THE ILLINOIS RIVERS DECISION SUPPORT SYSTEM

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Abstract

The Illinois River connects the Great Lakes with the Mississippi River through the Illinois Waterway consisting of eight lock and dams along the river. The Illinois River has become the focus of state and federal agencies interested in integrated watershed management. As a result, issues related to habitat restoration, floodplain management, navigation, erosion and sedimentation, and water quality are all being discussed at the watershed level. In support of this effort, the Illinois Scientific Surveys have initiated development of the Illinois Rivers Decision Support System (ILRDSS) for use in assessing and evaluating the effectiveness of different restoration projects. The ILRDSS will integrate and expand existing databases and models for segments of the Illinois River into an integrated decision support system for the entire watershed. New databases and models are also being developed for the watershed, as well as a comprehensive ILRDSS web portal to all available data and information on the Illinois River and its watershed.

1 INTRODUCTION

The Illinois River Watershed is important to the state of Illinois. The watershed has a drainage area of 75,156 square kilometers (28,906 square miles) of which approximately 64,000 square kilometers (25,000 square miles) are located in Illinois with the remainder in Indiana and Wisconsin as shown in Figure 1. The Illinois River Watershed is generally flat and covered with fine soil, making it one of the best agricultural regions in the United States. Over 80 percent of the Illinois River basin is presently used for agricultural purposes; the remnant contains 95 percent of Illinois' urban areas (Demissie et al, 1999). Ninety percent of Illinois' population resides within the watershed. The Illinois River is also one of the few remaining rivers with a functioning ecosystem critical to a vast array of fish and wildlife. The Illinois River, a major tributary of the Mississippi River, is part of the only inland waterway linking the Great Lakes to the Gulf of Mexico. As such, the Illinois Waterway is a nationally important commercial waterway with more than sixty million tons of commodities shipped annually, ranking Illinois third among the fifty states in domestic waterborne commerce.

Over the last one hundred years, there have been numerous attempts to control and manage low 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 first constructed to provide a 2.13-meter (7-foot) navigation channel in the lower Illinois River. These low-head dams provided adequate navigation depth during

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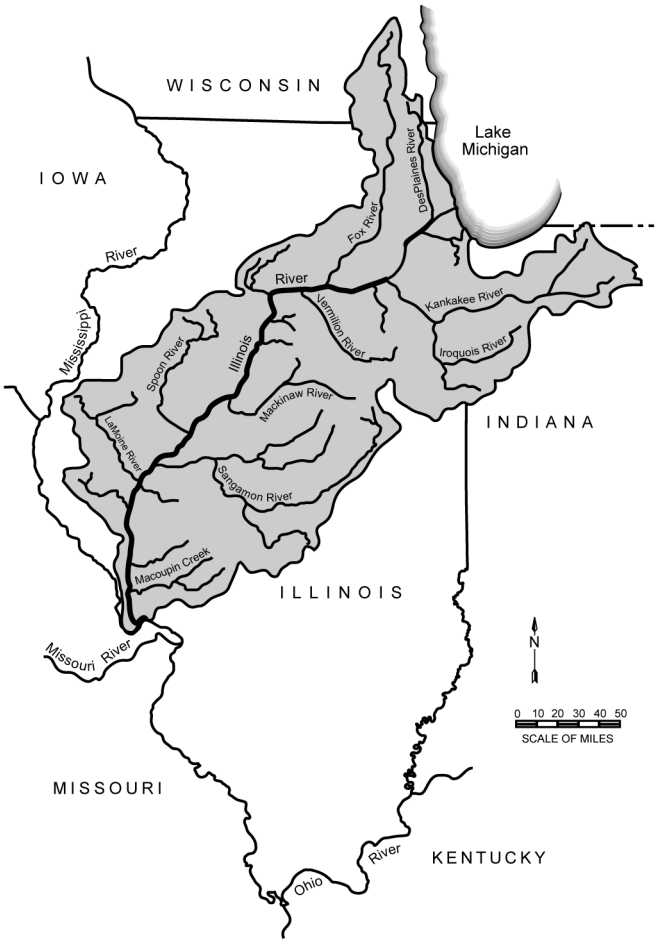

Figure 1. Location of the Illinois River Watershed

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 2.74-meter (9-foot) navigation channel along the Illinois River in 1927. In the 1930s, seven modern locks and dams were completed on the Illinois, Mississippi, and Des Plaines Rivers to create the Illinois Waterway as we know it today. The Illinois Waterway consists of the Illinois River, Des Plaines River, and the Chicago Sanitary & Ship Canal System and is made navigable by a series of eight locks and dams along the Illinois River and its tributaries, as shown in Figure 2. The waterway ends at Grafton, about 56 kilometers upstream of St. Louis, Missouri, where the Illinois River joins the Mississippi River.

Another major factor that has 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 (Vonnahme, 1996). The annual diversion from Lake Michigan to the Illinois River varied from approximately 85 to 283 cubic meters per second (3,000 to 10,000 cubic feet per second) for the

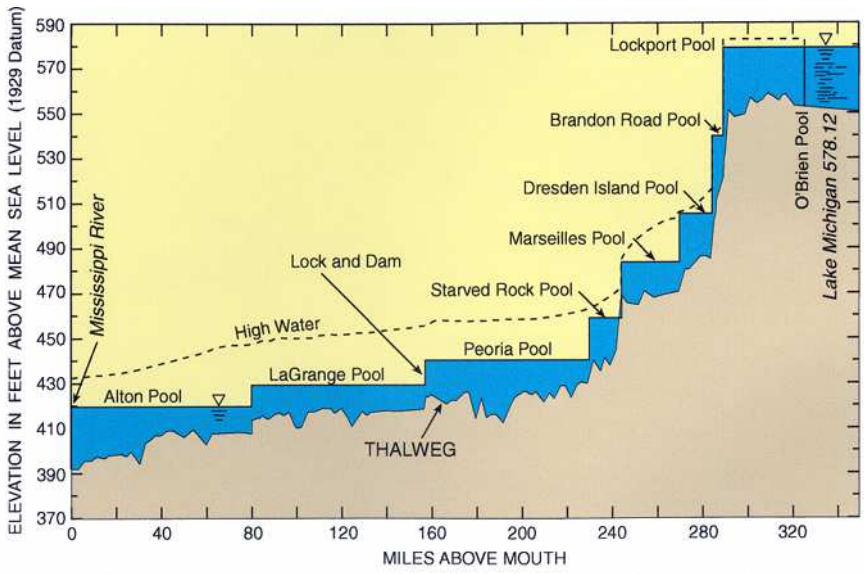

Figure 2. Profile of the Illinois River Waterway

period from 1900 to 1939. After 1939, the total diversion was limited to an average of 90.6 m^3/s (3,200 cfs) by the Supreme Court. Approximately 42.5 m^3/s (1500 cfs) of the diverted water was allocated for dilution and the remaining 48.1 m^3/s (1,700 cfs) for domestic water supply.

1.1 ILLINOIS RIVER ISSUES

The Illinois River has experienced significant changes in hydrology and water quality over the years because of its downstream location from the Chicago metropolitan area and significant land use changes in the watershed. The most significant influences have been related to commercial navigation, municipal and industrial waste discharges, and agricultural practices in the watershed. Over time these changes have resulted in environmental and ecological degradation along the river. Issues related to habitat restoration, floodplain management, navigation, erosion and sedimentation, water quality, and point and nonpoint source pollution are all being discussed at the watershed level by state and federal agencies.

> A result of these discussions is the Integrated Management Plan for the Illinois River Watershed (Kustra, 1997). The plan includes thirty-four recommendations that are in the process of being implemented by different agencies at different pace and intensity. The Illinois State Water Survey played a major role in the development of the Integrated Management Plan (IMP) and is actively participating in its implementation. To this end, the Water Survey initiated development of the Illinois Rivers Decision Support System (ILRDSS) in 1999, and this work is summarized in Demissie et al (1999).

In late October 1999, development started on a new long-range, comprehensive effort to restore and protect the Illinois River and its tributaries. The result of these efforts was *Illinois Rivers 2020* (IR2020), a voluntary, incentive-based approach to address threats to the economic and environmental sustainability of Illinois' waterways. Since implementation of this federal-state initiative will require substantial scientific support and access to high-quality information, the ILRDSS was included as the restoration program's primary support system for dissemination of scientific tools and information. With inclusion in this initiative, ILRDSS activity concentrated on developing the conceptual design of the support system for inclusion in IR2020 legislative drafts, increasing outreach efforts to inform potential collaborators on proposed system capabilities and garner their support, and coordinating communication and development efforts among the involved agencies (Demissie and Tidrick, 2001).

1.2 NEED FOR A DECISION SUPPORT SYSTEM

Major restoration efforts are underway to improve the hydrology, water quality, and habitats along the river and its watershed. A major challenge in these restoration efforts is the proper understanding of the watershed hydrology and river hydraulics so that watersheds and rivers are managed in such a way to promote and sustain ecological restoration while maintaining the economical functions of the river.

Also the issues that need to be examined on a watershed basis for the Illinois River are not limited to hydrology and hydraulics, but also include a whole gamut of issues related to water quality, sediment transport, ground-water/surface water interaction, impact of climate change or fluctuation, ecosystem restoration, and economic and societal impacts. Without basin-wide analysis, conclusions and recommendations will be limited to selected sites, and broad application of results will be impractical. There is a need for the development of an integrated system that can help decision-makers address these issues on a watershed basis. Currently, however, no formal basis for integrated watershed management exists.

A comprehensive support system is needed that will provide state and federal agencies, non-governmental organizations, local agencies, and stakeholders a better means for organizing, accessing, and evaluating a wide range of information and alternative strategies, and to establish informed and factual positions regarding the major issues. Benefits from such a support system include better access to information, tools, improved communication, and better project management.

2 ILLINOIS RIVER DECISION SUPPORT SYSTEM FRAMEWORK

The Illinois Rivers Decision Support System (ILRDSS) will provide scientific support and access to high-quality information for restoration of the Illinois River and its watershed. Once fully developed and tested, the ILRDSS will enable decision-makers to assess and evaluate the effectiveness of different restoration projects, and the consequences of other natural or human induced changes in the watershed. The decision support system also will improve dissemination of scientific tools and information by using the Internet as primary access to inventories of current and historical projects, data, simulations, and involved agencies/participants within the Illinois River Watershed. The ILRDSS website provides this information at a lower cost, in a more usable form, and in a much more timely manner than methods.

This technology and communication framework will include information resources, modular databases, and simulation models to evaluate the impact of water resources development, land-use changes, economic development, and climate variability on sedimentation, water quality, ecology, hydrology, and hydraulics in terms of long-term restoration and sustainability for the Illinois River.

Figure 3 displays in bold text the conceptual relationships between the four main components of the Illinois Rivers Decision Support System: (1) the information system containing data products; (2) simulation and assessment models in the analytical tools

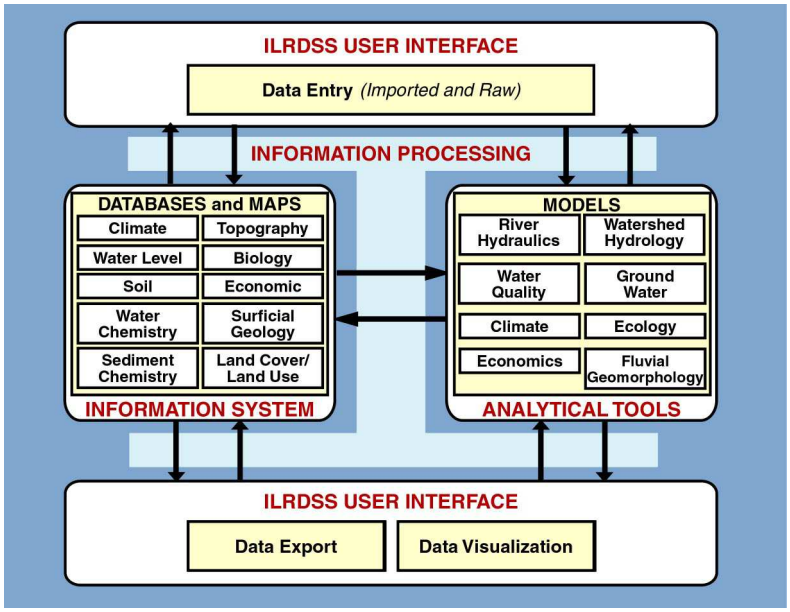

Figure 3. Simplified Conceptual Framework for the Illinois Rivers Decision Support System

component; (3) users of the system; and (4) information processing system, or communication pathways, that underpins the ILRDSS and allows information transfer among all the components. The diagram also details the data and modeling sub-components for inclusion in the information system and analytical tool modules. Early versions of the ILRDSS provides basic information exchange between the user and individual data and tool components via direct database access and web-based interfaces. Ongoing work will add web-based interactive modeling and simulation features and direct linkages between ILRDSS databases and models.

Expected users in the early years will be scientists and professionals within state and federal agencies. As the ILRDSS matures and more components are added to aid in decision processes, system users will expand to include a broader range of decision-makers.

At present, the ILRDSS consists of a prototype website containing water resource databases, reports, project description, and graphic animations. For the analytical tool sections, hydraulic and hydrologic models are being developed and tested.

3 INITIAL DEVELOPMENTS AND APPLICATIONS

Activities to date have focused on developing the ILRDSS conceptual design, garnering support of potential collaborators, and coordinating communication and development efforts among agencies involved. These efforts have resulted in the creation of a prototype website populated with water resource data, modeling products, and information generated by scientists at the five Illinois State Scientific Surveys: the Illinois State Geologic Survey, the Illinois State Museum, the Illinois State Natural History Survey, the Waste Management Research Center, and the Illinois State Water Survey.

3.1 Web Development

In December 2000, the Illinois State Water Survey created a web development team with the purpose to construct a comprehensive web portal to all available information and data on the Illinois River and its watershed. The team has five core members: a project coordinator who generates site content and acts as liaison between content donors and ILRDSS team members; a web designer/programmer who creates the graphic layout and coding for the ILRDSS web pages; and a GIS manager, a database administrator, and a web programmer who all work

partial percentage-time on the ILRDSS project. To date the team has created a prototype website (http://ilrdss.sws.uiuc.edu) that is dynamically generated from a web-link database currently containing over a thousand links to data, information, and graphical resources concerned with the Illinois River and watershed. By making the website dynamically generated, the team can update the ILRDSS site quickly and efficiently through new database entries. Database access also provides website users increased search capabilities, which are greatly needed with the expected volume of data and information within the ILRDSS website.

ILRDSS website navigation centers around four primary groupings as shown in Figure 4: products, watersheds, site resources, and tabbed search features. A user can browse using graphic maps to find data and information related to a specific site or region, or else search from a list for particular products related to the subcategory, such as online data, maps and GIS data sets, models and modeling information, publications, and research and program listings. If users initially desired a specific product, they can directly search for matching items using the products section, located in the middle left-hand side of the homepage, instead of searching via the categories section. The products grouping not only contains all products included on subcategory pages, but also includes an inventory (currently in progress) of all research and programmatic activities within the Illinois River watershed and all agencies and organizations related with these efforts. Website users wishing to browse by keywords or who are unsure of where to find specific information can instead utilize the primary search feature located in the tabbed section at the center of the site homepage.

3.2 Hydraulic and Hydrologic Modeling

An ongoing effort by the Watershed Science Section of the State Water Survey is to develop hydrologic and hydraulic models for the entire Illinois River Watershed. In 2000 Water Survey scientists developed an initial version, uncalibrated hydrologic model of the Illinois River Watershed based on BASINS 3.0 beta version. The BASINS model was selected for the Illinois River Basin because it offered the best-integrated modeling framework for examining management alternatives within Illinois River watersheds and can be developed within the shortest time frame as compared to other models. Water Survey scientists tested the Illinois River BASINS model utilizing only coarse data sets. Overall, the initial tests have shown that the BASINS model has the capability for large-scale hydrologic modeling of the Illinois River Basin.

Water Survey scientists also developed one- and two-dimensional hydraulic models for selected segments of the Illinois River. They have begun investigating the interaction of the Illinois River with its floodplain to better understand the influence of potential restoration efforts on river hydraulics. Presently one of the major restoration concepts is the reconnection of the Illinois River with its floodplain, and several levee and drainage districts have been purchased by state, federal, and non-governmental organization for such purposes. There is no consensus on

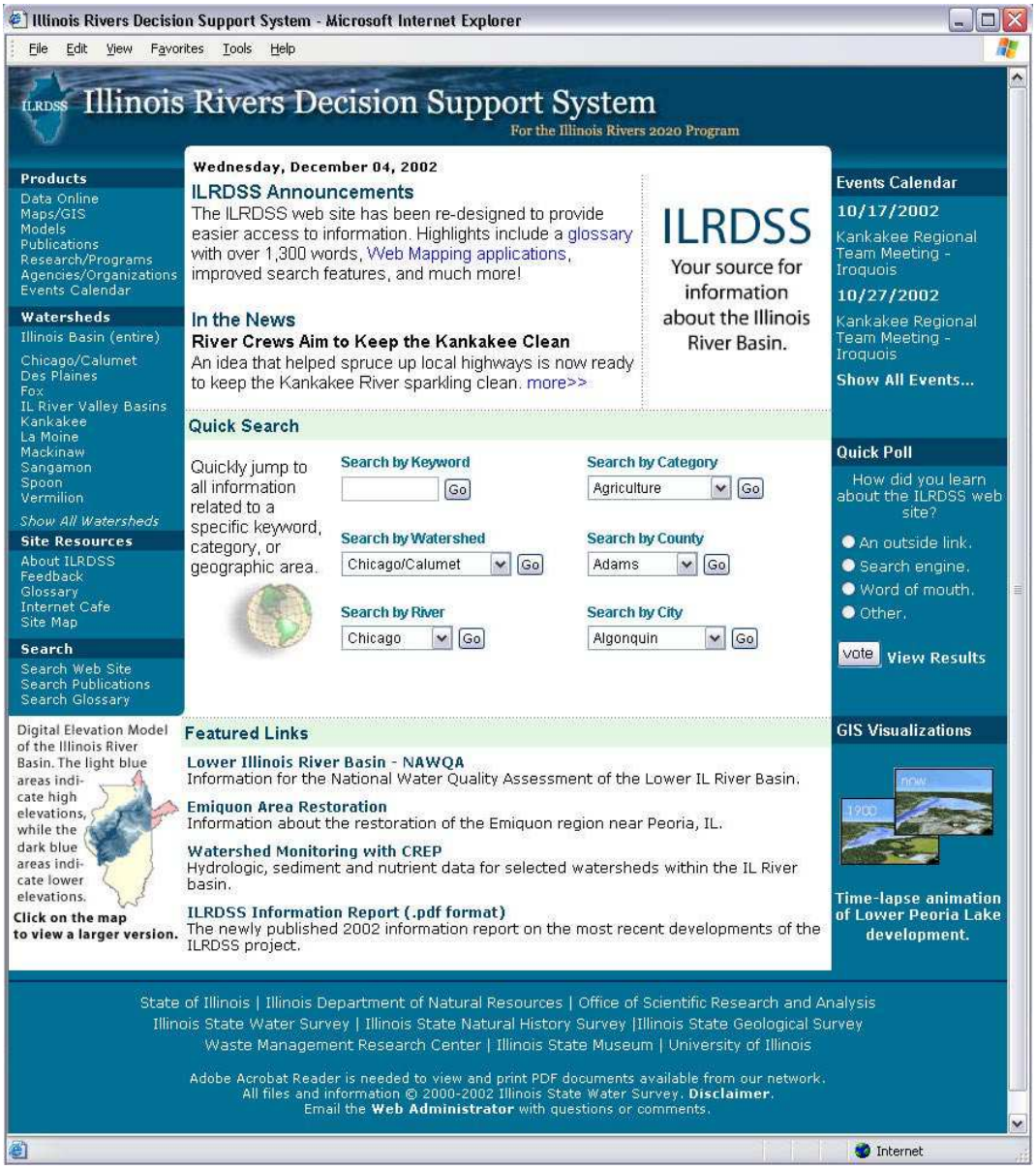

Figure 4. ILRDSS website homepage

how to reconnect the floodplain to the river or what the impacts of flooding in newly restored floodplains could be if reconnected.

The initial hydraulic model used for evaluating different floodplain management alternatives for the Illinois River is based on the UNET, a one-dimensional unsteady flow model supported by HEC (HEC, 1995). The output from the UNET model includes time-series stage and discharge values at selected locations and water surface profiles along the study reach. These values can then be used to evaluate changes in flood elevations and discharges for different floodplain management alternatives. For example, the UNET model for the Illinois River has been used to evaluate the impacts of using the Thompson Lake LDD in LaGrange Pool as temporal flood storage to reduce flood peaks. The model simulated the impacts of a 1,000-ft (305-m) wide spillway placed 2 ft (0.61 m), 4 ft (1.22 m), and 6 ft (1.83 m) below the Thompson Lake levee crest to allow floodwater to flow into the drainage district. Figure 5 shows the change in flood elevation at the levee district, while Figure 5 shows the change in flood elevations at Havana seven miles (11.3 km) downstream of the spillway. As shown in Figure 5, placing the spillway 2 ft (0.61 m) below the levee crest results in maximum reduction of flood peak for the flood analyzed.

A second hydraulic model was developed using RMA2, a two-dimensional hydrodynamic model developed by the U.S. Army Corps of Engineers (1996). The model was developed for the segment of the Illinois River that included the Thompson Levee and Drainage District (LDD) and the Lake Chautauqua Fish and Wildlife Refuge. The model was used to evaluate changes in flow patterns under different management alternatives such as placing a single spillway or two spillways on the Thompson LDD levee. Results show that two spillways along the levee allow flood conveyance through the drainage district while a single spillway permits only floodwater inflow into the LDD. Two-dimensional animations of these options are available for download in avi format at the ILRDSS website.

3.3 Graphic Visualization Tools

Using *World Construction Set 5* (a professional photorealistic terrain visualization, modeling, rendering and animation software package from 3D Nature), the GIS staff at the Illinois State Water Survey has created three-dimensional "fly-through" animations depicting current and historical conditions along segments of the Illinois River that include portions of the LaGrange Pool and Peoria Lake. Proposed dredging and island construction proposals have also been animated. These stunningly realistic landscape images will aid decision makers to visualize or demonstrate impacts of resource management options. The animations files are available for download in avi format at the ILRDSS website.

Utilizing linkages with the Illinois Natural Resources Geospatial Data Clearinghouse and other unique resources, ILRDSS staff has created within the ILRDSS website a portal to GIS data and imagery for Illinois River Basin hydrology, geology, biology, ecology, conservation, environment, land use, infrastructure, and more. Complex data can be displayed in two- or three-dimensional graphical formats to aid decision makers in organizing, accessing and evaluating a wide range of information on the Illinois River Watershed via the Internet.

3.4 Data and Textural Report

The Illinois State Scientific Surveys have a long history of research and data collection within the Illinois River Watershed. As a starting point, ILRDSS staff has focused on populating the ILRDSS website and databases with ‘in-house’ data, graphics, and information.

For example, ILRDSS staff has begun conversion of Critical Trends Assessment Project (CTAP) reports into Adobe Acrobat portable document format (pdf) for inclusion into the ILRDSS website. CTAP conducts statewide and regional assessments throughout Illinois to systematically monitor ecological conditions and provide information for ecosystem-based management. Since the Illinois State Scientific Surveys are major contributors to CTAP reports,

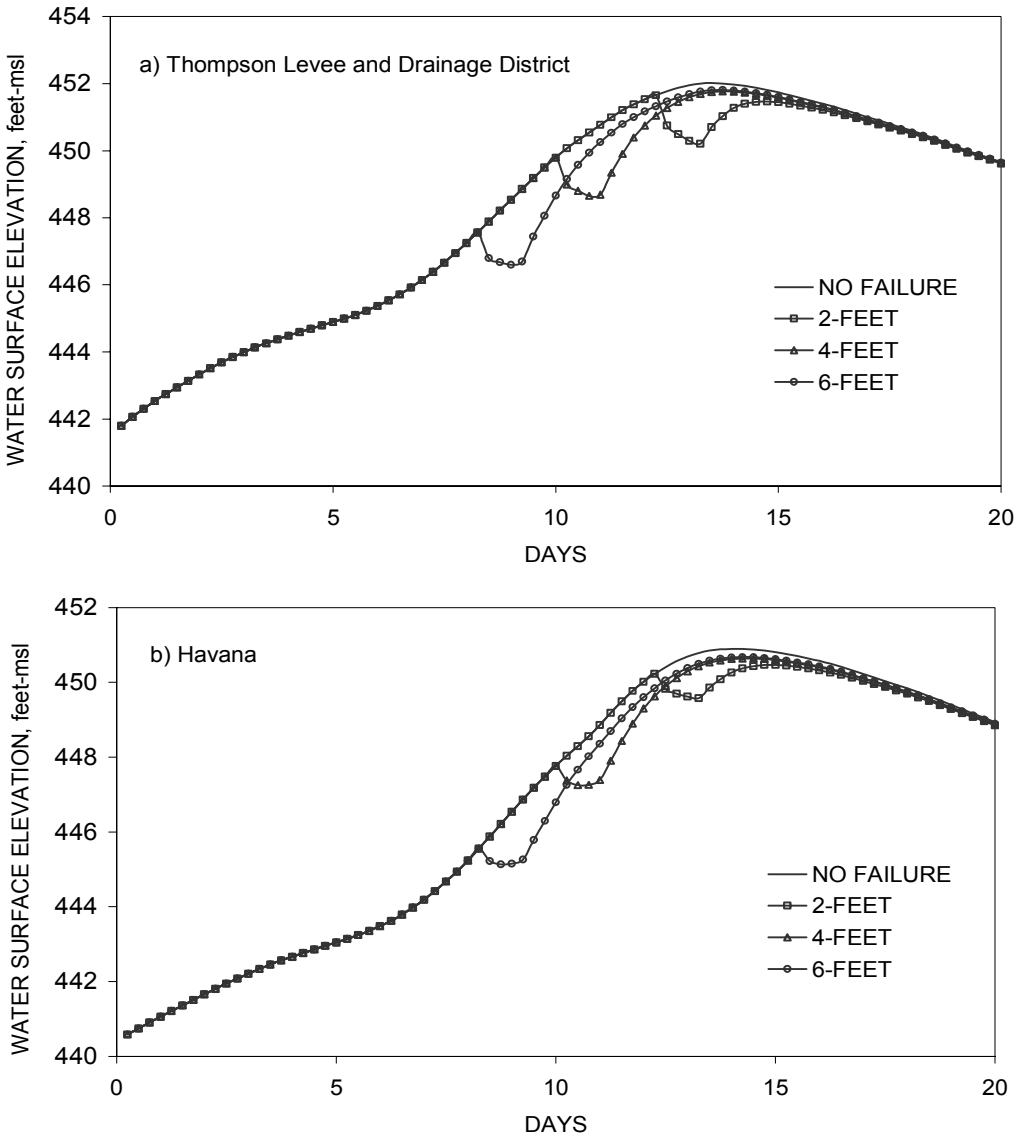

Figure 5. Impacts of using the Thompson Lake Levee and Drainage District as temporal flood storage to reduce flood peaks. The UNET model was used to simulated a 1,000-foot (305-meter) spillway placed 2 feet (0.61 meters), 4 feet (1.22 meters), and 6 feet (1.83 meters) below the Thompson levee crest to allow floodwater to flow into the drainage district. Figure 6a shows the change in flood elevation at the levee district. Figure 6b shows the change in flood elevations at Havana seven miles (11.3 kilometers) downstream of the modeled spillway.

ILRDSS staff has direct access to original text and graphics for individual reports covering geology, water resources, living resources, socio-economic profiles, environmental quality, archaeological resources, and historical accounts within the Illinois River Watershed. Currently public access to this data is restricted primarily to paper reports. Inclusion into the ILRDSS will greatly increase usability and access.

Another example is the collection of historical stage data available on the ILRDSS website. Raw, process, and frequency stage data for several locations on the Illinois River can be directly accessed by website users in graphical or tabular form and downloaded for use with analytical or modeling programs.

4 FUTURE DEVELOPMENTS AND APPLICATIONS

ILRDSS developments in the future will include continuing design, development, and maintenance for the comprehensive website as well as continued hydraulic and hydrologic model development. Web efforts will focus on expanding access to reports, databases, and simulations from sources outside the Illinois State Water Survey, including developing and maintaining a comprehensive, statewide inventory of activities, organizations, and data resources pertaining to the Illinois River and its watershed. ILRDSS modeling efforts will include linking the hydrologic model output into the hydraulic model to allow better investigation of flow routing along the Illinois River mainstem. GIS staff will continue to expand 2-D and 3-D animation efforts by incorporating additional projects and visualizing the scientists' work.

5 ACKNOWLEDGMENTS

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