species associated with the habitat created by off-bankline revetment. Seven species of centrachids (sunfish and bass species generally considered off-channel fishes) were collected inside the off-bankline revetment. The report stated that the off-bankline revetment provided excellent habitat for quality sized catfish. Species composition and number of young of the year fish present indicated that the inside of the off-bankline revetment was providing backwater habitat in a reach where such habitat was limited.

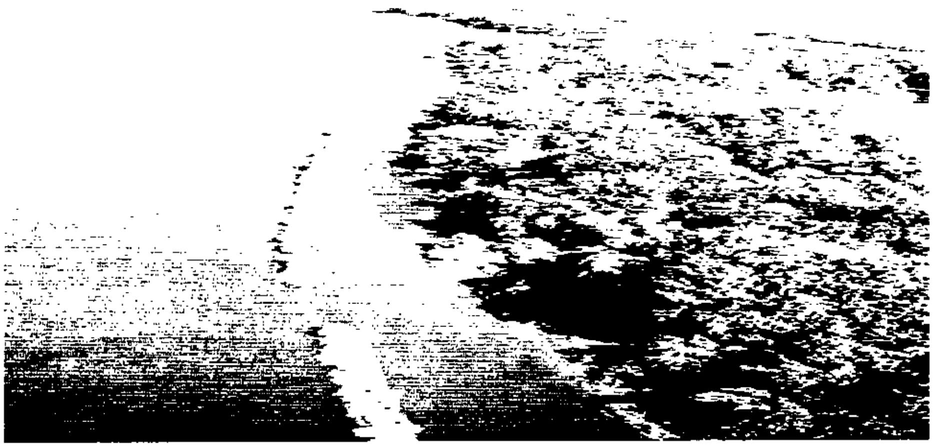

Figure E. Off-bankline revetment at Crider Island, Mississippi River mile 280. Note the notch in the structure to allow water exchange and angler and fish access.

BULLNOSE DIKES

Bullnose dikes are rock structures placed at the heads of degraded or eroding islands to protect the islands from further damage. Bullnose dikes, which look similar to chevron dikes, are placed upstream of islands to eliminate the erosion resulting from water or ice flows hitting and scouring the head of the islands. Like chevron dikes. during high flows bullnose dikes are overtopped, which creates a scour hole directly behind the dike. The material from the hole is deposited just downstream against the head of the island, further protecting the island from erosion. To allow fish access to the resulting scour holes and to the habitat created behind the dikes, either the dikes are notched or the dikes are left unconnected to the island. Prior to bullnose dikes, conventional maintenance would have been to place revetment on the head of the island. Revetment in those cases would have involved bank clearing and grading because the island heads had eroded to a vertical face. Bullnose dikes avoid further disturbance to the island, encourage deposition at the head of the island, and create off-channel habitat for fish and waterfowl. The St. Louis District has installed bullnose dikes at three locations on the Mississippi River.

Bullnose dikes have not been extensively monitored. Physical monitoring by the St. Louis District of a bullnose dike at river mile 267 found that depths behind the dike ranged from less than one meter to over five meters. Electro-fishing work completed by the Illinois Department of Natural Resources at the same dike collected 21 species of fish during one sampling trip (Atwood, pers. comm.). Work conducted by the Missouri Department of Conservation at a bullnose dike at river mile 292 (Brummett, 2001) also noted a diversity of depths behind the dike and an accumulation of woody debris which "will likely benefit aquatic organisms".

Figure F. Bullnose dike at the head of Peruque Island, Mississippi River mile 235. Note the notch in the structure and the deposition along the head of the island.

NOTCHED DIKES

The first notched dike in the St. Louis District was completed in 1972. Dikes were originally notched to try and create a pattern of flow through dike fields which would reduce deposition in those fields (Neimi and Strauser, 1991). What resulted was not reduced deposition but rather the formation of small bars in the middle of the dike fields, with the development of small chutes or side channels between the bars and the bank. In addition, the areas below notched dikes began to show a greater diversity of depths, and consequently greater habitat diversity than dikes without notches. Since those original efforts, almost 200 dikes have been modified within the District. Notches have been cut in closing structures to facilitate greater flow in side channels, below side channels to allow greater fish access to backwater habitat, to create islands within dike fields, and to create greater habitat diversity within dike fields.

Smith et al. (1982) found that while fish communities were similar between notched and unnotched dikes, there appeared to be a broader array of life stages using the notched dike fields. This is likely a result of the greater variety of habitats created below notched dikes. Smith et al. (1982) also found greater macroinvertebrate numbers associated with notched dikes.

Figure G. Islands created at Mississippi River mile 100 by notched dikes.

INNOVATIVE RIVER STRUCTURES ON THE ILLINOIS RIVER

Innovative river training structures have proven to be successful tools for both maintaining the navigation channel and for preserving, creating, and enhancing habitat on the Mississippi River. The same opportunities exist within the Illinois River. While all six structures have application on the Illinois River, three structures (chevron dikes, off-bankline revetment, and bullnose dikes) have widespread applicability. A closer look at three sites on the lower Illinois River demonstrates the potential of these structures for habitat improvement.

Twin Islands (River mile 38)

Twin Islands are representative of many of the islands on the lower Illinois River. The upper ends of both islands are severely eroded from ice and flow scouring. Scouring is to such a degree that trees have started to fall into the water, which only accelerates the erosion problem. If left unchecked, both islands will continue to erode, and will eventually disappear. The riverward side of the smaller upstream island also exhibits bankline erosion caused by passing tow and recreational traffic. At this site a bullnose dike placed across the head of these two islands would greatly curtail the existing erosion problem. Extending the bullnose dike down along the bank of the smaller riverward island would also protect that bank from further erosion. Notching the dike would still allow flow between the two islands. A bullnose dike at this location would also provide protected, slack water, off-channel habitat for fish.

Panther Creek Reach (river mile 38 to 35)

The Panther Creek stretch of the Illinois River provides an excellent opportunity to create deep off-channel habitat, improve the navigation channel, and provide an area for beneficial placement of dredge material. The river at this location is very wide. Because of that width, water velocities decrease in this stretch, dropping sediment out of the water column, resulting in deposition across the channel. What has resulted is the need for frequent dredging. Placement of the chevron dike, or a series of chevron dikes, along the shallow right descending bank would help increase conveyance through this reach by directing flows into the navigation channel. Placement of dredge material behind these dikes would result in island formation, creating not only new terrestrial habitat but new side channels as well. Once created, the chevron dikes would help protect the newly formed islands from being washed away, functioning similar to bullnose dikes. In addition, during high flows scour holes would form directly behind the chevron dikes, creating much needed deep, slack water over-wintering habitat for fish.

CONCLUSION

Innovative river training structures have been proven to be effective river training tools. Biological monitoring of these structures has shown increased habitat diversity in the river when compared to the habitat produced by traditional measures. Innovative structures have not only been found to provide valuable aquatic habitat, like over-wintering and nursery areas, but also used to create wetland habitat, islands, and side channels. Selective use of these structures on the Illinois River would protect and provide both terrestrial and aquatic habitat within the system. Many of the mechanisms needed to get these structures placed in the Illinois River are already available, although they have been rarely utilized.

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INVASION AND TRANSPORT OF NON-NATIVE AQUATIC SPECIES IN THE ILLINOIS RIVER

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ABSTRACT

Aquatic organisms, representing nearly every phylogenetic group, have been introduced beyond their native range throughout North America and the world. Reasons for these introductions are numerous and include real or perceived economic benefits, accidental introductions through escapement, and introduction as unknown "stow-aways" on transport vessels. Large rivers have been quite susceptible to invasion of aquatic organisms because of their use as national and international shipping lanes, continuity over a relatively large geographic area, and generally altered state due to various management practices. The Illinois River is no exception to this susceptibility and may actually be more disposed to invasion because of its connection to two major ecosystems (Mississippi River Basin & Great Lakes). Over the last two decades several aquatic species have established new populations in the Illinois River including zooplankton (e.g., *Daphnia Lumholtzi*, *Bythotrephes cederstroemi*), mussels (e.g., zebra mussel *Dreissena polymorpha*), aquatic vegetation (e.g., Eurasian water milfoil *Myriophyllum spicatum*) and fish (e.g., bighead carp *Hypophthalmichthys nobilis*, silver carp *Hypophthalmichthys molitrix*, white perch *Morone americana*) and the impacts of most of these organisms are not well known. However, based on life history characteristics, the influence some of these species may have on the Illinois River ecosystem could be fairly significant and therefore pose a serious threat to the biological integrity of the river. This paper provides an overview of non-native species introductions to the Illinois River and briefly discusses their potential impacts and dispersion throughout the Illinois River Basin.

INTRODUCTION

Aquatic organisms from nearly every taxonomic group have been introduced beyond their native range, not only in North America, but throughout the world. The impacts of these introductions are not completely known. However, the potential to interfere and influence native biological communities is substantial. These impacts could range from direct competition for resources to indirect influences that could resound through the trophic structure of the native communities.

Introductions of species beyond their native ranges can be classified into two general categories: 1) intentional and 2) non-intentional. Deliberate introductions of aquatic organisms have been widespread in much of North America due to real or perceived economic and recreational benefits. Many fish species have been introduced to increase sport fishing opportunities. Likewise, many non-native aquatic species have been used in the aquaculture and aquaria industries. It is equally important to acknowledge that many aquatic species are being introduced through unintentional means as well. Impacts of "stowaway" species on shipping vessels such as zebra mussels *Dreissena polymorpha* provide a clear illustration of how devastating unintentional introductions can be when they invade new systems.

Introductions of non-native species in the United States are not a recent phenomena. For example, Nico and Fuller (1999) summarized fish introductions since 1850. Nico and Fuller (1999) reported that at least 500 non-indigenous fish taxa had been recorded in the United States alone over this 150 year period. Of these recorded data, 317 taxa were introduced from within the United States (e.g., striped bass *Morone saxatilis*, rainbow trout *Oncorhynchus mykiss*, alewife *Alosa psuedoharengus*), 185 taxa were introduced into the United States from other countries (e.g., brown trout *Salmo trutta*, tilapia *Oreochromis spp.*, several Asian carp species), and 22 were cultured hybrids (e.g., tiger muskellunge *Esox masquinongy* X *Esox lucius*, hybrid striped bass *Morone saxatilis* X *Morone chrysops*, hybrid sunfishes). Unfortunately, the rate of establishment of these species appears to be increasing with improved transportation capabilities and the desire to improve fish culturing and recreational opportunities over the last half of the 20th Century. For example, data from the Long Term Resource Monitoring Program (LTRMP) along the La Grange Reach of the Illinois River show an increase in non-native fish from two species in 1990, to a cumulative total of 11 in 2000 (LTRMP, unpublished data). The objectives of this paper are to: 1) discuss conditions conducive to non-native species introductions into the Illinois River and 2) provide an overview of non-native species found in, or threatening to enter, the Illinois River.

CONDITIONS CONDUCIVE FOR INTRODUCTION

The Illinois River (Figure 1), was historically connected solely to the Mississippi River ecosystem, but is now also connected to the Great Lakes ecosystem through a series of canals built in 1900. These canals were built for numerous reasons including facilitating shipping and waste water removal from urban areas (Starrett 1971). Regardless of the reasons for this connection, a major result has been that the Mississippi and Great Lakes ecosystems have been artificially connected, creating a conduit for introductions of non-native aquatic species from either ecosystem to enter the other system via the Illinois River. Given the relatively recent increase in aquatic species introductions and because non-native species that have been introduced into the two respective ecosystems vary considerably in taxonomic origin and in function, substantial changes in community structure could occur as non-native organisms expand their range. Therefore, the Illinois River ecosystem is confronted with a stream of new non-native aquatic organisms encroaching from upstream and downstream areas. Summaries of existing information on non-native species in the Illinois River can then be loosely based on the origin of their introduction.

NON-NATIVE SPECIES IN THE ILLINOIS RIVER

Great Lakes Introductions

Many aquatic taxa have been introduced into the Great Lakes that have yet to become established in the Illinois River. Therefore, this discussion will largely focus on key species that are currently established in or appear to pose a serious, immediate threat to the Illinois River. Several zooplankters have been introduced into the Great Lakes that may pose threats to the Illinois River. Two that have most recently come to the forefront are the spiny waterflea

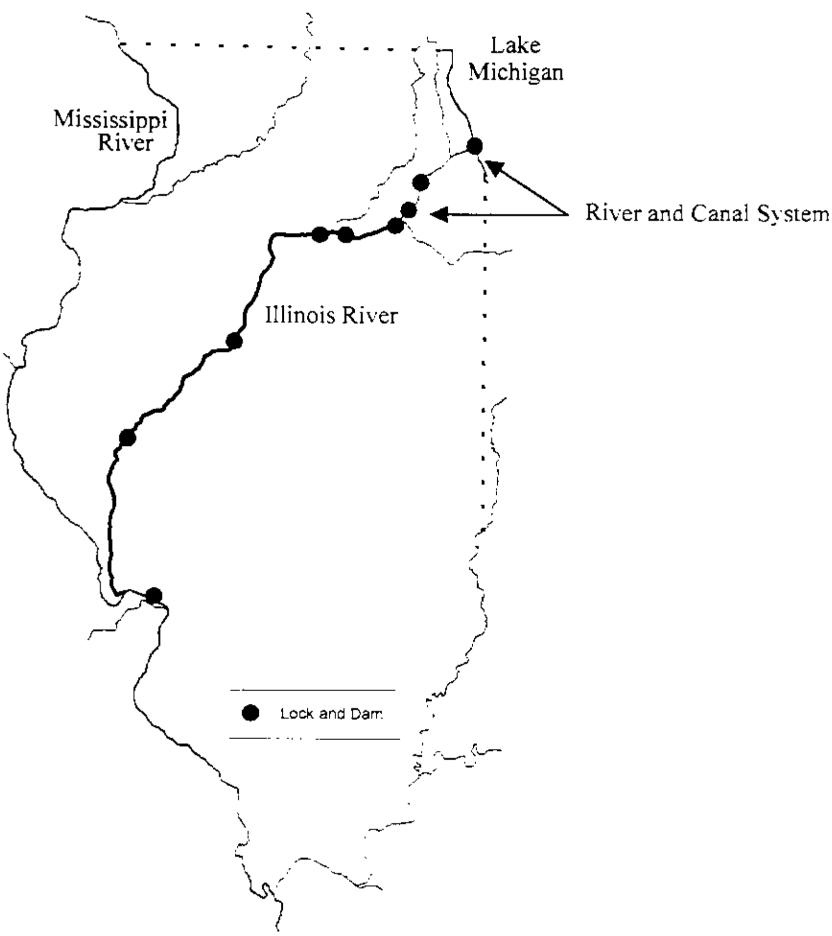

Figure 1. Map of the Illinois Waterway establishing a migrational link between the Great Lakes and Mississippi River ecosystems.

Bythotrephes cederstroemi, first recorded in the late 1980's, and the fishhook waterflea *Cercopagis pengoi*, first recorded in the late 1990's. Their body morphology is drastically different compared to native zooplankters being larger and having elongated spines and appendages. The impacts of these species are not clear, but will likely influence not only zooplankton community structure through competition, but also influence other trophic levels. For example, young-of-year fish may be reduced in their capacity to consume/digest these zooplankters if they become dominant in the Illinois River. Fortunately, there are some life history limitations (e.g., thermal thresholds) that may prevent large-scale establishment of these species in the Illinois River.

Zebra mussels are probably the most well known non-native species introduced from the Great Lakes. Zebra mussels were first recorded in the Illinois River in 1991 (Sparks and Marsden, 1991), and had established large populations in the river by 1993 (Miller and Payne, 1997). This species has consistently remained present in most reaches of the river, but at somewhat reduced numbers compared to their initial populations. The impacts of these mussels have been considerable in the Great Lakes due to their high filtering rates that can alter nutrient processes and their ability to colonize hard surfaces. One ecological concern is for the wide diversity of native Unionid mussels that are being affected by zebra mussel infestations. Similar concerns are also warranted along the Illinois River where Unionid communities have experienced high mortality rates in affected areas (INHS unpublished data). Additional concerns for the Illinois River relate to the link between two ecosystems in that the pelagic larvae can and are transported downstream, thus providing a significant source population for sustaining existing zebra mussel populations in the Mississippi River Basin. Researchers at the Illinois Natural History Survey are currently investigating these population dynamics and potential means of control.

Several fish species have also been established in the Illinois River through the Great Lakes. Round Gobies *Neogobius melanostomus*, originally from Eurasia, were first recorded in the Illinois River in the late 1990's. This species is rapidly expanding its populations and poses a serious threat to fish communities along the Illinois River. Round gobies are aggressive feeders and spawners that have the potential to strongly compete with native benthic species. This competition is a major concern due to the number of declining benthic fishes (e.g., darters and sculpins) in the Mississippi River Basin. An electronic dispersal barrier is currently being constructed in an attempt to control movements of round gobies and other non-native fish species into the Illinois River. Unfortunately, this species has already been documented downstream of the dispersal barrier construction site (U.S. Fish & Wildlife Service, 2001; http://midwest.fws.gov/LaCrosseFRO/projects/roundgoby.html).

Indigenous to the Atlantic coastal region of North America, white perch *Morone americana* have continued to expand their range into the Great Lakes region through various shipping waterways. White perch have been found in increasing numbers along the Illinois River since about 1991 (LTRMP unpublished data). These fish are small predators feeding almost exclusively on fish eggs during the spawning season and small cyprinids the remainder of the year (Schaeffer and Margraf 1987). This raises concern for high levels of predation on native species that coexist in similar habitats as white perch. Another major concern is that white perch are hybridizing with other *Morone* species that are native to the Illinois River and diluting their genetic integrity. In fact, Illinois Natural History Survey staff have collected some suspected individuals that are white perch X *Morone spp.* hybrids in the La Grange Reach.

Mississippi River Basin Introductions

Invasive species establishing populations in the Illinois River from the Mississippi River Basin are predominantly fish at this time. However, sources of introduction for some species are not known, but have been speculated to have moved throughout the Mississippi River Basin via various methods. Dispersal of the zooplankter *Daphnia lumholtzi* is one such species. Little is known about their establishment in the United States, but the Illinois River is their extreme northern known location at present. *Daphnia lumholtzi* is endemic to Africa, Asia, and Australia (Havel et al. 1995) and has physical characteristics (i.e., spines) similar to the non-native zooplankters introduced to the Great Lakes. Therefore, many of the concerns listed earlier hold for this species as well.

By far, the largest collection of invasive species threatening the Illinois River is a group of carp species originating from Eurasia, typically termed Asian carp. There are currently five species of Asian carp (common carp *Cyprinus carpio*, goldfish *Carassius auratus*, grass carp *Ctenopharyngodon idella*, silver carp *Hypophthalmichthys molitrix*, bighead carp *Hypophthalmichthys nobilis*) established in the Illinois River and one species (black carp *Acanthogobius flavimanus)* that may be on the brink of introduction. Collectively, these species may have detrimental effects on the native faunal communities because their feeding habits cover a wide breadth of trophic levels. Asian carp can be divided into two groups: 1) species introduced over a large geographic scale and 2) species introduced over a small geographic scale with expanding populations.

Large-scale Introductions

Common carp were introduced into North America in the 1800's primarily for food fish production (DeKay 1842) and were stocked into Illinois waters by the 1880's (Baird, 1887). Since that time, common carp have maintained viable populations on the Illinois River and have become a commercial fishery resource. Common carp are omnivorous and believed to be more tolerant of degraded environmental conditions than native Illinois River species. This tolerance has provided common carp an opportunity to thrive in areas where many native fish species could not because many water quality parameters during the early to mid 1900's were below today's standards. However, as water quality improves, there is some indication that common carp numbers are on the decline. For example, long term population data from 1957 through 2000 show that, while still abundant in all reaches of the river, a significant decline in carp numbers has occurred throughout the river over this period of record (Figure 2). This decline has been at least partially attributed to improved water quality that would allow native species to out compete common carp in improved conditions.

Goldfish may have been introduced as early as the 1600's by settlers wanting to add them to the fish diversity in North America (Courtenay and Stauffer, 1990). Goldfish are present in the Illinois River, but generally in low numbers. Little information is available on the ecological

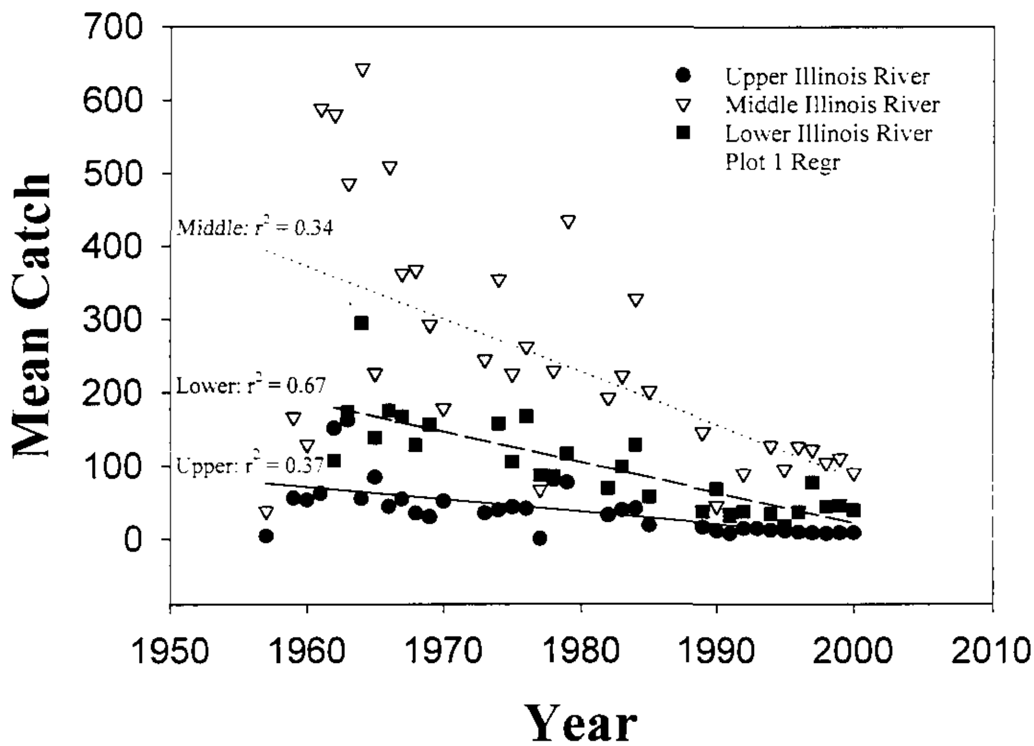

Figure 2. Population trends of common carp in the upper, middle, and lower thirds of the Illinois River 1957 - 2000. All regressions were significant at the $P < 0.05$ level.

impacts of goldfish in riverine systems. However, their population trends along the Illinois River appear to mimic those of the common carp in the last half of the 1900's.

Grass carp were introduced into Arkansas and Alabama in the 1960's. They were originally introduced as a means of vegetation control in aquaculture facilities because they are herbivorous. Soon after their introduction, many resource managers began to use grass carp as a management tool to control vegetation in public and private waters. Reproducing populations have been established along the Illinois River and continue to pose a threat to aquatic vegetation throughout the region (LTRMP unpublished data).

Small-scale Introductions

Bighead and silver carp were originally introduced into Arkansas from Taiwan in the 1960's and 1970's with the intent to create a second fish crop from existing catfish ponds (Henderson, 1979). Both of these species are large bodied planktivores and the original hope was that these fish would be able to utilize the abundance of food resources in the water column to establish another "crop" of consumable fish. However, almost as soon as they were brought into the United States, some individuals escaped into river systems linked to the Mississippi River. Both species have since expanded their range to most of the larger rivers in the middle of the United States including the Mississippi, Missouri, Ohio, and Illinois rivers and continue to expand their range (Tucker et al., 1996). As part of their range expansion, areas of the Mississippi and Illinois rivers presently supporting bighead and silver carp populations are observing high population growth rates (Chick and Pegg, 2001). Resounding negative impacts on the ecological communities could result if these two species continue to expand. Both species can attain sizes in excess of 15 to 20 kg requiring large amounts of energy from planktonic sources. Some of the impacts include direct competition with native filter feeding fish like paddle fish *Polyodon spathula* and the larval stages of all fish species as well as drastic changes in zooplankton community structure and abundances. All of these impacts could cause unforeseeable shifts in food web dynamics along the Illinois River.

Molluscivorous black carp were also brought into the United States through Arkansas and Alabama during the 1990's but have very limited ranges at the moment. The aquaculture industry wishes to use black carp to control snail populations in culture ponds because these snails are intermediate hosts to a nematode parasite that infects fish making the flesh unsaleable. There has been considerable debate on the use and introduction of black carp into other states. However, limited introductions have been authorized by a few states. This species has not yet been documented in the Illinois River but poses a serious threat to already declining native mollusk communities.

CONCLUSION

There is no doubt that the Illinois River is being invaded by non-native species from both ends of the system. Weighty questions remain as to whether the trend of new species found in the Illinois River will continue at its present pace, increase, or decrease. Steps are being taken to prevent the spread of more species into the Illinois River and the other major ecosystems in the region. For example, a dispersal barrier, aimed at preventing fish migrations, is nearing completion in the Illinois Waterway. While it is very important to implement management practices restricting the spread of species already present, it is equally, if not more, important to establish and enforce laws and regulations that hinder the introduction of new species.

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RESTORATION OF ILLINOIS RIVER FLOODPLAIN: THE NATURE CONSERVANCY'S SPUNKY BOTTOMS AND EMIQUON PROJECTS

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ABSTRACT

The Nature Conservancy is reestablishing natural habitat in the Illinois River floodplain as one strategy for restoring and conserving the biological diversity of the Illinois River ecosystem. Restoration is underway or being planned for over seven thousand acres of Illinois River floodplain property owned by the Conservancy at the Spunky Bottoms and Emiquon Preserves. Restoration and management of these areas are based on the best available science and undertaken in an adaptive management framework. The projects are intended to provide models for restoration and management of large floodplain river ecosystems, thereby contributing to the conservation of the native plant and animal communities they once supported.

INTRODUCTION

The phenomenal biological productivity and diversity of the pre-European settlement Illinois River, a large-floodplain river ecosystem, was dependent upon the dynamic relationship between the river and its floodplain. Predictable floods stimulated nutrient fluxes and provided many aquatic organisms access to habitats critical for completing their life cycles. During most years, relatively stable water periods from July through October facilitated the development of lush plant beds and bottomland forests that provided food, both directly and indirectly, and habitat for a diversity of animals. Over the last century, the river has been subjected to numerous human-induced stresses including being isolated from nearly one half of its floodplain by levees. Most backwaters that remain connected to the river have been degraded by excessive sedimentation and unnatural water level fluctuations. Aquatic plant communities have been decimated and species diversity of trees in bottomland forests has been significantly reduced; concurrently, animal populations dependent on these plant communities have been negatively impacted. Even so, the Illinois River has been identified as having important attributes that make it a key candidate for restoration (National Research Council 1992) and currently, heightened levels of interest in and understanding of the values of healthy river ecosystems help make restoration plausible.

During 1997 and 1998, the Illinois Chapter of The Nature Conservancy engaged over forty scientists and managers from local, state, and federal agencies; academia; and non-governmental organizations in a planning process to develop a comprehensive site conservation plan for conserving native biological diversity in the Illinois River. The group identified threats to biodiversity (Miller, Poiani, and Merrill 1998) and developed strategies to abate the threats (The Nature Conservancy 1998). Habitat loss and degradation were identified as key threats to the conservation of native plant and animal species in the Illinois River ecosystem. To abate this threat, the Conservancy is implementing a strategy to restore floodplain habitat and ecological processes that once supported the phenomenal biological productivity and diversity of the river valley (The Nature Conservancy 1998). Toward that end, the Conservancy has acquired a total of over seven thousand acres of former floodplain habitat at two projects along the Illinois River--the Spunky Bottoms and Emiquon Preserves. With partners, we are working to plan and implement restoration and management that will to the extent practical, restore important ecological processes and floodplain habitats at these sites.

SPUNKY BOTTOMS PRESERVE

The Conservancy purchased the 1157-acre Spunky Preserve from the John Hancock Life Insurance Company for $2 million in 1997. The property is adjacent to the Illinois River in Brown County and is part of the 1800-acre Little Creek Drainage and Levee District, located approximately 3 miles northwest of Meredosia and 11 miles southeast of Mount Sterling (figure 1). It is directly across the river from the U.S. Fish and Wildlife Service's 2900-acre Meredosia National Wildlife Refuge. The property had been leveed and drained for agricultural production in the 1920s. The current levee completely isolates the property from overland flow from the river. For agriculture, precipitation, inflow from three small ephemeral streams that enter the property from the bluff immediately west of the property, and groundwater accumulated in the system of ditches and was pumped over the levee and into the river. The land was not tiled to facilitate drainage. After a nearly two-year planning process that included participants from local, state, and federal agencies; academia; and other non-governmental organizations, a restoration plan for Spunky Bottoms was produced (The Wetlands Initiative 1999). The Conservancy started restoration and management of the site in January 1999. Initial actions included cessation of agricultural production and significantly reducing the amount of pumping to remove water from the preserve. Pumping water out of the preserve was initiated only when required to protect the primarily agricultural lands of the four neighboring landowners in the district.

To date, restoration at Spunky Bottoms has proceeded well and been encouraging, documenting the resiliency of wetland communities. In May 1999, we planted twenty species of native grasses and forbs on approximately 110 acres of higher elevation land along the foot of the bluff at the western edge of the property. All seeds were of the local ecotype, having been collected within 150 miles of the site. Germination and growth was good, and by August 1999, some of the planted grasses were over 6 feet tall. By September 2000, we had identified specimens of all twenty species planted.

From May 1999 through May 2000, we engaged over 300 volunteers and planted nearly 6000 bottomland hardwood trees along a ridge that runs parallel to the river and is likely a former natural levee. We used RPM-type, containerized trees produced from seeds collected within 150 miles of the preserve. Trees ranged from 3- to 7-ft tall and were planted at a density of 25-30 trees per acre over 220 acres. The twelve tree species were once abundant in the Illinois River floodplain but have declined dramatically over the past century because of over harvest, land use changes, and altered hydrology. Many tree species planted (e.g., Pin Oak *Quercus palustris*, Pecan *Carya illinoensis*, and Black Walnut *Juglans nigra*) formerly were important mast producers for native wildlife in the valley. An August 2000 survey showed survival rates over 90%.

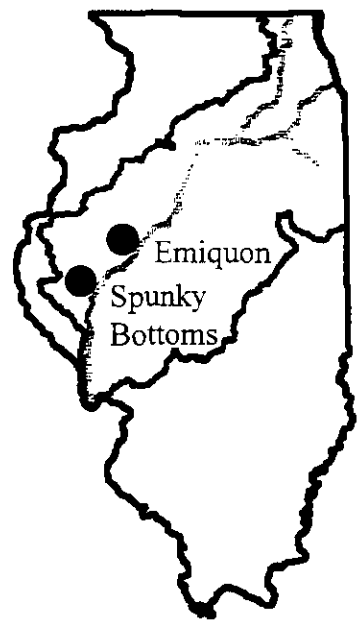

Figure 1. Locations of The Nature Conservancy's Spunky Bottoms and Emiquon Preserves in the Illinois River watershed.

Prior to restoration, The Wetlands Initiative investigated the seed bank at the site and found viable seeds of native wetland plant species. As a result, no major planting of wetland plant materials was undertaken. Soon after the reduction of pumping in January 1999, water filled the ditches and spilled onto adjacent low-lying areas. As a more normal hydrograph was reestablished, both plant and animal communities responded. To date, over forty-six species of moist soil and aquatic plant species have been documented at the site (Table 1). Likewise, native animal communities responded to the restored habitats. By fall 2001, ten state and/or federally threatened or endangered species had been documented at the site, and ten new county records were identified for amphibians and reptiles (Table 2).

While various animal species quickly returned to the restored habitats, without a river connection, access remains limited for aquatic organisms. Many native aquatic species need to move into and out of backwater habitats to fulfill various life history requisites--for example, backwaters may be needed by various fishes for spawning, nursery areas, feeding, and/or over wintering. Absence of an overland connection between the preserve and the river also limits the effectiveness of numerous other floodplain functions normally associated with floodplain backwaters--among them improving water quality, managing sediments, storing stormwater/floodwater, and stabilizing river flows. The Conservancy is cooperating with the Saint Louis District of the U.S. Army Corps of Engineers on plans for a Section 1135 environmental restoration project at Spunky Bottoms. A major feature of the project is an aquatic organism passage/water control structure that will provide a managed connection between the restored backwater habitats at the preserve and the adjacent mainstem of the Illinois River. The structure is being designed and will be managed to minimize, as practical, negative impacts of today's river (e.g., unnatural water level fluctuations, excessive sedimentation, and invasive species) while providing access for aquatic organisms and restoring other floodplain functions.

Table 1. Moist soil and aquatic plants that resulted from the seed bank or natural dispersal after restoration of a more natural hydrograph at the Conservancy's Spunky Bottoms Preserve.

Moist soil		Aquatic	
Common name	Scientific name	Common name	Scientific name
Beak Rush	*Rynchospora cephalantha*	American Elodea	*Elodea canadensis*
Bluejoint Grass	*Calamagrostis canadensis*	American Lotus	*Nelumbo lutea*
Boneset	*Eupatorium perfoliatum*	American Pondweed	*Potamogeton nodosus*
Bur Marigold	*Bidens cernua*	Arrow Arum	*Peltandra virginica*
Buttonbush	*Cephalanathus occidentalis*	Blunt Spikerush	*Eleocharis obtuse*
Cardinal Flower	*Lobelia cardinalis*	Bur-Reed	*Sparganium eurycarpum*
Curly Dock	*Rumex crispus*	Chara	*Chara spp.*
Daisy Fleabane	*Erigeron anuus*	Common Arrowhead	*Sagittaria latifolia*
Ditch Stonecrop	*Penthorum sedoides*	Common Cattail	*Typha latifolio*
Little Bluestem	*Andropogon scoparius*	Coontail	*Ceratophyllum demersum*
Nut Sedge	*Cyperus flavescens*	Humped Bladderwort	*Utricularia gibba*
Obedient Plant	*Physostegia virginiana*	Mosquito Fern	*Azolla mexicana*
Panicled Aster	*Aster simplex*	Narrowleaf Cattail	*Typhya angustifolia*
Rice Cut Grass	*Leersia oryzoides*	River Bulrush	*Scirpus fluvulatus*
Rose Mallow	*Hibiscus palustris*	Slender Spikerush	*Eleocharis acicularis*
Sedge	*Carex vulpinoidea*	Water Plantain	*Alisma subcordatum*
Sedge	*Carex hystericina*	Water Purslane	*Peplis diandra*
Sedge	*Carex stricta*	Water Smartweed	*Polygonum fluitans*
Sedge	*Carex lanuginoise*	White Water Butter Cup	*Ranunculus trichophyllus*
Sedge	*Carex prasina*		
Sedge	*Carex stipata*		
Sedge	*Carex diandra*		
Smartweed	*Polygonum spp.*		
Swamp Milkweed	*Asclepias incarnata*		
Tickseed	*Bidens aristosa*		
Water Parsnip	*Sium suave*		
Wild Millet	*Echinochloa crusaglii*		

EMIQUON PRESERVE

During 2000, the Conservancy initiated its Emiquon project with three acquisitions totaling 7604 acres along the Illinois River in Fulton County; the purchase price was $18.45 million. The majority of the purchase (7527 acres) was from Wilder Corporation of Delaware. The Conservancy property is 1 mile northwest of Havana and 3 miles southeast of Lewistown. The land is adjacent to the U.S. Fish and Wildlife Service's Emiquon National Wildlife Refuge (currently 2113 acres) and immediately across the Illinois River from the Service's 4488-acre Chautauqua National Wildlife Refuge, providing an opportunity for bluff-to-bluff protection of a segment of the Illinois River floodplain.

This Conservancy property once sustained diverse and abundant wetland complexes around two backwater lakes--Flag and Thompson. In addition to its importance to Native American cultures, in the late 1800s and early 1900s, this area was well known for its waterfowl hunting and fishing, both for recreation and for commercial markets. Similar to the Spunky Bottoms property, this floodplain was leveed and drained for conversion to agriculture in the early 1920s. Today, over 5500 acres of the Conservancy's Emiquon property is in the Thompson Lake Drainage and Levee District. District land is isolated from overland connection to the river by 12.3 miles of river and flank levee. The majority of the district is tiled and drained by ditches with accumulated water being discharged directly to the river via a single pump station.

Table 2. State and federally threatened and endangered species and new Brown County distribution records for animals documented at the Spunky Bottoms Preserve after restoration began in January 1999.

Common name	Scientific name	Status
River Otter	*Lontra canadensis*	ST
Bald Eagle	*Haliaeetus leucocephalus*	ST FT
Osprey	*Pandion haliaetus*	SE
Northern Harrier	*Circus cyaneus*	SE
Pied-Billed Grebe	*Podilymbus podiceps*	ST
Black Rail	*Laterallus jamaicensis*	SE
American Bittern	*Botaurus lentiginosus*	SE
Black-Crowned Night Heron	*Nycticoras nycticoras*	SE
Little Blue Heron	*Egretta caerulea*	SE
Henslow's sparrow	*Ammodramus henslowii*	SE
Eastern Spiny Softshell Turtle	*Apalone spinifera*	CR
StinkpotTurtle	*Sternothaerus odoratus*	CR
Common Snapping Turtle	*Chelydra serpentina*	CR
False Map Turtle	*Graptemys pseudogeographica*	CR
Western Ribbon Snake	*Thamnophis proximus*	CR
Prairie King Snake	*Lampropeltis calligaster*	CR
Five-Lined Skink	*Eumeces fasciatus*	CR
Eastern Tiger Salamander	*Ambystoma tigrinum*	CR
Green Frog	*Rana clamitans*	CR
Plains Leopard Frog	*Rana blairi*	CR

ST = State Threatened SE = State Endangered
FT = Federally ThreatenedCR = County Record

Currently the former owner has leased the property to continue agricultural operations through 2002 with an option to extend that lease through 2009. In the interim, the Conservancy is formulating a restoration and management plan for the preserve. The primary objective for the restoration and management of the lands within the boundaries of the Conservancy's Emiquon Project is to restore natural ecological processes and habitats that promote and sustain the native species and aquatic and terrestrial communities once found in this region of the Illinois River. Secondary objectives are to:

1. develop, test, and export successful techniques for restoring and sustaining the natural biological diversity of large floodplain river ecosystems;
2. incorporate the principles of adaptive management as a necessary component of natural area management;
3. demonstrate the benefits of ecological restoration of critical habitats for threatened and endangered species;
4. evaluate the potential for storing floodwaters and reducing unnatural water level fluctuations;
5. promote the ecological and cultural importance of the Emiquon area by developing and implementing educational programs;
6. demonstrate that natural area conservation efforts can be an important component of local and regional economic development strategies; and
7. provide excellent recreational opportunities.

During fall 2000, the Conservancy initiated the planning process for the Emiquon Preserve. Two advisory groups were set up to provide input and review during the planning--the Emiquon Science Advisory Council (ESAC) and the Emiquon Community Advisory Council (ECAC). The ESAC is composed of nearly forty scientists and managers, approximately two-thirds with experience on the Illinois River. In April 2001, after reviewing the Conservancy's objectives and visiting the site, the ESAC identified several information gaps and suggested the use of simulation modeling to identify and evaluate various restoration and management scenarios. Toward that end, numerous data collection efforts are underway (e.g., ground and surface water monitoring, topography, and seed bank) and models are being developed for hydrology, hydraulics, sedimentation, and vegetation.

The ECAC consists of over thirty community members including representatives from business, local government, local educational institutions, and sportsmen. As with the ESAC, the ECAC was given an overview of the Conservancy's goals for the preserve. During a facilitated workshop, the ECAC identified and prioritized ways the community could benefit from the project. Smaller, self-formed workgroups are further evaluating opportunities for recreation, compatible economic development, and education and providing input and review of relevant portions of the planning process.

At both the Spunky Bottoms and Emiquon Preserves, scientific monitoring is an important part of the Conservancy's restoration and management. The Conservancy benefits from partnerships with a multitude of agencies, universities, and non-government organizations that share in the desire to develop and implement science-based restoration and management approaches to conserving the Illinois River. At Conservancy sites, collected data and resulting information are used to (1) document change, (2) provide feedback for adaptive management, and (3) guide other floodplain river restoration and management. Implementing the Conservancy's strategy of floodplain restoration and management is but one piece of a large and complex puzzle for conserving the natural attributes of the Illinois River ecosystem. Other Conservancy strategies being employed in the watershed include promoting best management practices on agricultural lands, contributing to smart-growth initiatives in developing urban areas, using native vegetation to reduce erosion and stormwater impacts in urban areas, protecting river bluff habitat, and promoting water level management to effect a more natural flow regime in the Illinois River. Together with the efforts of the Conservancy, those of the many other individuals, groups, and agencies working toward sound ecological management of the Illinois River and its watershed should pay dividends that will sustain the native biological diversity the Illinois River ecosystem.

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Acquisition, planning, restoration, management, and monitoring of the Conservancy's Spunky Bottoms and Emiquon Preserves has been undertaken with assistance and cooperation from programs, agencies, organizations, institutions, and individuals too numerous to list. In addition to Conservancy members and donors, funding has been received from the National Fish and Wildlife Foundation, U.S. Department of Agriculture Wetland Reserve Program, U.S. Fish and Wildlife Service, The Wetlands Initiative, Grand Victoria Foundation, Rice Foundation, and Caterpillar Tractor Company. Conservancy staff including Joanne Skoglund, Tharran Hobson, and Kim Foster assisted in the preparation of this manuscript and the conference presentation.

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REMOVAL OR MODIFICATION OF BATAVIA DAM

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SUMMARY/ABSTRACT

This paper summarizes the results of the alternative development and evaluation process for the replacement of the Upper Batavia Dam. The dam was originally constructed in the 1800's to generate hydro- mechanical power for a saw and grist mill while the existing purpose of the dam is to maintain the upstream pool for aesthetic and recreational concerns. There is currently a breach near the east abutment. All of the alternatives presented in this paper look at maintaining an impoundment for the City of Batavia, while providing for recreational boat passage, fish passage and improved habitat, and environmental restoration. Two of the alternatives include lowering the elevation of the upstream pool in the river channel and river restoration in conjunction with the construction of a 12 foot high earthen dam to impound Depot Pond.

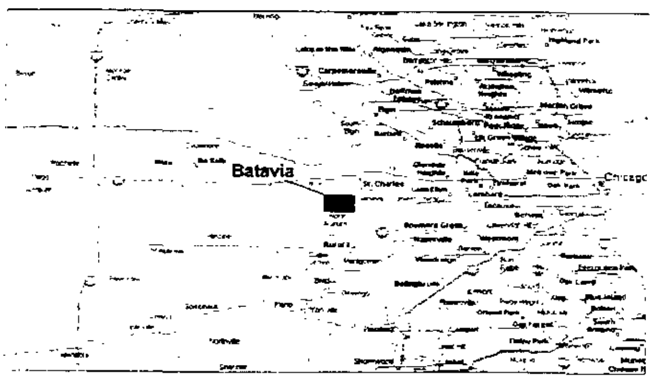

Figure 1 - Vicinity Map

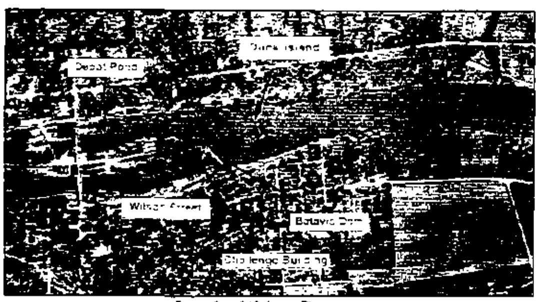

Figure 3 - 194? Aerial Photograph

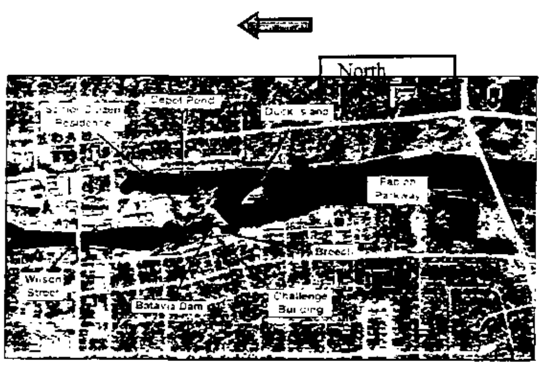

Figure 4 - 1998 Aerial Photograph

Location

The Upper Batavia Dam is located on the Fox River in Kane County, Illinois. Figure 1 is a vicinity map showing the general location of the study reach. There are 15 dams located along the Fox River in Illinois. The Upper Batavia Dam is on river mile 56.3 of the Fox River and within the City of Batavia.

DESIGN OBJECTIVES

The primary objective of this project was to identify rational concepts for the replacement of the Upper Batavia Dam. Statements of probable costs were created along with a comparative assessment of probable benefits. The alternatives offer unique configurations, so criteria other than capital cost needs to be reviewed to aid in the selection of the most appropriate alternative. To assist in this effort, specific design objectives used in the formulation of the alternatives are provided below.

Design objectives include:

- *Safety* - Create a low-hazard structure that does not result in a "drowning machine"
- *Flood Conveyance* - Maintain or improve the flood conveyance of the existing channel and dam.
- *Upstream Pool* - Maintain an upstream pool elevation of 664.7 ft.
- *Cost effectiveness* - Create alternatives that are integrated and efficiently meet practical criteria
- *Boat Passage* - Include boat passage to allow or promote recreational usage of the river.
- *Fish Passage* - Include effective fish passage.
- *Maintenance* - Reduce maintenance requirements.
- *Environmental Impacts* - Reduce negative environmental impacts associated with construction or design of the improvements.
- *Depot Pond* - Lower maintenance costs and improve water quality.
- *City Planning* - Coordinate and enhance planning and goals of the City of Batavia including those set forth in the Comprehensive Plan for the City of Batavia.

Studies reviewing fisheries design criteria and recreation were initiated. This information was then used to develop alternatives that would address some or all of the design objectives. Utilizing this criteria provides water depths and velocity that allow target fish species to ascend and descend past the Upper Batavia Multipurpose Structure. With an understanding of the target species present, the design team formulated alternatives that met project objectives.

Roughened channel approaches to fish passage have often been the best system to meet the design criteria because they mimic the natural channel and habitat. It also provides for resting areas and areas of lower-than-criteria water velocities in and amongst rocks and boulders. Because of the inherent integration with white water passage, roughened channel passage is incorporated into the various multi-purpose dam replacement alternatives.

PLANNING

The City of Batavia has a comprehensive plan, which sets forth goals for the City and specific objectives to achieve these goals. As it relates to the project at hand, the goals seek to improve the quality of the downtown core next to the river, to improve recreation opportunities, and take advantage of the natural landscape including the Fox River.

Specific open space and recreation objectives to achieve these goals are listed below:

- Respect the natural features of the Batavia landscape, including the topography, river, creeks, flood plains and wetlands.
- Preserve scenic views of the Fox River and other key features.
- Encourage continued development of recreation potential of environmental corridors including the Fox River, Mill Creek, and the Prairie Pun.
- Expand recreation activities on and along the Fox River. Consider limited boating activities in tandem with the Fox River Paddleway and canoe portage improvements. Expand pedestrian and bicycle river trails to promote recreation.

Additional objectives for the project area of Downtown Batavia that mention the Fox River:

- Maintain government uses on the island.... Integrate riverfront improvements with continued redevelopment efforts.
- South of First Street, consider appropriate adaptive reuse of the abandoned industrial structures along the river where feasible. Consider commercial uses, especially those that complement recreational activities along the river. Encourage multifamily development along the east side of the river north of Spring Street to Fayette Street. If feasible and appropriate, save existing underutilized structures for reuse.
- Upgrade the quality of the riverfront and encourage capturing its potential recreational and commercial opportunities. Encourage implementation of the recently prepared Batavia Riverwalk Plan. Continue developing river trails for pedestrian and bicycle use. Improve the Mill (Depot) Pond area in accordance with overall plans for the river.
  Ensure that the new development sensitively and appropriately incorporate the river as an amenity in the downtown.

Fisheries Concerns

Environmental groups have pointed to the harm dams do to the river as a living, changing entity and emphasize the original purposes of dams no longer exist. They seek the removal of all dams which obstruct fish passage and which serve no significant public value.

Fish sampling has demonstrated less diversity of fish species upstream of dams as compared with downstream reaches, the result of the inability of fish to migrate upstream. Dam removal offers an opportunity to restore the natural fish migration patterns and to improve the ecological health of the Fox River.

PROJECT ALTERNATIVES

All of the alternatives presented fall within the definition of a multipurpose structure; each provides both recreational and environmental benefits. The alternatives impound water yet provide for both fish passage and recreational boat passage.

Alternative 1 — Full-Width White Water Rapid

Alternative 1 includes replacement of the existing dam with a full-width river rapid. The alternative incorporates boat and fish passage into a single roughened channel with an approximate hydraulic grade of 0.65%. The upstream pool elevation of 664.7 feet is maintained while the crest of the dam is located approximately 900 feet upstream of the current location. A pool located just downstream of the existing dam would serve to dissipate residual energy and velocity from the rapid. The rapid is located entirely upstream of the existing dam, due to the constraints of the floodplain.

Alternative 2 River-flight White Water Bypass

Alternative 2 includes a stepped dam in the same location as the existing dam with a white water bypass around the west abutment. The white water bypass or boat chute would begin on the northwest side of the peninsula in Depot Pond and wrap around the peninsula. The course would end at the dam. The existing dam would be replaced with a step dam. It is angled so that flows would be directed away from the east bank of the river toward the center of the channel. The upstream pool elevation is maintained. The east side of the dam may abut downstream or upstream of the Challenge complex via an extension wall.

This alternative was rejected during the preliminary evaluation process. This was a decision made by the design team, IDNR, and the City of Batavia staff. It was not considered viable because it places high recreation traffic adjacent to the retirement community, it requires a levee or berm to mitigate flood impacts, and it causes negative impacts to the river walk.

Alternative 3 — White Water Course Through The Cut

This alternative is a refinement of an off-river white water course and would be located through the Rock Cut north of the Batavia City Hall. The course begins in Depot Pond and continues through the Cut with a minimum length of 900 feet. The Cut is widened in order to accommodate the course and adjacent area needed for maintenance, access and viewing. The existing roadway bridge to the retirement home, and pathways are replaced and relocated as necessary, but parking is lost in the city's lot south of the Cut. The upstream portion of the course is separated from Depot Pond by a divider wall. This structure is designed to withstand the difference in water surface between the pond and the lower water surface in the white water course. An intake structure would control the flow of water diverted to the course. This allows the course to be closed for maintenance, such as debris removal, and to adjust the level of difficulty in the course.

A roughened channel type fish passage is incorporated into the banks of the white water course. The course ends approximately1000 feet downstream of the replaced dam. This produces the need for a formal fish ladder structure (located on the face of the stepped dam) to accommodate fish that do not find the outlet of the off-channel white water bypass. Another ramification of having the white water channel outlet downstream of the dam is that the 1000 foot section of river between the dam and course outlet may be nearly dry or stagnant during low-flow periods.

The existing dam is replaced with a step dam located near the current location. The east side abuts either downstream or upstream of the Challenge Building via a concrete extension wall.

Alternative 4 — Small White Water Rapid with Depot Pond

This is a low gradient river rapid, which spans the entire width of the river. As with Alternative 1, it: 1) combines the boat and roughened channel fish passage into a single design element, 2) has a hydraulic gradient of approximately 0.65 percent, 3) has a Class II to III level of difficulty, and 4) is constructed with rigid weirs interspersed with loose rock, vegetated banks, and various channel features.

The crest is located approximately 400 feet upstream of the existing dam location and the rapid is approximately 500 feet in length. The existing dam is lowered and modified to serve as the most downstream weir structure. The pool located just downstream of the existing dam serves as an energy dissipater and boater recovery pool.

Due to its reduced length, Alternative 4 only has two intermediate weirs, rather than the three included in Alternative 1. The west side of the upper weir abuts into Duck Island. The east side of this entrance weir partially abuts to bedrock at the east river bank. Similar to the berm in Alternative 1, an earthen berm runs from the south side of Duck Island to the northern tip of the peninsula. An additional earthen berm extends from Duck Island to the east river bank. These berms impound the water within Depot Pond and convert it to an actual pond rather than a dead-end finger of a river bifurcation. The result of this is the elimination of the high sediment load that is currently transported to Depot Pond by the river. The water surface elevation in Depot Pond could remain at an elevation of 665 feet or slightly higher, even during low river flows. A pump (powered by an electric motor and possibly a windmill) or ditch is planned to replace water lost from the pond due to leakage or evaporation. A spillway is located at the Cut to convey local runoff that is currently tributary to the pond. If this alternative is selected, redirection of local inflow around the pond and into the river would be investigated as a means to improve water quality in Depot Pond.

Alternatives 4 and 4a/4b include rehabilitation efforts to the channel upstream of the lowered dam crest. In Alternative 4, the upstream pool elevation is lowered by about four feet. The water surface area from the existing dam upstream to the Causeway will be decreased during typical summer flows from approximately 60 acres to 40 acres. With a lower water surface elevation, portions of the channel bottom are exposed and much of the shoreline is covered with a wide and unstable zone of mud. After years, this "mud flat" washes downstream, or stabilizes and develops into floodplain overbank. However, this process leaves the area in an undesirable condition for this interim period. When the dam is lowered, sediment is released. This may have negative impacts on the river ecology fish habitat.

Sediment is considered a pollutant and its release into the riverine environment has become a focus of various federal agencies. For these reasons, Alternative 4 and to a greater extent, Alternative 4a/4b, include creation of an overbank area using existing sediments in the river. To aid in this effort, structural stabilization features (further described under Alternative 4a/4b) and plantings and seeding in the overbank or "bio-stabilization" are included.

It is anticipated that some sediments will be removed entirely from the channel including those in Depot Pond and in the backwater area created by the Causeway. Some may also be removed from the active channel, however it is anticipated that most sediments currently in the active channel would remain in place or be used to create new overbank floodplain area. Stabilization techniques to create the overbanks include toe protection and impervious jetties as described in the following section.

Alternative 4a/4b —Riffle/Pool River Restoration with Depot Pond

This alternative removes most of the existing dam, and includes a series of islands, riffles and pools in the "free flowing" reach created by the significant lowering of the dam crest. Like

Alternative 4, Depot Pond is maintained with its current water surface elevation and the inflow of sediment from the river is cut off. As with all of the alternatives, it has minimal impact downstream of the dam. The water surface elevation upstream of the dam is lowered so that only a natural-looking riffle appears at the location of the dam. This drop height is on the order of six to twelve inches. A small pool is located upstream and downstream of the existing dam, and several other riffles and pools are located between the dam and the Forest Preserve causeway, making up the remainder of this free flowing reach of the river.

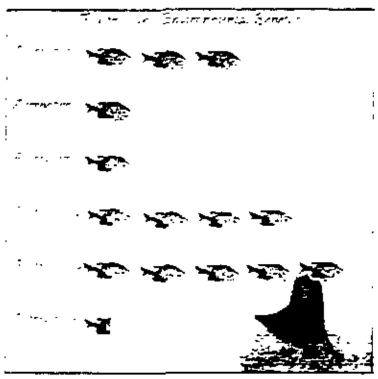

Figure 47 - Aquatic Habitat Quality

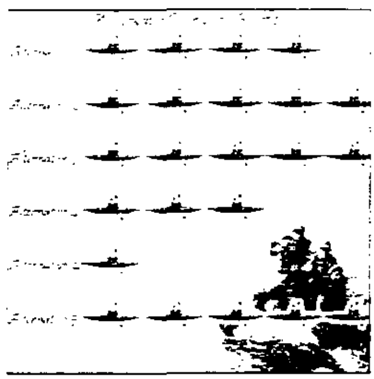

Figure 45 - Whitewater Recreational Quality

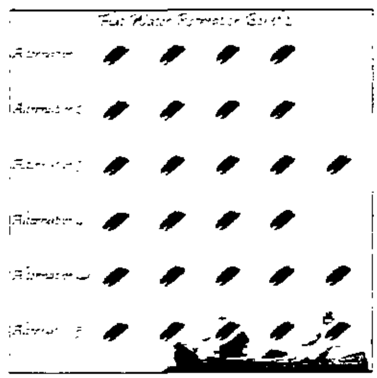

Figure 46 - Open Deck Canoeing Recreational Quality

Ref: McLaughlin Water Engineers Ltd.

As with Alternative 4, an earthen dam is constructed from the north end of the peninsula and to the east river bank to create Depot Pond. Alternative 4a takes the berm through Duck Island while 4b avoids Duck Island. The final alignment will be made based upon public and city input. In any alignment, the dam disconnects Depot Pond from the river and allows the existing water surface elevation to be maintained. A spillway is located at the Cut to prevent overflow into the pond from the basin. Benefits and further details of the improvements to Depot Pond are outlined above in Alternative 4.

Upstream restoration is much more extensive than included in Alternative 4. Depot Pond and (optionally) the Forest Preserve causeway pool are dredged to maintain pool depth, and sediment within the channel is stabilized in the form of floodplain overbanks. However, much more sediment is stabilized since there is very little impoundment and velocities associated with a free flowing river require a greater stabilization effort.

Alternative 4a/4b differs from Alternative 4 and the other alternatives in that stabilization efforts include the formation of islands, jetties, and riffles.

Comparison of Alternatives

To assist in the comparison of alternatives, the design team has summarized the anticipated comparative performance in three categories including:

1. Aquatic habitat quality
2. White water recreational quality
3. Open deck canoeing recreational quality

SUMMARY

Replacement of the Batavia Dam with a multi-purpose dam that includes white water recreation and fish passage is progressive by current national standards. While the technology is over 25-years old, there are only a handful of new low-bead dams that have been built in the US in this fashion. The approach is holistic in that it addresses concerns and objectives of a wide variety of interests by integrating flood control, recreation, fish habitat, environmental, and aesthetic concerns.

The alternatives developed for this project provide a different focus on environmental, recreation, planning, and aesthetic issues. Initially, the project was conceived as a dam replacement with the possible addition of added fish passage and boat chute bypass. Alternative 3 is the only alternative that meets this initial conception. The other alternatives were developed as a result of innovative thought processes and an integrated approach with the IDNR design team and representatives of the City of Batavia.

The alternatives developed by the IDNR design team provide a wide range of options and choices for the Batavia Dam replacement project. Alternatives 1 and 3 create a very high quality white water rapid that would certainly become a regional attraction for white water enthusiasts. Alternative 3 is the least cost alternative, but has the most impact on local community planning. Alternatives 4a and 4b return the river to a free flowing river, which optimizes fish habitat and open deck canoeing recreation. Alternative 4 falls somewhere between Alternatives 1 and 4a/4b.

Many individuals, interest groups, communities and agencies have provided input on the selection of a unique set of alternatives for the replacement the Batavia dam. All of the alternatives will provide valuable amenities that will become a legacy for many generations.

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BACKWATER RESTORATION OPPORTUNITIES: ILLINOIS RIVER

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During the past two centuries the Illinois River and its hydrology have been altered numerous times. Early navigation works, levees, diversion, agricultural and urban drainage practices, locks and dams and other changes all contributed to habitat modification. Over the years the river has changed from a free flowing stream bisecting a broad floodplain to a series of pools with substantial areas of leveed floodplain. The image conjured by the term "restoration" varies with the time frame used as a base. Given that all major navigation dams were in place by the1940's, a common vision of a restored river includes permanently flooded lakes and backwaters with sufficient depth to support the flora and fauna which were abundant in the early 1950's as well as recreational boating. Others envision a relatively free flowing river with a variety of backwater and side channel habitats.

A realistic concept will attempt to provide the habitat diversity necessary to support the historical species within the constraints of a navigation system and other economic and social factors. Backwater restoration and that of the main stem can be driven by determining which important habitat types are most degraded or in limited supply and seeking to protect or recreate them. For example, the river has limited fast flowing or riffle habitat. This fact makes the rapidly flowing area below the Marseilles dam particularly valuable and worthy of protection. Likewise, relatively deep water off the main channel has virtually disappeared in recent times. On the other hand, shallow water, mudflats and willow covered floodplain abound, although their habitat value is degraded by unnatural water level fluctuations.

Historic maps of the river valley can guide restoration efforts. They show areas which historically were water, marsh or land. For example, while the Peoria Lakes have been flooded since the 1940's, topographic maps show that in the 1890s they had substantial areas of marsh and several large islands downstream of Spring Bay (Fig.1). The area of the lake between Spring Bay and Chillicothe included large amounts of marsh as well as farmed land and roads (Fig. 2). The area from Chillicothe to Lacon was largely marshland with some permanent lakes and connected backwaters (Fig. 3), while Lake Senachwine was mostly marsh with connected backwaters. The reach between Chillicothe and Lacon will be emphasized in this paper as it illustrates several points.

The Woerman maps were produced by the Corps of Engineers in 1903 and show the river and floodplain during low water after Diversion from Lake Michigan began in 1900. The higher water levels expanded the area of backwater lakes and side channels. Fig. 4 shows Meadow Lake above Chillicothe in an area shown as marsh in the 1890s. Likewise Fig. 5 shows enlarged Wightman and Gar Lakes near Lacon in 1903.

By comparing the historic maps with current topographic maps and satellite imagery it is possible to identify areas which may be most suitable for restoring particular habitats. For example, sediment removed to restore depth could be placed on old island sites or shallow areas which would provide a firm base to support the material. Similarly locations that were water on the old maps are likely spots for dredging deeper pools. They are filled with relatively soft sediment which is more readily removed than original floodplain soil and less likely to contain stumps and other debris. Areas that were never deep are likely candidates for wetland, marsh and moist soil habitat restoration, and elevated habitat for mast producing trees.

By comparing maps using GIS technology it is possible to see where sedimentation has built up land over the past century. They also indicate where sediment deposits in today's uniformly shallow backwaters are deepest.

Figures 6 and 7 show Meadow Lake and Wightman and Gar lakes respectively. The figures show the 1903 Woermann map superimposed on the topographic map based on 1970 aerial photography. The small black dots depict soundings taken in backwaters for the Woermann maps, and indicate historically deeper water. On the superimposed maps the dark gray areas were water in 1903, including the main channel. The heavy line indicates the extent of water on the topographic map. This additional area was originally marsh or elevated floodplain before the navigation dams raised the water level. At that time Gar and Whightman lakes were joined. Note there are small islands and peninsulas on both figures. Areas where the Woermann soundings overlay water in figures 6 and 7 are likely locations where sediment could be readily removed from the backwaters to restore areas that were historically deep.

Figures 8 and 9 are satellite photographs of Meadow and Wightman lakes taken in the fall of 2000 (1903 sounding data is superimposed on the Meadow Lake photo). The photos clearly show that the peninsulas in both areas have greatly expanded due to sedimentation and now encompass the former small islands. A new island is forming in Wightman Lake. The sounding dots from the Woermann map are superimposed on Meadow Lake. It is apparent that the original area of Meadow and Wightman Lakes are still covered by water, but that much of Garr Lake is now covered by accumulated sediment. Inspection at ground level confirms that willows are invading this new land. Goose Lake to the right of the Lacon Bridge has shallow water over its once deep areas.

Historic maps of other sections of the river mainstem show where islands and other features have existed since the 1800s. Restoration of water depth and relative land elevation in these areas could significantly increase habitat diversity.

Environmental Management Program (EMP) projects on the Mississippi and Illinois Rivers have successfully restored selected island, backwater and wetland habitat and are providing useful insights for large scale restoration. DNR is conducting some small pilot projects on habitat restoration techniques using sediment removal and placement technology. One project involving geotextile tubes and a new dredge which uses a displacement pump to move sediment without adding water was demonstrated at the Woodford County State Fish And Wildlife Area near Chillicothe in May of 2000. Figures10 through13 show the construction of a small island as part of that project. Figures 14 and 15 show island building with a conventional clam shell dredge.

Knowledge of the Illinois River valley's physical and biological history combined with information gained from pilot projects will provide the basis for future restoration projects.

ACKNOWLEDGMENTS

Various assistance was provided by Kress Corp.; Caterpillar Inc; Illinois State Water Survey, Illinois Geological Survey, Illinois Department of Natural Resources; the Rock Island District, USACE; Wisconsin DNR; J.F. Brennan Co. Inc.; Midwest Foundation; Mike Duke; and Jack Fowler among others.

This paper is adapted from a powerpoint slide presentation given at the Governor's Conference on the Management of the Illinois River in October 4, 2001.

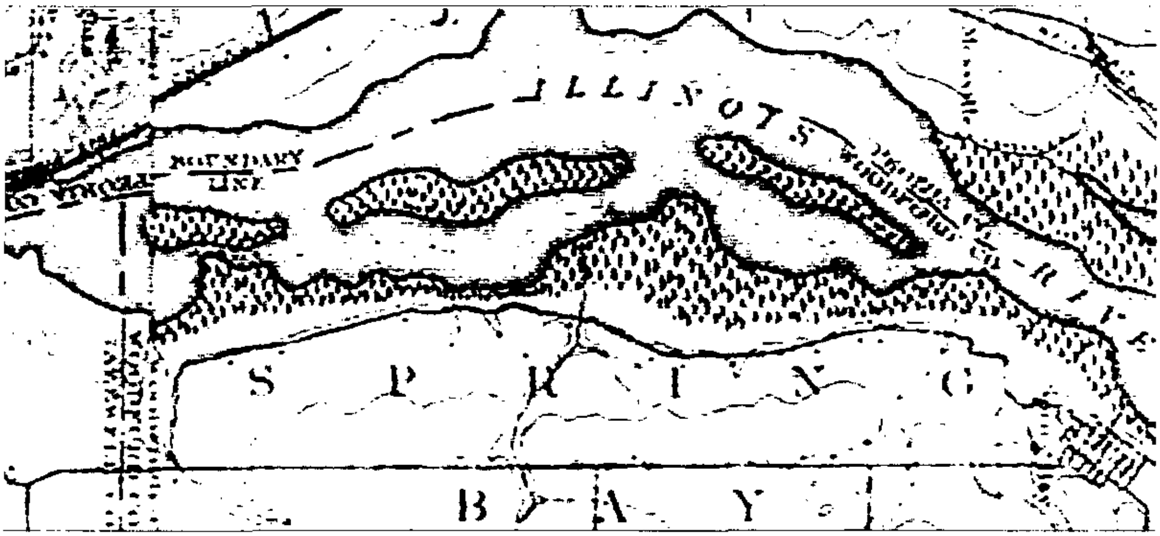


Figure 1. This topographic map from about 1890 shows Upper Peoria Lake between the narrows and Spring Bay (lower right). The Stippled area is marsh and three islands are clearly visible. The islands, marsh and some floodplain were covered with water by the navigation dam. Sediment removed to deepen the lake could be placed on the old islands restoring both aquatic and island habitat.

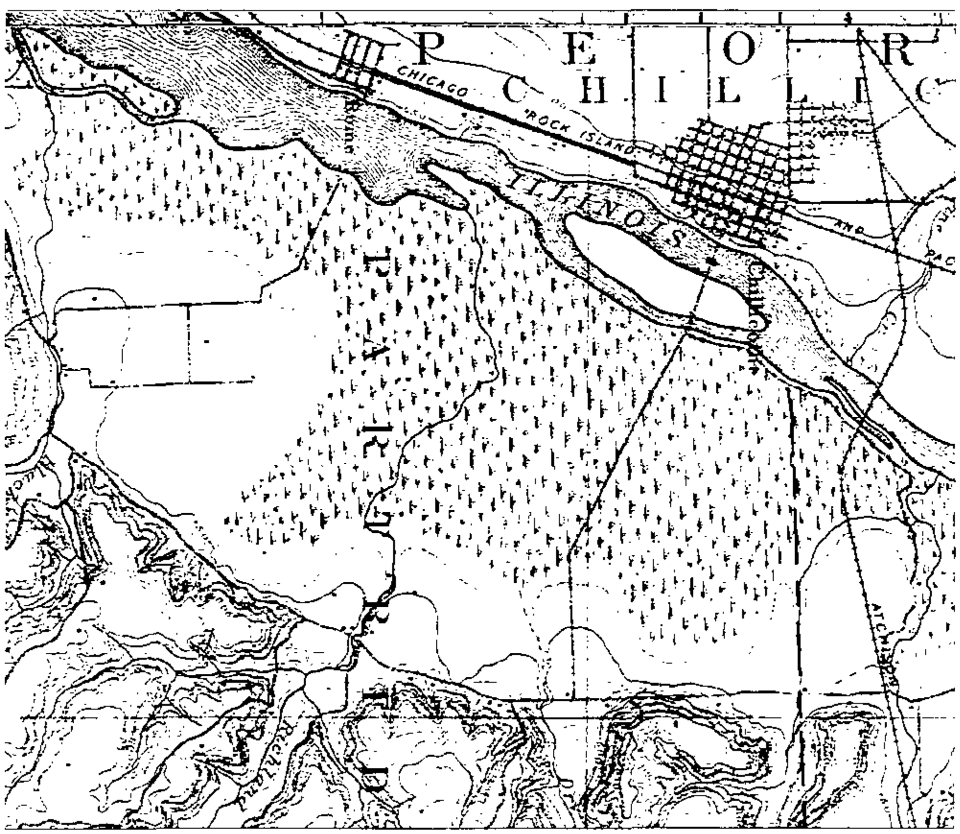


Figure 2. Upper Peoria Lake near Rome and Chillicothe in the late 1890s was largely a marsh. Roads and farm fields were covered with water by the navigation dam. Much of this area was subject to frequent flooding, especially in the spring.

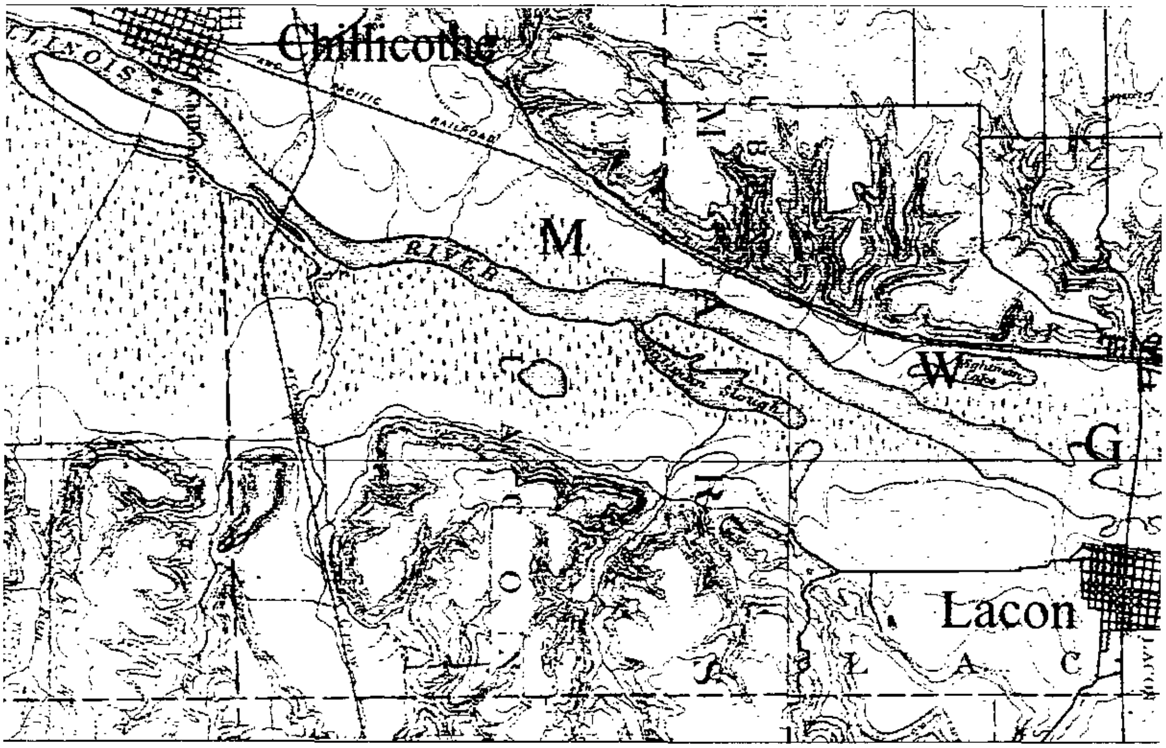


Figure 3. In 1890 the area between Chillicothe and Lacon (lower right) was largely marsh and low lying floodplain. Several permanent backwaters existed, some of which were connected to the river even at low water. During most years the natural flood cycle provided fish spawning habitat on the floodplain in the spring. When flood waters receded, moist soil plants favored by waterfowl grew on mudflats and aquatic plants thrived in the marshes. The natural flood cycle has been disrupted to the detriment of many species. M marks the spot now occupied by Meadow Lake, while W and G are on Wightman and Gar Lakes respectively.

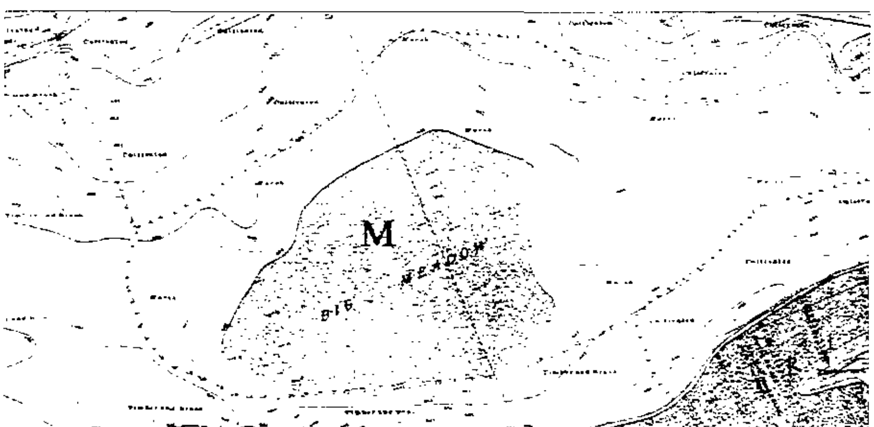


Figure 4. The water level rose when water was diverted from Lake Michigan in 1900. This figure from a Woermann map shows Meadow Lake at low water after diversion. The dark areas are permanent water and the lines are one foot contours. The main channel is at the bottom.

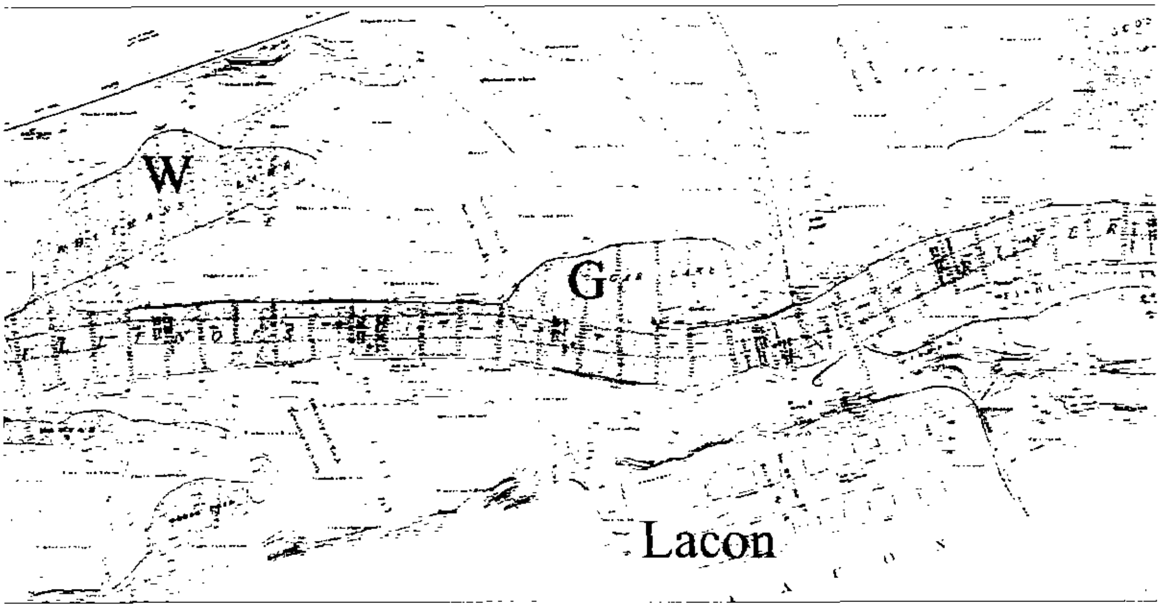


Figure 5. The Woermann map near Lacon shows Wightman Lake (W) and Gar Lake (G) as permanently connected backwaters. Goose Lake is the dark area in the upper right.

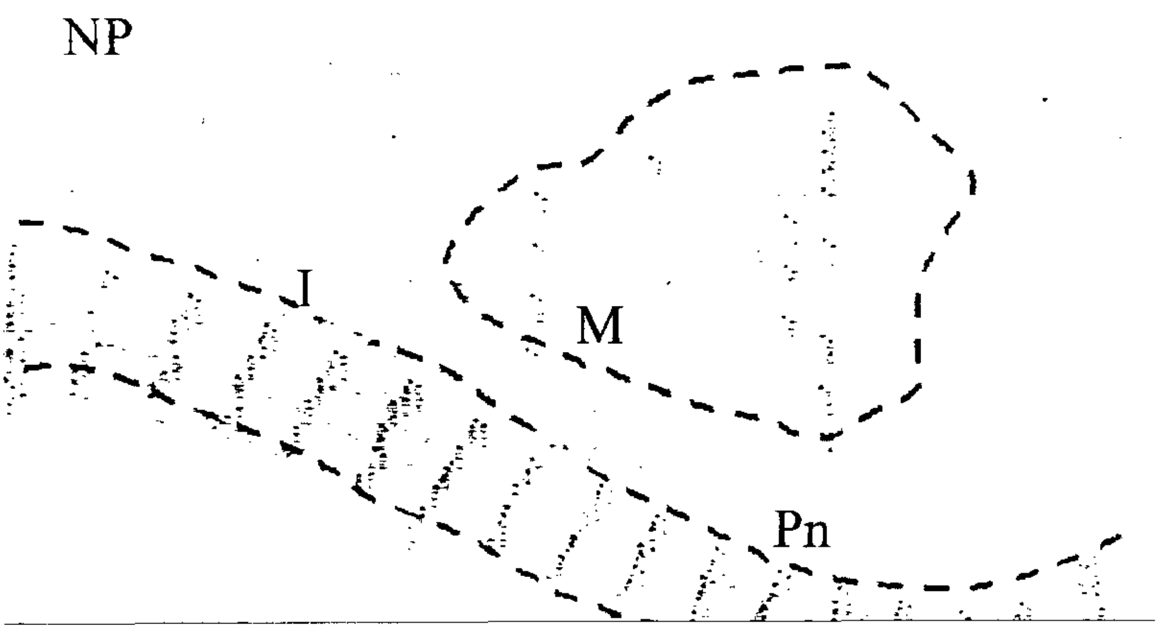


Figure 6. When the Woermann map is superimposed on the topographic map (Chillicothe quadrangle, 1972, based on 1970 photography) the influence of the navigation dam becomes apparent. The dark gray areas were water in the early 1900s. The light gray area outlined by the line marked NP (normal pool) is the extent of the water surface in 1970. Note the island (I) and peninsula (Pn) forming as a result of sediment deposition.

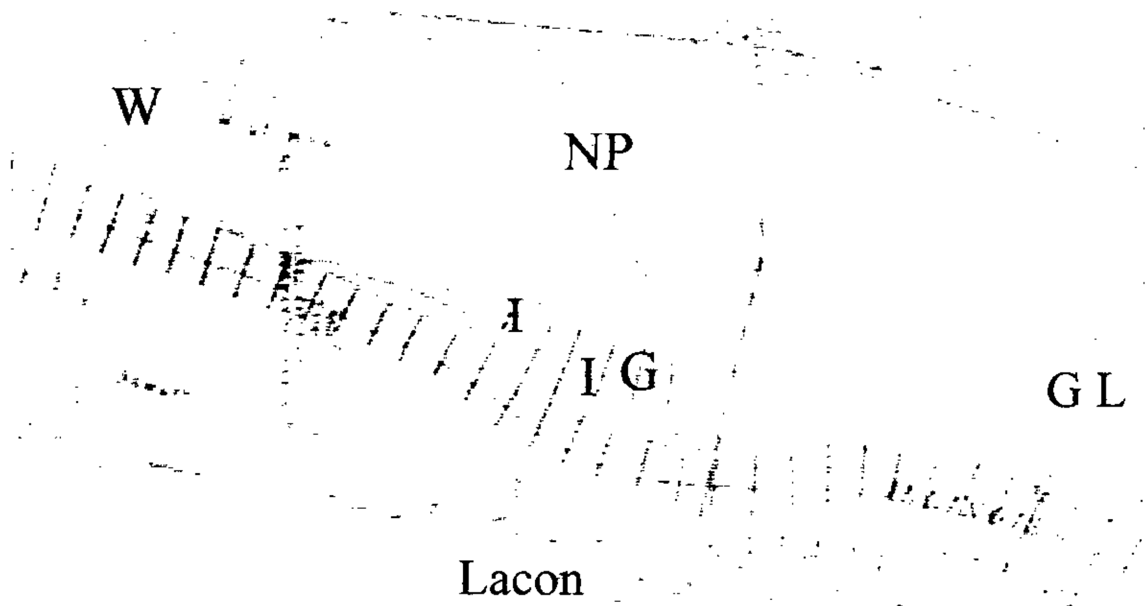


Figure 7. The superposition of the Woermann and topographic maps of the Lacon area (Lacon quadrangle, 1972) show that Wightman and Gar Lakes were joined when the dam raised the water level, although sediment islands were forming in the Gar Lake area by 1970. Much of the lower end of Goose Lake (GL) was still covered by water in 1970. The dots on the Woermann maps marked soundings in the backwaters.

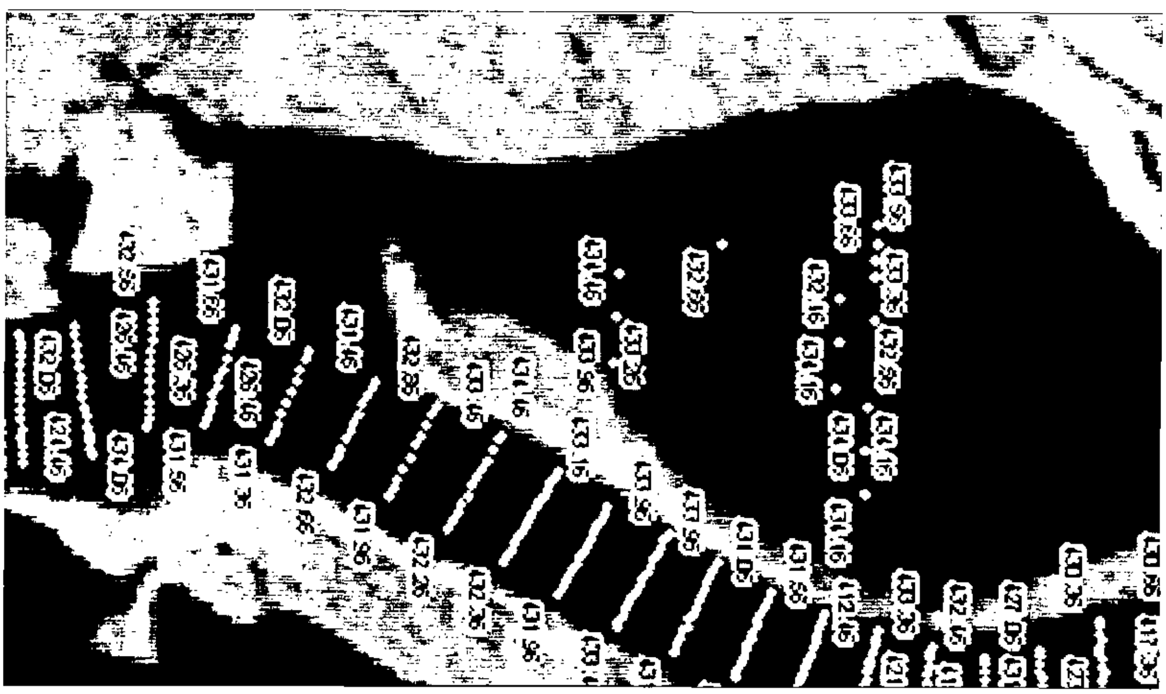


Figure 8. This is a landsat photo taken in the fall of 2000 with the Woermann map soundings superimposed. It shows that most of the deeper parts of Meadow Lake that were water prior to the dam are still covered with water. However, the peninsula shown on the 1970 map has grown and merged with the island. Meadow Lake appears to be a good candidate for restoration as a connected backwater.

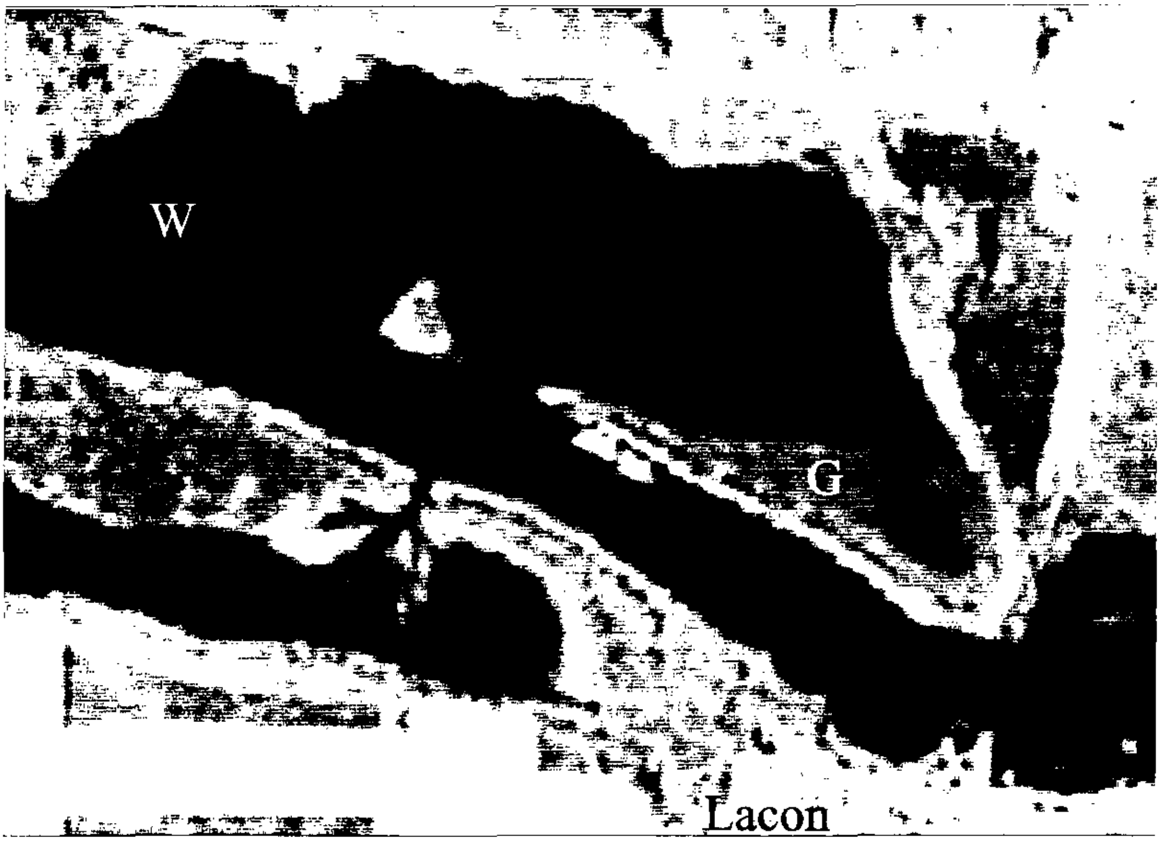


Figure 9. A fall 2000 photo of the Lacon area shows that the Wightman Lake remains as water while much of Gar Lake is filled with sediment that forms a large peninsula. This location could also support a variety of restored habitats.

Figure 10. Small geotextile tubes were placed in Upper Peoria Lake near Chillicothe in the Spring of 2001. When filled with sediment the tubes formed a small trapezoidal island. The tubes are intended perform like a berm, hold the sediment in place, and prevent it from being eroded by wave action.

Figure 11. The Dry Dredge shown here lifts sediment from the lake bottom and uses a displacement pump to move it without adding water. The pump filled the geotubes with sediment and then pumped sediment with the consistency of toothpaste behind the tubes to form a small island. The island was filled on May 2.

Figure 12. Engineers are shown standing on a tube taking samples on May 22. The sediment developed dessication cracks almost immediately and consolidated rapidly. Despite high water, which flooded the island during most of June, researchers could walk on it in early July.

Figure 13. A DNR site manager stands on a geotube in August. The sediment is well consolidated and supports volunteer vegetation. Plants began growing on the island after the first week, but were generally eaten by waterfowl or killed by high water. The geotubes successfully protected the island from erosion during the summer and fall, despite frequent water level fluctuations and high winds.

Figure 14. A conventional clamshell bucket was used during high water to gently remove sediment and create small islands in several locations on June 12. The sediment was disturbed as little as possible to preserve its structural integrity.

Figure 15. By July 7 researchers could walk on the clamshelled islands. By observing the small islands, researchers will gain insights useful for building large islands and developing sediment handling techniques for Illinois River restoration projects.

FEATURED SPEAKER

Brad McMillan

U.S. Representative Ray LaHood 18th Congressional District
100 N.E. Monroe, Room 107, Peoria, Illinois 61602

I don't know if many of you realize this, but last night when you where able to spend time on our riverfront, at the beautiful Gateway Building, and looked over all of the development that has occurred there, it is really through Jim Baldwin's leadership that the development has taken place. Not only that but after retiring from Caterpillar and leaving the Riverfront Development Commission, Jim then decided to serve as the Executive Director of the Heartland Water Resource Council with no Salary. He does these thing from the goodness of his heart and because he cares so deeply about the river.

There are a couple of people, before I get to my remarks, that I really feel need to be thanked. One of them is a person I love to work with, she attends to all of the details of the conference. I always laugh when I talk to her she's just great to work with and that's Wendy Russell with Heartland Water Resources Council. Wendy please stand up. This conference has been put together by so many wonderful people, but Bob Frazee and Steve Havera have worked tirelessly at putting together another great conference. It really does take a lot of work, let's give them a real warm round of applause for all their efforts.

Congressman LaHood sends his best wishes and heartfelt thanks for all of your collective work in restoring and preserving our greatest natural resource, the Illinois River.

This afternoon I would like to briefly talk to you about the three "Ps" to the success on continuing our efforts to at restoring and preserving the Illinois River.

The first "P" is Passion. Passion is the first step to achievement. Experts spend a lot of time trying to figure out what makes certain people successful. They often look at a person's credentials, their education, their intelligence, and many other factors. But more than anything else, passion makes the difference. Did you realize that over 50% of the CEOs of Fortune 500 companies had a "C" average, nearly 75% of the U.S. presidents were in their bottom half of their class and over 50% of all millionaires never finished college. I don't know about you, but those statistics make me feel a whole lot better. The bottom line is that our desire determines our destiny. Passion makes the seemingly impossible, possible. As one author puts it, "Man is so made, that whenever anything fires his soul, impossibilities vanish". Leaders who are passionate about their mission create vision, which in turn, ignites positive change. This room is filled with leaders responsible for the mission and vision of restoring the Illinois River. It is your passion for seeing the Illinois River preserved and restored that will create the power to actually make it happen. Passion fuels vision and vision focuses passion. I know if Ray where here today, he would tell you to keep passionate about your vision. The lasting legacy of restoring and preserving the Illinois River for future generations, is truly a worthwhile mission worth investing your lives into. I can tell you that Congressman LaHood, himself, remains truly passionate about this mission. Ray is a very focused leader, he has a few top priorities that everyday he wakes up and he tries to figure out how he can advance those priorities. Without question, the Illinois River is at the top of the list. And as long as Ray LaHood is in Congress, the Illinois River will remain at the top of the list.

The second "P" is Perseverance. Many of you have been working on saving and restoring the Illinois River for a very long time. At times I know there is frustration at not seeing more action taking place, however we must not lose sight of the incredible progress that has been made.

Our CREP program is leading the nation. The islands near Chillicothe have stood up extremely well and white pelicans and bald eagles are returning to the Illinois River in great number. Lake Chitaqua has been beautifully restored. The Nature Conservancy has turned around the Mackinaw River and has recently purchased Wilder Farms, which will one day become the incredible Emiquon. John Marlin and the IDNR have been out in the mud and have taken it and grown crops, which are as good as the crops grown on our farm land. Congress has passed a one hundred million dollar authorization for Illinois Rivers 2020 in its first attempt. Those of you who know anything about the legislative process realize that is an amazing feat. The list could go on and on and many of you in this room are responsible for the progress made, but we all know that there is so much important work yet to be done. Congressman LaHood is doing everything in his power to get construction dollars appropriated to start Illinois Rivers 2020 projects this fiscal year. The tragic events of September 11th however, have necessarily changed the focus in Washington. Much money will go to the war on terrorism, increasing security at airports and helping the airline industry to stay afloat. Right now, even today there are negotiations going on between the white house and congress to determine what the new funding levels will be for the overall budget. Until those decisions are made, we will now know where projects like Illinois Rivers 2020 will come out in this fiscal year. You must remember that this is the first year the Congressman LaHood was appointed to the Appropriations Committee, he has spoken directly and often to the appropriations committee chair responsible for the Water Resources Development Act about Illinois Rivers 2020. Let's just say that it is a very good thing for the Illinois River that Ray LaHood sits on the Appropriations Committee. He will persist this year, next year and on into the future in securing funds to help restore and preserve the Illinois River.

The final "P" stands for Partnerships. The theme of this year's conference is appropriately entitled " The Illinois River, Partnerships for Progress, Restoration and Preservation". One of the truly great things about working with Congressman Ray LaHood, is his ability to bring divergent groups together to work on solving problems. I've seen it time and time again. And in preparing the remarks today, I remember back a couple of years ago when we held a meeting at Caterpillar, which Ray convened, we brought together IDNR, IEPA, USACOE, The Nature Conservancy, Heartland Water Resources Council, ag groups and the list goes on and on. And in this meeting we decided that we were all going to work together to save the Peoria Lakes. We were going to find a way to remove the silt from the river and find a way to stop the silt from coming into the river. As I look back two years from that meeting, there has been a lot progress, a lot of positive progress. Ray has also spearheaded the push to get all members of the Illinois Congressional Delegation on board with Illinois Rivers 2020, republicans, democrats, members of the house, senate, it really is a unified front in congress with respect to Illinois Rivers 2020. As we look to the future these partnerships between federal and state agencies and local community groups need to be strengthened and encouraged. By sharing expertise and yes, even resources we can accomplish so much in our efforts at restoring and preserving the Illinois River.

So let me conclude by saying, keep your passion, persevere, nurture you partnerships and the future of the Illinois River will indeed be very, very bright.

Now since Ray was unable to attend the luncheon today, he is in Washington they're debating the Farm Bill, Bob and others thought ahead, we have prepared a taped interview with Ray which I feel is very well done. So we will now see that, and thank you very much for including me today.

CLOSING ADDRESS

Stephen P. Havera

Illinois Natural History Survey, Forbes Biological Station
P.O. Box 590, Havana, Illinois 62644
E-mail: shavera@mail.inhs.uiuc.edu

I would like to thank all of you for attending the eighth Governor's Conference on the Management of the Illinois River System. The first conference was held in 1987 and we are now in our third decade of hosting conferences. Although we have accomplished much, we still have a lot to do. Your interest in the welfare of the river, as demonstrated by your participation in this conference, is essential if we are going to enter our fledgling century with a biologically and economically sound river system. The twentieth century witnessed many changes to the Illinois River system ranging from the significant diversion of Lake Michigan water into the waterway in 1900 to the excessive sedimentation and unnaturally fluctuating water levels with which we are dealing today. What the twenty-first century will bring to the Illinois River system and, correspondingly, what benefits the river will provide, can be greatly influenced by us. We have more than a century of knowledge to build upon. We need to draw upon that knowledge, integrate new methodology, techniques, and information as they emerge, and incorporate these aspects into our desire to extend the longevity, biological productivity and economical benefits of the Illinois River system.

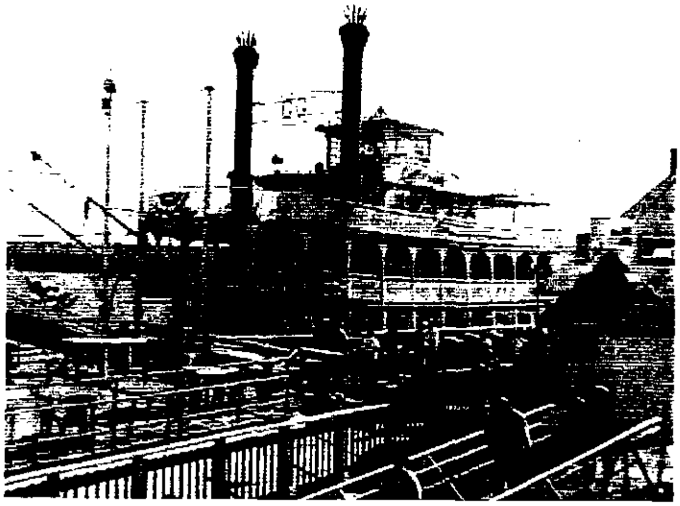
We must work together toward these goals, and here too, we already have vehicles to do so, including the Lt. Governor's Integrated Management Plan for the Illinois River Watershed, the Conservation Reserve Enhancement Program, the Wetland Reserve Program, the Illinois River Ecosystem Restoration Program, the Illinois Rivers 2020 Program, and watershed programs, among others. The Illinois River system directly or indirectly affects almost everyone in our state. The river is one of our most important natural resources and it is up to all of us to do our part to ensure its continued livelihood.

I want to thank you for your participation in this conference; I want to thank our more than 60 co-sponsors for their support and financial contributions; I offer our very special thanks to Co-Chair Bob Frazee, Jim Baldwin and Wendy Russell of the Heartland Water Resources Council, and our exceptional multiagency steering committee, all of whom devoted numerous hours toward the success of this conference. We are grateful for the addresses sharing comments and insights offered by our featured speakers—Lt. Governor Corinne Wood, Congressmen Ray La Hood and Brad McMillan—by the state agency directors and their representatives, and by all of our many presenters. Now it is time for us to carry the information acquired here to our respective disciplines and accept our responsibilities in sustaining the Illinois River system.

Our 2001 conference stands adjourned.

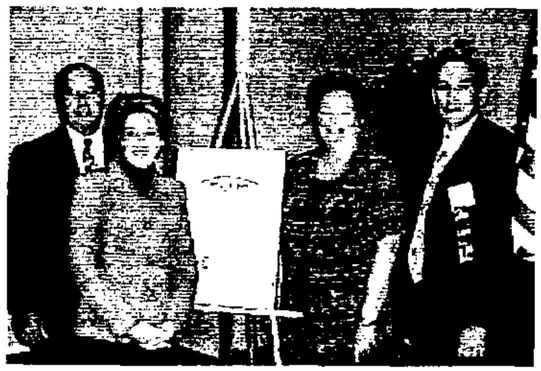
Appendix A: Photographs

Conservation Cruise participants aboard the Spirit of Peoria.

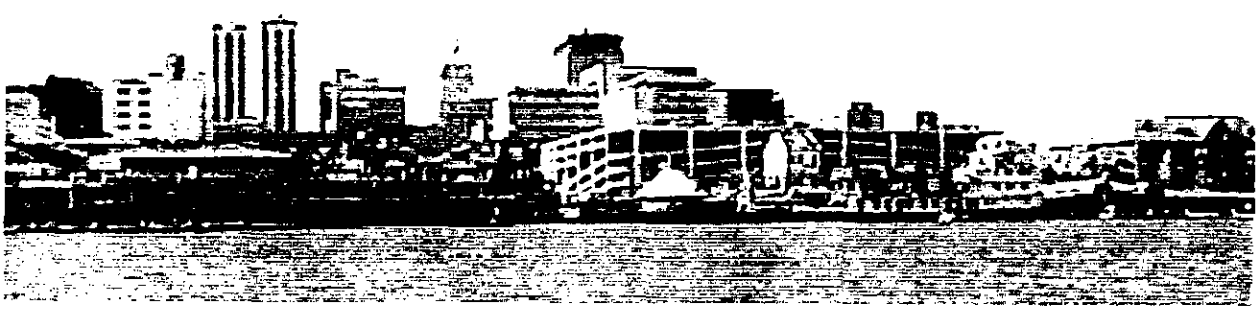


A new feature at the 2001 Conference was the Conservation Cruise aboard the Spirit of Peoria.

Conference Co-Chair Bob Frazee presents the Opening Address.



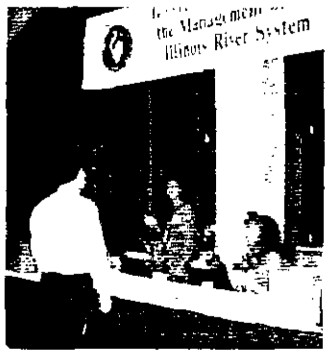
Bob Frazee, Lt. Governor Corinne Wood, Mary Alice Erickson from the Lt. Governor's Coordinating Council, and Conference Co-Chair Steve Havera with the Executive Proclamation.



The Peoria, Illinois riverfront.

Above, upper right, and right: A look at the Sessions.

Lt. Governor Corinne Wood was the Featured Speaker at Wednesday's lunch.



The Conference registration table at the Holiday Inn, City Centre.

The Wednesday evening Barbecue was held at the Gateway Building on Peoria's riverfront. The evening featured a presentation by the Friends of the Illinois River about the Illinois River Sweep.

Exhibits and visiting during breaks.

Conference participants enjoy the Thursday lunch.

U.S. Representative Ray LaHood addresses the Conference via video tape at Thursday's lunch.

18th Congressional District Assistant Brad McMillan (above) and Conference Co-Chair Steve Havera (below) speak during Thrusday's lunch.

Appendix B: Exhibitors

Heartland Water Resources Council
Illinois American Water Company
Illinois Chapter of American Fisheries
Illinois Department of Commerce and Community Affairs
Illinois Department of Natural Resources
Illinois Department of Natural Resources
Illinois Department of Natural Resources
Illinois Department of Agriculture
Illinois Department of Agriculture
Illinois Farm Bureau
Illinois Protection Agency
Illinois River National Wildlife & Fish Refuges
Illinois River Soil Conservation Task Force
Illinois State Geological Survey
Illinois State Geological Survey
Illinois State Water Survey
Illinois State Water Survey
Illinois State Water Survey
Illinois-Indiana Sea Grant College Program
J.F. Brennan Co. Inc.
Mar Mac Manufacturing Co
Phoenix Process Equipment Co
Prairie Rivers RC&D
Sierra Club, Illinois Chapter
TC Mirafi
The Nature Conservancy
Trees Forever
Tri-County Riverfront Action Forum, Inc.
University of Illinois Extension and Outreach
University of Illinois
U.S. Army Corp of Engineers
U.S. Army Corp of Engineers
U.S. Geological Survey
U.S. Geological Survey
U.S. Geological Survey
USDA, NRCS
YSI Inc.

Appendix C: Participants

Adams, Ross, U.S. Fish and Wildlife Service
Allison, Melvin, Illinois Department of Natural Resources
Anderson, Brian, Illinois Department of Natural Resources
Anderson, Jason, Trees Forever
Anstine, Bob, Illinois Department of Commerce and Community Affairs
Arnold, Jeff, Illinois Natural History Survey
Atherton, Sue, Illinois American Water Company
Austin, Tom, USDA-FSA
Baldwin, Jim, Heartland Water Resources Council
Barfield-Roop, Susan, Office of Lt. Governor
Barthel, Dick
Barthel, Mary
Baur, Dick, Illinois Department of Natural Resources
Bayles, Bill, U.S. Army Corps of Engineers
Beissel, Tom, Illinois Department of Natural Resources
Bellovics, George, Illinois Department of Natural Resources
Bera, Maitreyee, Illinois State Water Survey
Beverlin, Jason, Illinois Department of Natural Resources
Bhowmik, Nani, Illinois State Water Survey
Blodgett, Doug, The Nature Conservancy
Blumenshine, Joyce, Heart of Illinois Sierra Club
Bogner, Bill, Illinois State Water Survey
Bonardelli, Mark, Illinois Department of Natural Resources
Borah, Deva, Illinois State Water Survey
Braden, John, University of Illinois
Brimberry, Tom, City of East Peoria
Brown, Kathleen, U of I Extension
Buese, Mark, Kirby Corporation
Burke, Terry, Illinois Department of Natural Resources
Bushur-Hallam, Cindy, Illinois Department of Natural Resources
Cahill, Richard, Illinois State Geological Survey
Campion, Dennis, U of I Extension and Outreach
Carmack, Charlene, U.S. Army Corps of Engineers
Cavanaugh-Grant, Deborah, University of Illinois
Cecil, Kyle, University of Illinois
Chard, Steve, Illinois Department of Agriculture
Christe, Clarence
Christe, Rosemary
Church, John, University of Illinois
Clark, Gary, Illinois Department of Natural Resources
Clevenstine, Bob, U.S. Fish & Wildlife Service
Cochran, Mike, Illinois Department of Natural Resources
Compton, Bill, Caterpillar Inc.
Condit, Don, Prairie Rivers RC&D
Cook, Thad, Illinois Natural History Survey
Copeland, Sam, Rushville High School

Cottrell, Kirby, Illinois Department of Natural Resources
Cross, Jeff, Caterpillar Inc.
Crowder, David, Illinois State Water Survey
Curtis, Dana, Illinois Department of Natural Resources
Darmody, Bob, University of Illinois
Davis, Tom, City of Henry
Day, Dave, Illinois Department of Natural Resources
Dean, Bob, USDA-NRCS
Demissie, Mike, Illinois State Water Survey
Depenbrock, Jason, ADM Growmark
Dorworth, Leslie, Illinois-Indiana Sea Grant College Program
Drake , Barb, Peoria Journal Star
Eicken, Gary
Emken, Claudia, The Nature Conservancy
Erickson, MaryAlice, Illinois Coordinating Council
Erickson, Nancy, Illinois Farm Bureau
Ernenputsch, Todd, U.S. Army Corps of Engineers
Ewbanks, Kevin, U.S. Army Corps of Engineers
Fowler, Jack, TC Mirafi
Fox, Rick, Peoria Audubon
Frank, Steve, Illinois Department of Agriculture
Frazee, Bob, U of I Extension
Gee, James, City of Washington
Geunther, Greg, Illinois Corn Growers Association
Girard, Tanner, Illinois Pollution Control Board
Goetsch, Warren, Illinois Department of Agriculture
Gosch, Rick, Illinois Department of Natural Resources
Graff, Bill, USDA-FSA
Granados, Rick, U.S. Army Corps of Engineers
Granados, Rick, U.S. Army Corps of Engineers
Green, Glenn, J.F. Brennan Co. Inc.
Groschen, George, U.S. Geological Survey
Gulso, Alan, Illinois Department of Agriculture
Gulso, Alan, Illinois Department. of Agriculture
Habben, Rudy, Heart of Illinois Sierra Club
Halvorson-Block, Kirsten, The Nature Conservancy
Hampton, Joe, Illinois Department. of Agriculture
Haring, Chris, Soil & Water Conservation Dist.
Harris, Mitch, U.S. Geological Survey
Harrison, Vicki, Rushville High School
Hartzold, Sharon, USDA-NRCS
Havara, Steve, Illinois Natural History Survey
Hendrickson, Harry, Illinois Department of Natural Resources
Herndon, Wayne, Illinois Chapter of American Fisheries
Herricks, Ed, University of Illinois
Hervey, Dennis, Illinois Department of Natural Resources
Herzog, Bev, Illinois State Geological Survey
Hewings, Geoffrey, University of Illinois
Hilsabeck, Rob , Illinois Chapter of American Fisheries

Hingson, Paula, UDSA-NRCS
Holm, Tom, Illinois State Water Survey
Holmes, Bob, U.S. Geological Survey
Holmes, Bob, U.S. Geological Survey
Horath, Michelle, Illinois Natural History Survey
Hubbert, Jon, USDA-NRCS
Hulett, Durinda, Illinois River National Wildlife & Fish Refuges
Hull, Rear Admiral, Dist 9 U.S. Coast Guard
Hummel, Aleshia, USDA-NRCS (Summer Intern)
Ingram, Wayne, Harding ESE
Iwaniec, Maria, University of Illinois
Jennings, Christopher, Illinois State Water Survey
Johns, Chris, University of Illinois
Johnson, Gary, U.S. Geological Survey
Johnson, Brian, U.S. Army Corps of Engineers
Johnston, Jim, Illinois Valley Yachet & Canoe Club
Joseph, Josh, Illinois River Soil Conservation Task Force
Juhl, Arlan, Illinois Department of Natural Resources
Keefer, Laura, Illinois State Water Survey
Kenney, Jason
Kief, Denny, City of Pekin
Kincaid, Teresa, U.S. Army Corps of Engineers
King, Robin, U.S. Geological Survey
Kinney, Wayne, USDA-NRCS
Knapp, Vern, Illinois State Water Survey
Kraft, Steve, SIU Carbondale
Laatscht, Tim, University of Illinois
Lambie, Pete, Woodford County Board
Leitch, David, Illinois State Representative
Lerczak, Thomas, IL Nature Preserves Commission
Lewis, Rich , Illinois Department of Natural Resources
Leyland, Marilyn, Caterpillar Inc.
Leyland, John
Lieberoff, Barb, Illinois Protection Agency
Liu, Linda, Caterpillar Inc.
Loftus, Tim, SIU Carbondale
Look, Russ
Look, Jane
Loss, Gary, U.S. Army Corps of Engineers
Luman, Bryan, University of Illinois
Luman, Don, Illinois State Geological Survey
Lundberg, Denny, U.S. Army Corps of Engineers
Luttherbie, Gary, Illinois Chapter of American Fisheries
Machesky, Mike, Illinois State Water Survey
Malone, Tim, USDA-NRCS
Manning, Brent, Illinois Department of Natural Resources
Markus, Momcilo, Illinois State Water Survey
Marlin, John, Illinois Department of Natural Resources
Mathur, Ravi, Illinois Department of Natural Resources

Mattson, Guy, USDA-FSA
McKenna, Dennis, Illinois Department of Agriculture
McLeese, Bob, USDA-NRCS
McMillan, Brad, 18th Congressional Dist
Meinen, Don, Tri-County Riverfront Action Forum, Inc
Mick, Jim, Illinois Department of Natural Resources
Miller, Mike, Illinois Geological Survey
Miller, Tom, Trees Forever
Miller, T, U.S. Army Corps of Engineers
Miller, Mike, Peoria Park District
Miller, Byron, Kankakee River Conservancy District
Mollahan, Rick, Illinois Department of Natural Resources
Morford, Lynn, Department of Commerce & Community Affairs
Morris, Bill, National Weather Service
Morrow, Bill, U.S. Geological Survey
Nicholes , Rich, U of I Extension
Nielson, Adam, Illinois Farm Bureau
Norris, Larry, YSI Inc.
Odle, Don, Construction Materials
Olson, Paula, Soil & Water Conservation Dist.
Orrick, Lloyd, City of Pekin
Papanos, Laurie, Prairie Rivers RC&D
Patrick, Richard, Illinois Department of Natural Resources
Pegg, Mark, Illinois Natural History Survey
Phillips, Andrew, Illinois State Geological Survey
Pisani, Frank, Illinois Department of Natural Resources
Plumer, Mike, University of Illinois
Rahe, Mike, Illinois Department. of Agriculture
Ranney, Greg, City of Pekin
Ransburg, Dave, Mayor City of Peoria
Richardson, Dan, Kress Corporation
Roat, Katie, Illinois Natural History Survey
Robinson, JeanAnn, Mazon River Watershed Planning Committee
Rodsatter, Jon, Illinois State Water Survey
Roseboom, Don, Illinois State Water Survey
Russell, Steve, U.S. Army Corps of Engineers
Russell, Wendy, Heartland Water Resources Council
Ryan, George, Governor of Illinois
Santure, Sharron, USDA- NRCS
Schultz, Richard, Kankakee River Basin Partnership
Shackleford, Dana, Illinois State Water Survey
Sharpe, Jennifer, U.S. Geological Survey
Shepler, Jack
Shilts, Bill, Illinois State Geological Survey
Simon, Nedda, Illinois Association of R C & D
Skoglund, Joanne, The Nature Conservancy
Slifer, James, Illinois Department. of Transportation
Slone, Ricca, Illinois State Representative
Slowikowski, Jim, Illinois State Water Survey

Snider, Ted, Illinois State Water Survey
Sobaski, Steve, Illinois Department of Natural Resources
Solomon, Jay, University of Illinois
Soong, David, U.S. Geological Survey
Sparks, Rip. University of Illinois
Sronce, Kevin, Illinois Department. of Natural Resources
St John, Kim, Prairie Rivers RC&D
Staebell, Jodi, U.S. Army Corps of Engineers
Stevenson, Kip, Illinois State Water Survey
Strawn, Alesia, University of Illinois
Stumpf, Andrew, Illinois State Geological Survey
Sullivan, Gary, Illinois Department of Natural Resources
Taylor, John
Terrio, Paul, U.S. Geological Survey
Thompson, Brad, U.S. Army Corps of Engineers
Tidrick, Melinda, Illinois State Water Survey
Timmons, Randy, Illinois Department of Natural Resources
Todd, Dick
Tuecke, Joe, U.S. Army Corps of Engineers
Urban, Christine, U.S. EPA- Region 5
Van Es, John, University of Illinois
Van Leussen, Wim, Dutch Ministry of Transport
VanMill, Mike, Kankakee River Basin Partnership
Verencak, Joe, Illinois Department of Natural Resources
Vessering, Lu Ann, Prairie Rivers RC&D
Vogel, LT Paul, U.S. Coast Guard
Vonnahme, Don, Illinois Department of Natural Resources
Wade, Angela, Rushville High School
Wade, Amy, Rushville High School
Waugh, John, Phoenix Process Equipment Co
Wefer, Mike, Illinois Department of Natural Resources
Weibel, Pius, Illinois State Geological Survey
Weir, Bob, Mar Mac Manufacturing Co
Whiles, Matt, SIU Carbondale
Whitlock, Kay, Christopher B. Burke Engineering, LTD
Willhite, Marcia, Illinois Environmental Protection Agency
Winstanley, Derek, Illinois State Water Survey
Wolland, Donald
Wood, Lt. Governor Corinne, Office of Lt. Governor
Woodruff, Mary Jo, Illinois Department of Natural Resources
Xia, Jim, Illinois State Water Survey
Zerbonia, Mike, U.S. Army Corps of Engineers
Zhang, Bill, Caterpillar Inc.