SECTION 3 PLAN FORMULATION

A. DESCRIPTION OF THE STUDY PROCESS

The Illinois River Basin Restoration Comprehensive Plan follows the Corps of Engineers' six-step planning process specified in Engineering Regulation (ER) 1105-2-100. The process identifies and responds to problems and opportunities associated with the Federal objective and specified State and local concerns. The process provides a flexible, systematic, and rational framework to make determinations and decisions at each step so that the interested public and decision makers are fully aware of the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, and the significant implications of each alternative plan. As a comprehensive plan for the Basin, the formulation of alternatives was not limited to Corps and Illinois DNR activities. Implementation on a basin scale will require the work of numerous Federal, State, local, and private agencies and organizations.

If a Federal and State interest is identified, the process culminates in the selection of a plan to be recommended to Congress for implementation. The Federal interest in ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. As part of identifying the selected plan, a number of alternative plans are developed and compared with the no action alternative, allowing for the ultimate identification of the National Ecosystem Restoration (NER) plan.

The NER plan reasonably maximizes ecosystem restoration benefits compared to costs, considering the cost effectiveness and incremental cost of implementing other restoration options. In addition to considering the system benefits and costs, it will also consider information that cannot be quantified, such as environmental significance and scarcity, socioeconomic impacts, and historic properties information.

The steps used in the plan formulation process include:

1. Identify Problems and Opportunities: The specific problems and opportunities are identified, and the causes of the problems discussed and documented. Planning goals are set, objectives established, and constraints identified. Specifically for this study, the restoration objectives were set based on the desired future conditions established by system resource managers. The desired future was based on published literature and the expert opinion of resource managers as to what the system should look like in the future to restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them.

2. Inventory and Forecast Resource Conditions: This step characterizes and assesses conditions in Illinois River Basin as they currently exist and forecasts the most probable without-project condition (no action alternative) over the period of analysis. This assessment gives the basis by which to compare various alternative plans and their impacts. The without-project condition is what the river basin and its uses are anticipated to be like over the 50-year planning period without any restoration implemented as part of the study. The with-project condition is what the river and its uses are anticipated to be like if restoration measures, identified in each alternative, are implemented. An important part of this step for this study was to identify "desired future conditions." The information describing this step of the planning process is presented in Section 2 of this report.

3. Formulate Alternative Plans: Alternative plans were developed in a systematic manner to ensure that reasonable alternatives were evaluated. For this study, ecological integrity was the overarching goal and drove the identification, development, and selection of restoration measures and alternative plans. The alternative plans all address ecosystem integrity, but vary in terms of restoration efforts associated with each of the remaining six study goals.

4. Evaluate Alternative Plans: The evaluation of each alternative consists of measuring or estimating the ecosystem benefits (acres of habitat or stream miles restored, tons of sediment not delivered to the system, etc.), costs, technical limitations, and risk and uncertainty of each plan, and determining the difference between the without- and with-project conditions. Due to the size and scale of the analyses and differences in output by goal category, a complete cost effectiveness and incremental cost effectiveness analysis based on habitat units could not be conducted. The quantifiable measures of system output that provide comparability across all goal categories were the percentage attainment of restoration objectives (desired future), acres, and stream miles. These measures of benefit allowed for the completion of a cost effectiveness-incremental cost analysis for five of the seven goal categories (Goals 1-5). The outputs for the Overarching Goal and Goal 6 could not be fully quantified and, as a result, were assessed qualitatively. As part of future site-specific restoration projects, detailed and complete cost effectiveness and incremental cost analysis would be conducted.

5. Compare Alternative Plans: Alternative plans are compared, focusing on the differences among the plans identified in the evaluation phase and public comment.

6. Select Recommended Plan: A Recommended Plan is selected and justification for plan selection prepared. If a viable alternative is not identified, the Recommended Plan will be the No Action alternative.

The following sections provide a description of the system problems, goals and opportunities, objectives, and constraints pertaining to the study area as a whole. Next, the report describes the affected environment, and specific objectives and alternative formulation conducted for the overarching goal and goals 1 through 6. Finally, in the System Evaluations section, alternative plans are summarized. While these steps do follow a progression, they are iterative, i.e., as additional information was learned in subsequent steps, it was often necessary to back up and repeat portions of a previous step(s). Section 4 of this report describes the preferred comprehensive plan alternative, followed by a discussion of the environmental impacts, in Section 5.

B. ASSESSMENT OF PROBLEMS, OPPORTUNITIES, AND CONSTRAINTS

1. Problem Statement. The Illinois River Basin has experienced the loss of ecological integrity due to sedimentation of backwaters and side channels, degradation of tributary streams, increased water level fluctuations, reduction of floodplain and tributary connectivity, and other adverse impacts caused by human activities.

2. Opportunities. A restoration vision was developed for the Illinois River in 1997 as part of the development of the State of Illinois' *Integrated Management Plan for the Illinois River Watershed.* This vision for the Illinois River Basin has been accepted by the Federal, State and local stakeholders involved in the development of the Illinois River Basin Restoration Program with the minor modification of replacing the word "Valley" with "Basin." It is understood that attaining this vision will likely take decades and that various types of projects will be necessary to maintain some features until natural ecological processes are reestablished. The vision is for:

> *A naturally diverse and productive Illinois River Basin that is sustainable by natural ecological processes and managed to provide for compatible social and economic activities.*

With the *Integrated Management Plan* providing context, the list of Illinois River Basin system-wide ecosystem restoration goals was developed (Goals 1 through 6 are not listed in priority order):

Overarching Goal. Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them

Goal 1. Reduce sediment delivery to the Illinois River from upland areas and tributary channels with the aim of eliminating excessive sediment load

Goal 2. Restore aquatic habitat diversity of side channels and backwaters, including Peoria Lakes, to provide adequate volume and depth for sustaining native fish and wildlife communities

Goal 3. Improve floodplain, riparian, and aquatic habitats and functions

Goal 4. Restore aquatic connectivity (fish passage) on the Illinois River and its tributaries, where appropriate, to restore or maintain healthy populations of native species

Goal 5. Naturalize Illinois River and tributary hydrologic regimes and conditions to restore aquatic and riparian habitat

Goal 6. Improve water and sediment quality in the Illinois River and its watershed.

3. Constraints

- No increase in flood elevations as required by Illinois law – Illinois state law specifies that any action in the floodplain that increases flood heights is not allowable or must be accompanied by mitigation of adverse effects. Due to the potential high cost associated with mitigation actions, efforts will be made to avoid this threshold.
- No significant adverse impact on the 9-Foot Channel Navigation Project on the Illinois Waterway.
- State of Illinois limitations – For efforts sponsored by the State of Illinois constraints include funding and land ownership or the ability to acquire land interests from willing landowners.
    - Funding Limitations – As a Non-Federal Sponsor, the ability of the State of Illinois to afford various features, and the associated operations and maintenance, represents a potential limiting factor.
    - Land Ownership, Willing Landowners, etc. – As a Non-Federal Sponsor, the State of Illinois will be required to provide the necessary real estate interests for projects they sponsor. The State will only acquire the lands, easements, and rights-of-way from willing landowners.

- A final legal determination has not been made as to ownership of submerged lands in the Illinois River Basin.
- Legal Compliance – Due to the geographic size, scope, and purpose of this study, multiple levels of legal authority apply to the project area. All efforts conducted in the implementation of the Comprehensive Plan shall comply with all Federal regulations and all applicable State and local regulations pertaining to the activities undertaken by the Corps of Engineers and the non-Federal sponsor in this study.
- Efforts will be made to minimize the unnecessary and irreversible conversion of prime farmland to non-agricultural uses. These efforts include: (1) identify and take into account the adverse effects on the preservation of prime farmland; (2) consider alternative actions, as appropriate, that could lessen adverse effects to prime farmland; and (3) ensure to the extent practicable, the project is compatible with state and units of local government and private programs to protect prime farmland.
- Landowner Rights – No site investigations (such as surveys or geotechnical investigations) will be conducted without contacting property owners and obtaining permission to access potential project areas.

4. Conceptual Framework. In addition to the overall problem statement and system goals listed previously, the system team developed a specific problem statement and objectives for each of the system goals to facilitate adequate formulation. The objectives were identified for the ecosystem integrity of the system as well as for the other goal categories by the study team, resource managers, and stakeholders based on extensive research and literature. These objectives represent a desired future condition or virtual reference of ecological condition for the Illinois River Basin.

The goals and objectives developed as part of this study were formulated to address the system limiting factors. In particular, the goals for this study were adapted from published literature for the Upper Mississippi River System, specifically, the Upper Mississippi River Conservation Committee's (UMRCC) report, *A River That Works and a Working River.* The UMRCC is comprised of more than 200 resource managers working in the fisheries, recreation, wildlife, water quality, and law enforcement disciplines, whose goal is to "Promote the preservation and wise utilization of the natural and recreational resources of the Upper Mississippi River (UMR) and to formulate policies, plans and programs for conducting cooperative studies."

Additional reports and studies evaluated include: The Environmental Management Program's *Habitat Needs Assessment*; the UMR-IWW System Navigation Feasibility Study; the State of Illinois' *Integrated Management Plan for the Illinois River Watershed*; and The Nature Conservancy's *Threats to the Illinois River Ecosystem*. These documents and studies were developed by scientists and local resource managers, and included multi-agency collaboration. The information from these sources was refined in the development of the goals for this study.

Overarching Goal. Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them

Problem. The combined effects of habitat losses through changes in land use, human exploitation, habitat degradation and fragmentation, water quality degradation, and competition from aggressive invasive species have significantly reduced the abundance and distribution of many native plant and animal species in the Illinois River Basin. In addition, human alterations of Illinois River Basin landscapes have altered the timing, magnitude, duration, and frequency of habitat forming and seasonal disturbance regimes. The cumulative results of these complex, systemic changes are now severely limiting both the habitats and species composition and abundance in the Illinois River Basin.

Overarching Objectives

- Identify and address system-wide limiting factors to ecological integrity (structure and function), including, but not limited to:

  ***Goal 1* -** excessive sedimentation

  Goal 2 (backwaters, side channels, and islands) - reduction and fragmentation of aquatic habitat

  Goal 3 (floodplain, riparian, and aquatic) - reduction and fragmentation of aquatic and terrestrial habitat, altered disturbance regimes, and invasive plant species

  Goal 4 (aquatic connectivity) - reduction and fragmentation of aquatic habitat

  ***Goal 5* -** altered hydrologic regimes

  ***Goal 6* -** water and sediment quality

- Restore and conserve natural habitat structure and function, including, but not limited to:

  - Concentrations of flora and fauna or areas that are:
    high in biodiversity;
    especially vulnerable to disturbance; and/or
    important in fulfilling a life-history requirement of the species present.

  - Specific suitable habitat for Federal and State endangered and threatened species, or other species of concern that is capable of supporting long-term sustainable populations at the site and protect additional acres of the identified suitable habitat, as appropriate.

  - Representative examples of all community types in the Illinois River Basin, best of kind or as needed, to protect and restore habitat structure and function at the system level.

- Establish existing and reference conditions for ecosystem functioning and sustainability against which change can be measured; monitor and evaluate actions to determine if goals and objectives are being achieved, at both the project and system levels.

Goal 1. Reduce sediment delivery to the Illinois River from upland areas and tributary channels with the aim of eliminating excessive sediment load

Problem. Increased sediment loads from the basin have severely degraded environmental conditions along the main stem Illinois River by increasing turbidity and filling backwater areas, side channels, and islands. Improved conservation practices have reduced the amount of sediment generated from many agricultural areas, but large quantities of sediment are still delivered to the river due to eroding channels and tributary areas, including urban and rural construction sites. The most critical problems resulting from the increased sediment loads are the loss of depth and habitat quality in off-channel areas connected to the main stem river. Similar problems can be seen at other areas within the basin where excessive sediment has degraded tributary habitats.

Objectives

- Reduce total sediment delivery to the Illinois River by at least 10 percent by 2025 [reduction from an average of 12.1 to 10.9 million tons per year above Valley City, based on Illinois State Water Survey (ISWS) estimate of delivery for water year (WY) 1981-2000].
- Reduce total sediment delivery to the Illinois River by at least 20 percent by 2055 (reduction to an average of 9.7 million tons per year above Valley City, based on ISWS estimate of delivery for WY 1981-2000).
- Eliminate excessive sediment delivery to specific high-value habitat both along the main stem and in tributary areas.

Goal 2. Restore aquatic habitat diversity of side channels and backwaters, including Peoria Lakes, to provide adequate volume and depth for sustaining native fish and wildlife communities

Problem. A dramatic loss in productive backwaters, side channels, and islands due to excessive sedimentation is limiting ecological health and altering the character of this unique floodplain river system. In particular, the Illinois River has lost much of its critical spawning, nursery, and overwintering areas for fish, habitat for diving ducks, other waterbirds, and aquatic species, and backwater aquatic plant communities. There is a need for timely action. If restoration is not undertaken soon, additional productive backwater and side channel aquatic areas will be converted to lower value and increasingly common mudflat and extremely shallow water habitats.

Objectives

- Restore, rehabilitate, and maintain up to19,000 acres of habitat in currently connected areas (1989 data shows approximately 55,000 acres of backwaters during summer low water). Restoration should result in a diversity of depths. For restored backwaters, a general target would be to have the following distributions of depths during summer low-flow periods: 5% >9 feet; 10% 6 to 9 feet; 25% 3 to 6 feet; and 60% <3 feet.
- Restore and maintain side channel and island habitats.
- Maintain all existing connections between backwaters and the main channel (connections at the 50 percent exceedance flow duration).
- Identify beneficial uses of sediments.
- Compact sediments to improve substrate conditions for aquatic plants, fish, and wildlife.

Goal 3. Improve floodplain, riparian, and aquatic habitats and functions

Problem. Land-use and hydrologic changes have reduced the quantity, quality, and functions of aquatic, floodplain, and riparian habitats. Flood storage, flood conveyance, habitat availability, and nutrient exchange are some of the critical aspects of the floodplain environment that have been adversely impacted.

Objectives

- Restore up to an additional 150,000 acres of isolated and connected floodplains along the Illinois River main stem to promote floodplain functions and habitats.
- Restore up to 150,000 acres of the Illinois River Basin large tributary floodplains.
- Restore and/or protect up to 1,000 additional stream miles of riparian habitats.

Goal 4. Restore aquatic connectivity (fish passage) on the Illinois River and its tributaries, where appropriate, to restore healthy populations of native species

Problem. There is diminished aquatic connectivity on the Illinois River and its tributaries. Aquatic organisms do not have sufficient access to diverse habitat such as backwater and tributary habitat that are necessary at different life stages. Lack of aquatic connectivity slows repopulation of stream reaches following extreme events such as pollution or flooding and reduces genetic diversity of aquatic organisms.

Objectives

- Restore main stem to tributary connectivity, where appropriate, on major tributaries.
- Restore within-tributary connectivity.
- Restore passage for large-river fish at Starved Rock, Marseilles, and Dresden Lock and Dams where appropriate.

Goal 5. Naturalize Illinois River and tributary hydrologic regimes and conditions to restore aquatic and riparian habitat

Problem. Basin changes and river management have altered the water level regime along the main stem Illinois River, stressing the natural plant and animal communities along the river and its floodplain. Land use changes, the construction of the locks and dams (which create relatively flat navigation pools), and isolation of the river main stem from its floodplain have all impacted the water level regime to varying extents. Increased frequency and increased magnitude of water level fluctuations, especially during summer and fall low water periods, are two of the most critical results from the basin changes and river management. The lack of the ability to mimic natural hydrologic regimes in areas upstream of the navigation dams is also a problem. Increased flow variability has reduced ecological integrity in tributary areas as well.

Objectives

- Reduce low water fluctuations along the main stem Illinois River where possible, concentrating on the months of May through October and using pre-1900 water level records as a reference.
- Reduce peak flows from the major Illinois River tributaries by 2 to 3 percent for 2- to 5-year recurrence storm events by 2023. This will help to reduce peak flood stages and reduce high-water fluctuations along the river. Long term, reduce tributary peak flows by at least 20 percent for these events.

- Reduce the incidence of low-water stress throughout the basin by increasing tributary baseflows by 50 percent.
- Remove the dramatic water level changes associated with the operation of wicket dams at Peoria and La Grange.
- At an appropriate resolution (approximately 1 square mile in urban areas, 10 square miles in rural areas) identify and quantify the land and drainage alterations that contribute to unnatural fluctuations and flow regimes.
- Draw down the pools at Peoria and La Grange for at least 30 consecutive days at least once every 5 years.

Goal 6. Improve water and sediment quality in the Illinois River and its watershed

Problem. Water resources in the Illinois River Basin are impaired due to a combination of point and non-point sources of pollution. Although effective regulatory efforts have reduced contributions from point sources, non-point sources of water quality impairment (such as sediments and nutrients) continue to degrade the surface waters.

Objectives

- Achieve full use support for aquatic life in all surface waters, as defined in 305(b) of the Clean Water Act (CWA), of the Illinois River Basin by 2025.
- Achieve full use support for all uses on all surface waters of the Illinois River Basin by 2055.
- Encourage remediation of sites with contaminant issues that affect habitat.
- Achieve Illinois EPA nutrient standards by 2025, following standards to be established by 2008.
- Minimize sedimentation as a cause of impairment as defined by 305(b), of the CWA, by 2035.
- Maintain waters that currently support full use.

C. SYSTEM FORMULATION CONCEPT

As a basin level study addressing approximately 44 percent of the area of the State of Illinois—approximately 30,000 square miles—some modification of the general formulation approach used for a site-specific project was required. The goals and objectives were first set to address the specific resource problems (system limiting factors). Then, the focus became identifying the potential restoration measures and alternatives. In general, the system alternatives developed were not specific to particular sites (i.e., Babb's Slough, Richland Creek, etc.), but instead focused on the level of restoration effort needed to reach system restoration goals and objectives. More detailed cost information using MCACES software and benefits using habitat models will be defined as part of future site-specific project evaluations.

Since no systemic measure of ecologic integrity exists, the original measures of benefit varied by goal category, e.g. acres of wetland, backwater, floodplain; tons of sediment not delivered; stream miles; percentage changes in flows (table 3-1). Based on HQUSACE guidance, the study team also quantified system benefits for each goal category into outputs of acres or stream miles to better estimate the total system area benefited. While only the benefit area was measured, it should be recognized that the area would experience a dramatic increase in habitat quality compared to the without project condition. No single habitat suitability unit could be used for the system due to the number of habitat types and complex relationships of the benefits. However, the percent of goal attainment analysis originally conducted for this study does roughly equate to a quality and sustainability assessment.

Table 3-1. Type of Benefit Quantification by Goal

Goal	Benefit - Output By Goal	Benefit - System Area Estimate
Ecosystem Integrity	Indicators Under Development	Indicators Under Development
Sediment Delivery	Tons Not Delivered	Stream Miles
Backwaters & Side Channels	Acres (backwater) x Quality	Acres
Floodplain, Riparian, and Aquatic	Acres and Stream Miles	Acres (Floodplain and Riparian) and Stream Miles (Aquatic)
Aquatic Connectivity	Stream Miles	Stream Miles
Water Level Management	# of fluctuations % decrease in tributary peak flow % increase in tributary base flow	Acres (Main Stem) Stream Miles (Tributary)
Water Quality	Impaired Reaches, Dissolved Oxygen, Sediment, Nutrients	Not Quantified

Rather than fully developed site concepts, the evaluation of restoration measures highlighted the most promising measures and general level of effort needed (e.g., X number of riffle-pools, bank stabilization, and sediment basins to meet the system sediment tonnage reduction goal). However, the system formulation did consider the general locations of various needs and the information on available restoration measures. The primary outcome of the system formulation was a preferred comprehensive plan alternative identifying how much restoration is needed to restore the ecological integrity of the system and the associated measures and funding level needed to meet the intent of the 519 authorization.

System alternative development started with consideration of the measures available (e.g., bed and bank stabilization, backwater dredging, wetland creation, etc.) to address the problems and objectives developed under each goal category. For each of the measures, the relative cost and system benefits were identified. This information was then used to put together various alternative plans for each goal (i.e., combining benefits and costs for a certain amount of bed and bank stabilization, water and sediment retention basins, etc., in putting together a plan for sediment reduction). At this level of analysis, the various measures were evaluated, comparing their costs and benefits. The most cost-effective measures were used to develop the goal and system level alternatives.

D. AFFECTED ENVIRONMENT

Section 2 D, *Existing Conditions*, describes the general affected environment of the Illinois River Basin. As illustrated in table 3-1, each goal being evaluated affects differing amounts and types of habitat. Ecological integrity (the Overarching Goal) is expressed as increases or decreases in ecological integrity and/or impacts to the quantity and/or quality of habitat available; sediment delivery (Goal 1) is expressed in % reductions in delivery from various tributaries targeted; backwaters, side channels, and islands (Goal 2) indicates units of habitat affected in acres (backwaters), or the actual number of islands and side channels proposed; floodplain, riparian, and aquatic (Goal 3) exhibits acres of main stem and tributary areas being proposed, while the aquatic portion is expressed in miles of stream proposed; connectivity (Goal 4) references actual tributary rivers/streams that may be relevant to dam removal for fish passage, and the number of dams on the main stem that have potential to improve fish passage; water level management (Goal 5) is expressed as either % tributary peak flow reductions, % tributary base flow increases, or % reductions in main stem water level fluctuations; and water quality (Goal 6) is expressed in levels and areas of improvement. The detailed descriptions for each goal below provide insight as to which habitat type or aspect of the environment may be affected from implementation of the proposed project. When future site-specific projects are identified and evaluated, Environmental Assessments (EA) or, if required, Environmental Impact Statements (EIS), will be written detailing the alternatives and potential impacts of the proposals. Those site-specific EAs will give detailed information on what aspects of the environment would be affected based on the management measures proposed for that specific project.

E. OVERARCHING GOAL: ECOLOGICAL INTEGRITY

Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them.

Problem. The combined effects of habitat losses, through changes in land use, human exploitation, habitat degradation and fragmentation, water quality degradation, and competition from aggressive invasive species have significantly reduced the abundance and distribution of many native plant and animal species in the Illinois River Basin. In addition, human alterations of Illinois River Basin landscapes have altered the timing, magnitude, duration, and frequency of habitat forming and seasonal disturbance regimes. The cumulative results of these complex, systemic changes are now severely limiting both the habitats and species composition and abundance in the Illinois River Basin.

Ecological (or Biological) Integrity. Definition - A system's wholeness or "health," including presence of all appropriate elements, biotic and abiotic, and occurrence of all processes that generate and maintain those elements at the appropriate rates (Angermeier and Karr 1994). The capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and a functional organization comparable to that of natural, unimpacted habitat of the region (Karr and Dudley 1981, Adamus 1996).

Overarching Objectives. Objectives to restore ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them are discussed in the following paragraphs.

- Identify and address system-wide limiting factors to ecological integrity (structure and function), including, but not limited to:

    Goal 1 - excessive sedimentation

    Goal 2 (backwaters, side channels, and islands) - reduction and fragmentation of aquatic habitat

    Goal 3 (floodplain, riparian, and aquatic) - reduction and fragmentation of aquatic and terrestrial habitat, altered disturbance regimes, and invasive plant species

Goal 4 (aquatic connectivity) - reduction and fragmentation of aquatic habitat

Goal 5 - altered hydrologic regimes

Goal 6 - water and sediment quality

- Restore and conserve natural habitat structure and function, including, but not limited to:

  - Concentrations of flora and fauna or areas that are:
    high in biodiversity;
    especially vulnerable to disturbance; and/or
    important in fulfilling a life-history requirement of the species present.

  - Suitable habitat for Federal and State endangered and threatened species—or other species of concern—that is capable of supporting long-term sustainable populations.

  - Representative examples of all community types in the Illinois River Basin, best of kind or as needed, to protect and restore habitat structure and function at the system level.

- Establish existing and reference conditions for ecosystem functioning and sustainability against which change can be measured; monitor and evaluate actions to determine if goals and objectives are being achieved, at both the project and system levels.

1. Introduction. The goal of ecosystem management is to restore and sustain ecosystem integrity by protecting native biodiversity and the ecological and evolutionary processes that create and maintain that diversity. In order to achieve this goal, desired ecosystem structure, function, and variability must be characterized and measured against current conditions. This requires ecologically meaningful and measurable indicators that mark progress toward ecosystem management and restoration goals (Richter et al. 1996). The primary cause in the loss of ecological integrity is not direct human exploitation but rather the habitat destruction and disruption of natural processes that result from the expansion of human populations and activities (Wilson 1988).

In river systems, the physical structure of the environment, and consequently the habitat, is primarily defined by physical processes, especially the movement of water and sediment through the system. To understand the sustainability of river ecosystems and biodiversity, one must understand the dynamic and variable physical environment created by the river, as well as the human alterations to this system. The main stem Illinois River and its backwaters are the receiving body that integrate the products from all its tributaries and, in turn, store or deliver them to the Mississippi River and eventually the Gulf of Mexico. The historical diversity of in-channel and floodplain habitat types supported species that exploited the shifting habitat mosaic created and maintained primarily by the hydrologic variability. Human-induced changes to the ecosystem include habitat alteration and/or destruction, construction of dams, navigation, urbanization, agriculture, tile drainage, levees and channelization, and groundwater pumping (Poff et al. 1997). These alterations to the physical environment and hydrology, habitat loss and fragmentation, water quality degradation, and introduction of invasive species all threaten the ecological integrity of the Illinois River Basin, its natural communities, and populations of native species. In order to restore the basin to a more natural and self-sustaining state, restoration efforts must include activities to address degradation in all of these areas. Finally, education of the general public about the values of our environment is crucial to the future health of the system.

The Illinois River Basin is ecologically degraded because of 150 years of intensive human development in the region. Not only are landscapes changed, major initiatives to dredge channels, dig ditches, and increase drainage have altered the hydrologic regimes that drive the ecology of streams and rivers. In some cases, the landscape and streams are still adjusting to changes imposed by human development, especially where suburban sprawl is encroaching into sensitive habitats. In other cases, the ecosystem has stabilized within the bounds imposed by development.

2. System Limiting Factors. The Illinois River Basin has experienced the loss of ecological integrity due to sedimentation of backwaters and side channels, degradation of tributary streams, increased water level fluctuations, reduction of floodplain and tributary habitat and connectivity, and other adverse impacts caused by human activities. Although today's flora and fauna are but a remnant of these historic levels, they still include some of the richest habitat in the Midwest, even some unique in North America (Talkington 1991), however, the physical habitats (structure) and the processes that create and maintain those habitats (function) have been greatly altered. The following areas, discussed below, have been identified as the physical factors that limit restoration of ecological integrity. Figure 3-1 illustrates how projects could be formulated addressing these system limiting factors, in turn, improving ecosystem integrity. Monitoring, at both the system and individual project level, would provide the vital feedback loop needed to ensure success and increase understanding of the Illinois River Basin ecosystem.

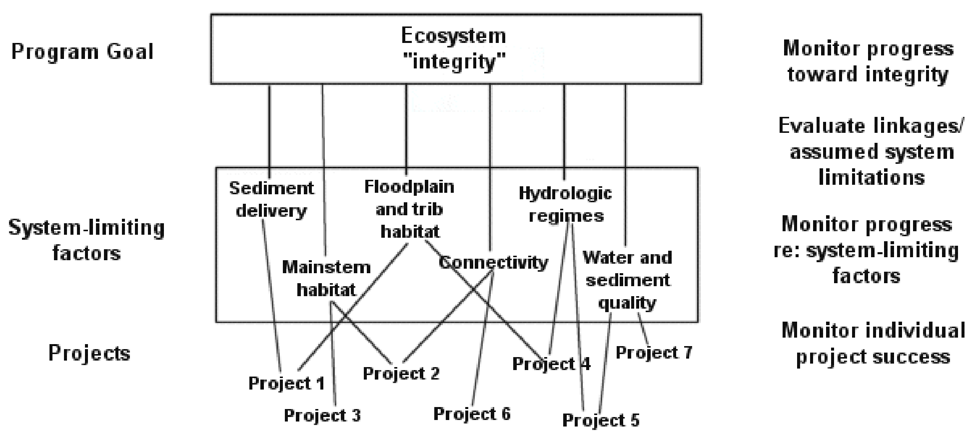


Figure 3-1. Conceptual Model of Illinois River Basin Restoration Program and Monitoring

3. Desired Future Conditions. In a meeting held in August 2003 as part of this study, natural resources professionals from the Rock Island District of the Corps of Engineers, the Illinois DNR, the USFWS Rock Island Field Office, and The Nature Conservancy met to discuss the desired future conditions of the Illinois River Basin. In addition to the declines in the biotic communities previously discussed, land conversion to urban use and development in the State of Illinois is currently estimated at 40,000 to 50,000 acres of land per year. Much of this development is in the Illinois River Basin, particularly in the western Chicago suburbs. In light of continuing habitat degradation, fragmentation, and losses, the expert panel identified preferred levels of restoration needed to restore and maintain ecological integrity to the Illinois River Basin. This expert panel also stressed that ecological integrity is the overarching goal for this restoration program and should drive the identification, development, selection, and implementation of restoration projects. In addition, the project identification and selection process should focus on the habitat quality and threats to ecological integrity and habitat sustainability. Though no specific projects or alternatives were formulated for the overarching goal, projects formulated under all of the other program goals would contribute toward restoring the ecological integrity of the Illinois River Basin.

Mapping of habitats for the evaluation species should consider edge effect and patch size. Although most birds are highly mobile, habitat fragmentation may affect species that have high fidelity to specific nesting localities. Mammals, reptiles, amphibians, and some invertebrates are particularly likely to be affected by fragmentation from development activities, and focusing protection on the relatively large tracts of natural lands remaining in the study area may conserve biological diversity. The development of corridors between terrestrial environments greatly increases the value of the formerly isolated areas. Habitat size and distribution (per pool or sub-basin) recommendations to address ecological integrity are: bottomland forest patches of at least 1,000 acres; grasslands of 100 to 500 acres each, nonforested wetlands of at least 100 acres, spaced 30 to 40 miles apart; a riparian zone at least 100 feet wide per side or 200 to 300 feet total width; and backwater depth for overwintering of at least 6 feet and spaced 3 to 5 miles apart. These recommendations are based on research and published literature, and expert panel input. Smaller areas than those described above would still provide benefits to many species and should be considered for restoration.

Preservation has a critical role in conservation of diversity; however, by itself, it is not an adequate strategy. Numerous species are already on the brink of extinction and their habitats have been degraded, reduced to a remnant, or even eliminated. Preservation of existing biodiversity, in the face of continuing change, is not enough to offset continuing declines in ecological integrity (Jordan 1988). Preservation must be coupled with restoration of both habitat structure and function in order to restore ecological integrity to the Illinois River Basin.

a. Criteria for Prioritization

- Combining habitat restoration and/or protection projects should be closely coordinated with projects developed under other goals, in order to maximize systemic ecological integrity and effectiveness of restoration efforts and dollars.
- The assessment process should focus on quality of the habitat and the presence of threats to the integrity of the quality area under consideration. Those areas threatened most immediately should be targeted for protection.
- Connectivity to the Illinois River and major tributaries and between protected areas should be key focus area.
- Preference given for improving and protecting existing moderately degraded habitat areas near rare and unique communities.
- Give special consideration to rare areas.
- Altered hydrologic regime most relevant disturbance regime.
- Terrestrial patch size recommendations (amount shown or greater):
  - Bottomland hardwood forest = 500 to1000 acres; 3000 acres needed for some interior avian species
  - Grasslands = 100 to 500 acres
  - Nonforested wetland = 100 acres, spaced 30 to 40 miles apart
  - Riparian zone = 100 feet each side; 200 to 300 feet wide total

- Aquatic habitat recommendations:
  - Main stem backwaters/side channels $\geq$ 6 feet deep, spaced 3-5 miles apart
  - In-stream riffles - Depending on the size of the stream, the number of structures required ranges from 4 per mile for large tributaries to 22 for minor tributaries

b. Restoration Measures Available

- Identify, restore, and maintain habitat structure and function in relation to limiting factors identified in Goals 1through 6
- Identify, protect, and restore high-quality communities on state-owned lands that are not dedicating or registering identified communities as appropriate
- Identify, protect, and restore representative examples of all community types on other lands. Where no high-quality communities can be defined, identify the best of kind and apply restoration techniques to improve ecological integrity.
- Improve areas within or adjacent to conservation sites (i.e., groupings of ecologically significant features in a geographically discrete area) by identifying degraded components of, or are adjacent to, the site and implementing restoration practices to improve resource quality
- Permanently protect lands (permanent conservation easements, Nature Preserve designation, or acquisition)
- Improve general habitat quality at the system level by restoring specific habitats, and/or net functional value, within major tributaries and pools of the Illinois River Basin
- Increase connectivity between habitat areas; focus on both lateral and aquatic connectivity of aquatic, riparian, and terrestrial habitats
- Increase use of prescribed burning **-** Implement the federally approved Aquatic Nuisance Species Management Plan, and other accepted management plans, to reduce invasive species in the basin. Implement invasive species control through burning, herbicide, removal, and bio-control.
- Manage currently isolated backwater areas to improve the hydrologic regime as it relates to relevant ecological processes through controlled water level management (drawdowns/flooding)

4. Risk and Uncertainty. Biological data on which to base objectives generally are not known accurately. Quite often, the most that can be achieved is to express a parameter as a best estimate and include a set of plausible bounds (i.e., range or confidence interval) (Todd and Burgman 1998).

Ecological predictions have three fundamental, interacting problems: uncertainty, contingency, and reflexivity. In most cases, the uncertainty of ecological predictions is not rigorously evaluated. Ecological predictions are contingent on drivers that are difficult to predict, such as human behavior. Conservation biology continually confronts situations in which decisions must be made in the face of uncertainty. It is suggested that the appropriate response to uncertainty depends on the degree of uncertainty and the degree to which a system can be controlled. When control is difficult and uncertainty is high, scenario planning may provide an effective way to manage various futures for the basin. In addition, adaptive management and optimal management may also be effective ways to address uncertainty (Peterson et al. 2003).

Adaptive management is the systematic acquisition and application of reliable information to improve natural resource management over time. Ideally, under adaptive management, conservation strategies are implemented as a deliberate experiment. This approach can establish cause-and-effect relationships and point the way toward optimal strategies. Adaptive management has been promoted as essential to management under uncertainty. However, funds spent on adaptive management reduce the amount available for habitat restoration, so limited financial resources require an effective balance between restoring habitat and acquiring knowledge (Wilhere 2002).

F. GOAL 1: SEDIMENT DELIVERY. Reduce sediment delivery to the Illinois River from upland areas and tributary channels with the aim of eliminating excessive sediment load.

Problem. Increased sediment loads from the basin have severely degraded environmental conditions along the main stem Illinois River by increasing turbidity and filling backwater areas, side channels, and islands. Improved conservation practices have reduced the amount of sediment generated from many agricultural areas, but large quantities of sediment are still delivered to the river due to eroding channels and tributary areas, including urban and rural construction sites. The most critical problems resulting from the increased sediment loads are the loss of depth and habitat quality in off-channel areas connected to the main stem river. Similar problems can be seen at other areas within the basin where excessive sediment has degraded tributary habitats.

Objectives

- Reduce total sediment delivery to the Illinois River below current levels by at least 1.2 million tons per year by 2025 (10 percent reduction from an average of 12.1 to 10.9 million tons per year above Valley City, based on ISWS estimate of delivery for 1981-2000)
- Reduce total sediment delivery to the Illinois River below current levels by at least 2.4 million tons per year by 2055 (20 percent reduction to an average of 9.7 million tons per year above Valley City, based on ISWS estimate of delivery for 1981-2000)
- Eliminate excessive sediment delivery to specific high-value habitat areas along the main stem and along tributaries

Expected Outputs

Anticipated project outputs related to Goal 1 include: stabilizing tributary streams by reducing downcutting and widening of the streambed, reducing sediment delivery to the Illinois River, reducing turbidity in the Illinois River main stem and its backwaters and tributaries, and increasing the life of existing and restored backwaters as critical habitats for native species. Anticipated benefits to the Illinois River and its tributaries resulting from Goal 1 include:

- Increased light penetration - will help lead to increased production by phytoplankton and aquatic vegetation. Increased light will also aid sight-feeding fish, such as sauger and largemouth bass.

- Improved substrate conditions - will benefit benthic invertebrate and macroinvertebrate communities (i.e. mussels, fingernail clams, and mayflies) as well as most fish species (i.e. bass and bluegill), who rely on this food source and need silt free areas for spawning (i.e. paddlefish).
- Increased aquatic habitat – The riffles and other structures proposed as part of the project will provide habitat for a wide variety of species, including darters, redhorse, and suckers. Reduced sedimentation rates in existing and restored Illinois River Backwater areas will also help to protect and maintain habitat.

Working Concepts

- Stream "stability" refers to the condition under which a stream has adjusted its cross-sectional geometry, slope and planform such that it transports the water and sediment loads applied to it without experiencing aggradation, degradation or significant planform changes. "Unstable" stream systems are those that are out of balance with their sediment or water regimes, and these demonstrate progressive changes in planform or sediment storage with time. Note that stable streams transport sediment and exhibit change in planform, or cross section, over time—instability refers to the degree of adjustment required to adapt to current geomorphic conditions.
- There are different ways to define "excessive" sediment load. From a geomorphologic perspective, excessive sediment load is simply that which exceeds the sediment transport capacity of a given reach. From a watershed management perspective, an excessive sediment load may be that which is generated by unstable behavior of tributary streams, or that above an expected level of delivery. From a habitat perspective, excessive load is that which leads to increased degradation of habitat quality. For the purposes of this goal, "excessive" can refer to either perspective, but it should be noted that a load to a system might be excessive from one perspective but not the other.
- Watershed-level planning is necessary to identify the most effective means to reduce erosion within and sediment delivery from each river or stream.

1. Inventory Resource Conditions

a. Historic Conditions. Soil erosion and sedimentation are natural processes that have been accelerated by anthropogenic changes to the landscape. Prior to the last glacial period, the Illinois River Valley was carved by the Mississippi River which has much higher flow rates than the Illinois River; therefore, the valley is oversized for its current flow rate. This led to the inability of the Illinois River to transport all of the sediment it received even before land disturbance and subsequent sedimentation in many areas of the valley (Bhowmik and Demissie 1989). Early observations suggest that prior to land clearance, the rate of sediment delivery from most Midwestern watersheds was significantly lower than current rates, although no monitoring data exists for verification. Native vegetation promoted infiltration of rainfall and stabilized erodible soils (Meek 1892). Many streams or ditches of today's landscape were historically ephemeral channels, wetland swales, or simply did not exist (Rhoads and Herricks 1996). The historical hydrologic and hydraulic conditions within the basin limited sediment delivery to the Illinois River. Even under these moderate flow and erosion conditions, however, sediment transport to the Illinois River was still sufficient to form deltas at points where streams fed into slower river reaches. Because of its flat slope, the lower portion of the river has had a depositional environment since the last ice age, accumulating some of the sediment delivered from the basin within its associated backwater and floodplain areas.

The clearing of land (especially on marginal land) in the Illinois River Watershed, for cropping and for construction activities, has led to high erosion rates because soil-retaining vegetation was removed, thereby creating conditions that resulted in larger storm flows (Knox 2002). Eroded sediment carried into tributary waterways resulted in very turbid streamflows (Meek 1892) and increased sediment delivery to the Illinois River. The effects of land clearance on sediment production and transport tend to be especially pronounced in steeply sloped areas (Knox 1977). Eroded sediment degraded ecosystem integrity by both reducing water clarity and covering or filling downstream habitat. Eroded sediment also contributed to water quality impairments by transporting sorbed compounds, such as the nutrient phosphorus.

The higher levels of sediment transport accelerated the rate of sedimentation in downstream areas. Analyses completed by the Illinois State Water Survey (ISWS) indicate that, on average, the backwater lakes along the Illinois River have lost 72 percent of their original capacity. Peoria Lake is a classic example of the sedimentation problem along the Illinois River. Demissie and Bhowmik (1986) found that Peoria Lake had lost about 68 percent of its 1903 capacity by 1985. They estimated that the rate of sediment accumulation of this lake was 1.7 million tons per year for the period 1965 through 1976 and about 2 million tons per year from 1976 to 1985.

In response to the negative impacts of soil erosion from nonpoint sources (eroding farm fields and urban construction projects) and the resulting sedimentation, the Illinois General Assembly passed the Illinois Erosion and Sediment Control Program and Standards Law. The goal of the law was the incremental reduction of soil erosion to tolerable soil loss levels (“T”) by the year 2000, and the “T by 2000” program was instituted. In 1982, a statewide inventory showed that more than 40 percent of the State’s rural land was exceeding tolerable soil loss levels. The average soil loss from cropland was estimated to be about 6 tons per acre per year (NRCA 1997).

b. Existing Conditions. Effective erosion control due to the implementation of conservation practices has reduced the average rate of erosion from croplands (NRCS 1997, Knox 2002). Technical, educational, and financial assistance to landowners through conservation programs has significantly reduced the level of soil erosion within the Illinois River Basin. The most recent estimates indicate that only about 13 percent of the cropland acres statewide exceed “T” (IDA 2000).

Despite conservation efforts, soil erosion and sediment transport from most of the basin is still higher than occurred pre-settlement. Channelization, increased flows within the basin and increased flow velocities have resulted in high levels of channel erosion (photograph 3-1). Channel erosion can be manifested as either down-cutting or lateral migration of streambeds, or both, and leads to significant downstream sediment transport. Research by the ISWS indicates that channel erosion from unstable streams accounts for 30 to 40 percent of sediment delivered from eastern Illinois watersheds and as much as 80 percent of the sediment delivered from watersheds in the western part of the basin. Odgaard (1984) observed comparable contributions in two Iowa rivers.

Sediment transported from the watershed continues to deposit in deltas, backwaters, and floodplain areas along the Illinois River. The sparse coverage of ongoing sediment data collection efforts makes it difficult to evaluate basin-scale sediment transport trends with confidence, but using the available information, the ISWS estimated that an average of 12.1 million tons of sediment per year were delivered to the Illinois River above Valley City for water years (WY) 1981-2000 (Appendix D-3, Demissie et al. 2004).

Photograph 3-1. Incised Stream

Figure 3-2 illustrates the relative contributions from various tributaries. If the extreme water year of 1993 is not included, the average amount delivered to the river is approximately 10.5 million tons per year. Of this, 6.7 million tons per year (5.1 million tons per year without 1993) were retained within the river and its bottomlands. Most of this sediment is presumably deposited within the backwater lakes along the Illinois River, located from Lake DuPue to Meredosia Lake. It should be noted that average annual precipitation in recent years has been higher than occurred during some previous historical periods (Changnon et al. 1997) and that sediment delivery tends to be sensitive to shifts in climate conditions, especially in agricultural basins (Knox 2001). Sediment budgets for future years will be influenced by climate conditions that must be considered when interpreting any observed changes.

The size of sediment transported from the basin largely determines its potential effects on the main stem environment. Although sands and gravels (bed material) have deposited where high-gradient streams enter low-gradient reaches and have filled certain high-quality areas (Bhowmik et al. 2001), it is the finer particles (silt and clay) deposited in backwater areas that have most disrupted the ecological integrity of the Illinois River system (Lee and Stall 1977, Bellrose et al. 1983, Demissie and Bhowmik 1986). Silt and clay particles make up the bulk of the sediment load delivered to the Illinois River and approximately 80 to 90 percent of the load transported in the river (Bhowmik and Demissie 1989). Demissie et al. (2004) estimate that bed material load ranges from 5 to 20 percent of total sediment loads throughout the watershed. Unlike sand, which often deposits as a bar immediately downstream of erosion sites (Odgaard 1984), finer particles remain within the water column and tend to be transported into downstream lakes or floodplains. Because of the dominant influence of fine sediment on a system-wide scale, control of silt and clay particles bound for the river will be a major project focus to reduce the level of suspended sediment transported into the Illinois River floodplain and backwater lakes. Control of sand-sized particles will also have ecosystem benefits in specific locations, such as in rivers or backwater lakes with valuable habitat being filled or covered by materials from direct tributaries, and projects to control sediment delivery in these areas may be developed as well.

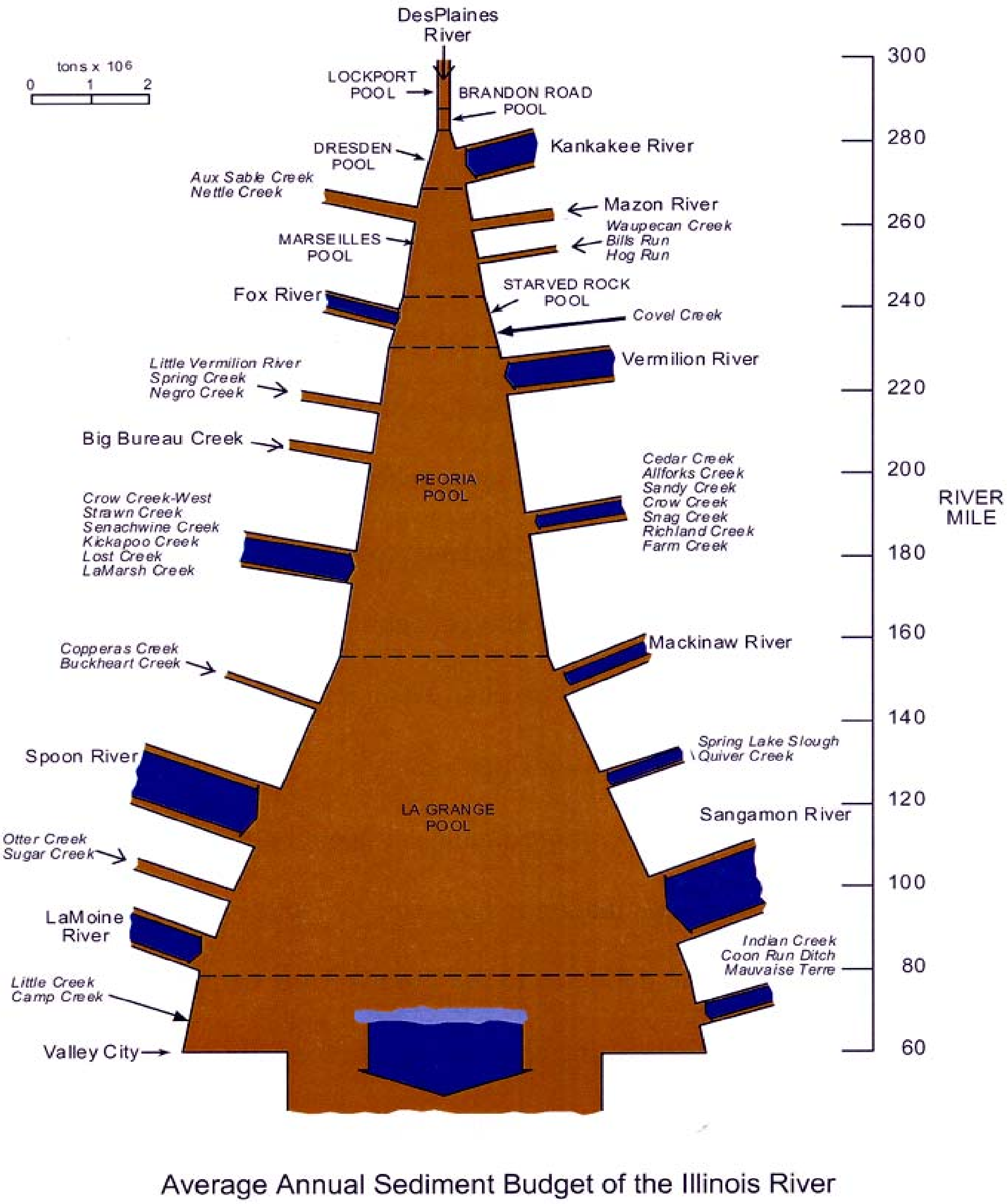


Figure 3-2. Sediment Budget Along the Main Stem Illinois River (Demissie et al. 2004) Brown shaded areas represent quantity of sediment.

The magnitude and characteristics of sediment delivery differ from watershed to watershed. At their confluence, the Kankakee River generally has a much larger flow than the Des Plaines River, and it carries a great quantity of sand as bed material load. The Des Plaines River carries proportionally much less sediment. The Fox, Mazon, and Vermilion Rivers are other major water sources upstream of the Peoria Lake. Numerous small creeks and streams (local tributaries) that drain from bluff line watersheds are often significant sources of fine sediment (silt and clay). Although the local tributaries of Peoria Lake contain only 4 percent of the drainage area, the sediment budget developed by Demissie et al. (2004) indicates that they contribute approximately 31 percent of the sediment delivered to the lake. Data collected in the La Grange Pool similarly indicate that local tributaries contribute a significant portion of the sediment load to the pool (U.S. Geological Survey, unpublished data). The Mackinaw, Spoon and Sangamon Rivers all drain into the La Grange Pool where they transport substantial quantities of materials from the basin. Bluff line tributaries drain directly to the main stem through Alton Pool. Some watersheds have excessive sediment transport from upland sources, others are dominated by in-channel erosion and yet others may be stable in that the sediment transport is at a relatively “natural” rate. Although west-central Illinois watersheds and direct tributaries to the river have the highest sediment production rates (delivery per unit area) in the basin, sediment sources such as unstable stream banks, mining activity, and construction sites occur throughout the Illinois River Basin. Because of this, effective measures to reduce sediment delivery must be developed on a watershed-by-watershed basis and must consider the geomorphologic characteristics of each particular area.

c. Future Without-Project Conditions. Depending on economic and political conditions, the programs that have reduced sediment loading from upland practices may expand or contract in the future. Although far from certain, it is anticipated that the benefits of conservation practices will probably remain constant and possibly increase somewhat in the future. However, there will continue to be significant sediment transported to the Illinois River from areas not addressed by these programs.

Significant sediment sources will continue to arise at points in the basin where sediment control regulations are inadequate or inadequately enforced. It is expected that without this program there would be no overall program to address stream instability throughout the Illinois River Basin and that future channelization projects may destabilize additional stream miles. Without measures to naturalize the sediment transport in these streams, they will continue to incise or migrate into the foreseeable future, contributing sustained high rates of sediment loading to the main stem Illinois River.

Without action, the sediment loading to the Illinois River from unstable streams and other sources in the basin will continue at unacceptably high levels. Sediment loading will continue to degrade vulnerable habitats and impede downstream restoration efforts. Local projects may show site-specific benefits, but the effects of high sediment loading will limit the extent where benefits may be observed.

Among the significant unknowns that will affect future sediment conditions are climate, land use, and land cover conditions. These are generally beyond the influence of the Illinois River Basin Restoration Project. Increases in precipitation could lead to increased sediment loads despite improved watershed conditions; likewise, decreases in precipitation could reduce sediment loads even if no beneficial actions were taken. Land use and land cover changes could similarly increase or decrease sediment delivery from the basin, depending on the nature of the changes. Without additional monitoring, it will be very difficult to determine trends in the sediment transport processes within the Illinois River and its basin or to evaluate systemic benefits of improvement projects.

d. Desired Future Conditions. Under the desired future conditions the rate of sediment transport within the Illinois River Basin and the main stem river, especially the transport of silt and clay particles, would be reduced to a level that will better support ecological processes. At this time the understanding of the interconnections between sediment transport and Illinois River Basin ecosystem processes is insufficient to support definitive numerical targets for ecosystem improvement. In the absence of a scientific model of sediment effects, Corps of Engineers and State of Illinois scientists and managers generally agree that an overall 20 percent reduction of sediment transport to the main stem Illinois River is an appropriate initial long-term target that would demonstrate measurable positive benefits for the system. Monitoring for the Demonstration Erosion Control (DEC) project in the Mississippi River indicated that such a reduction of watershed sediment delivery is possible using proven technology (Watson and Biedenharn 1999). An interim target of 10 percent reduction after 20 years was chosen to represent a measurable improvement and is feasible by treating the most significant sediment sources first. Using the sediment budget developed by Demissie et al. (2004) for WY 1981-2000, 10 percent and 20 percent reductions represent 1.2 and 2.4 million tons per year below current levels, respectively. Slightly smaller reduction targets would arise if the extreme year of 1993 were excluded.

Although these objectives are formulated in terms of sediment delivery to the main stem, the benefits will be achieved nearly exclusively by projects within the tributary basin. These projects would have significant benefits within their particular tributary areas as an overall 20 percent reduction would necessitate higher reductions in the immediate vicinity of each project. It is envisioned that additional ecosystem benefits will be gained by placing the sediment reduction projects in areas likely to benefit high-value downstream habitats.

Achievement of the sediment reduction objectives will require four components: maintaining existing sediment control benefits, identifying and controlling sources of sediment in upland areas, identifying and treating unstable streams, and assessing system response to individual projects. To maintain existing benefits, it will be necessary to ensure that the conservation practices currently installed within the basin remain effective. It is also necessary that existing regulations are enforced and are evaluated to determine if they could better protect the resources within the Illinois River system. Under these conditions, it is assumed that without-project sediment loads would remain constant at WY1981-2000 levels. Additional sediment control practices would be implemented through this project and coordinated efforts based on assessment of sources within specific watersheds.

Recognizing that streams always transport sediment, reduced delivery would be accomplished by implementing projects that reduce bank erosion, allow streams to reach a relatively stable state, or control upland sediment as appropriate based on watershed conditions. To guarantee an accurate understanding of the sediment transport status and trends, assess project success and guide future project development, a basin-wide monitoring network is needed to compile and evaluate sediment data. The systemic understanding gained from the monitoring data will be used to refine basin-wide hydrologic and sediment models so as to forecast system response to additional management activities.

2. Formulation of Alternative Plans. The objectives for this ecosystem goal were formulated to reduce sediment delivery to both the Illinois River and to high-quality areas within the basin. Because of their effects on the river's ecological functions, much of this effort will concentrate on the control of silt and clay particles. Sediment control requires assessing sediment transport on a watershed scale, identifying major sources of erosion as related to downstream sediment delivery, and addressing these sources as feasible. It cannot be overstressed that the benefits achieved through these efforts would be erased if inadequate enforcement of local regulations or unmitigated land-use changes allow large amounts of sediment to enter the river system. The efforts here are designed to augment, and not replace, local and regional sediment control efforts.

Sediment delivery would be reduced using a combination of upland controls and stream stabilization as appropriate for each individual watershed (e.g. White et al. 2003). Information such as that developed for NRCS Erosion and Sediment Investigations can be used to identify the major sources within each watershed and develop treatment measures. Stream stabilization measures would be undertaken using measures that take into account system geomorphological influences (Shields et al. 2003). For each watershed, an alternative analysis would be developed to determine the most cost-effective set of projects to address the sediment delivery issues particular to that watershed.

a. Approach/Assumptions. Although it is unlikely that incremental changes in sediment load will always have directly proportional benefits for ecosystem integrity, there is currently no model to relate these factors on a system-wide level. For the purposes of plan formulation, the study team assumed a direct relationship between sediment load reduction and ecosystem benefits for the range of changes considered. The team also generally agreed that a 20 percent reduction from current levels would lead to significant improvements in ecological integrity within the Illinois River Basin. Because the river was a depositional environment even prior to land clearance (Bhowmik and Demissie 1989), it is expected that a load reduction of that magnitude would not have adverse geomorphic effects.

Systematic alternatives were developed based on strategies to achieve specific reductions (tons per year) in sediment delivery to the river. Due to differences in watershed conditions and restoration potential, basin tributaries were divided into three regions, based on the Physiographic Regions of the Illinois River Basin (Appendix D-1); the tributaries that drain to the river upstream of Peru and also the Mackinaw River are categorized as “eastern,” “southern” tributaries drain to the river from the left bank downstream of the Mackinaw River, and “western” tributaries are the rest, including all direct tributaries to Peoria Lake (figures 3-2 and 3-3). The eastern, western, and southern tributaries contribute approximately 3.8, 5.2, and 3.1 million tons per year, respectively, of sediment to the Illinois River. The percent reduction to be achieved within each tributary region was set by the various alternatives, and the sediment delivery calculated for the Sediment Budget of the Illinois River (Demissie et al. 2004) was used to develop quantitative reduction goals for each region. The differing characteristics between regions led to differences in the effectiveness of sediment control measures and thereby differences in the cost to control sediment delivery.

The maximum attainable delivery reduction for large watersheds was estimated to be 20 percent of current levels. Delivery reduction in the immediate vicinity of stabilization projects, however, tends to be significantly higher, implying that larger reductions are possible when viewed at smaller scales. Applying this to entire watersheds suggests that potential reduction may be a function of watershed area. Figure 3-4 proposes a relationship between watershed size and potential maximum reduction of watershed sediment delivery assuming a threshold maximum at 200 square miles (the size of the larger DEC watersheds) and that delivery reduction is a function of watershed area to the –0.3 power, as suggested in Figure 12.10.4 of Shen and Julien (1993). This relationship is consistent with the experience of state resource managers that significant reductions in sediment delivery are achievable when working with small but highly disturbed watersheds.

For all of the alternatives, the sediment sources and potential reduction options will be assessed on a watershed basis to preserve or restore systemic geomorphic balance. Out of these assessments, plans encompassing both structural and non-structural actions will be developed. It is expected that existing efforts such as federal and state conservation programs as well as state and local erosion control ordinances will play an important role in delivery reduction, and that the assessments may provide a basis for expanding these efforts.

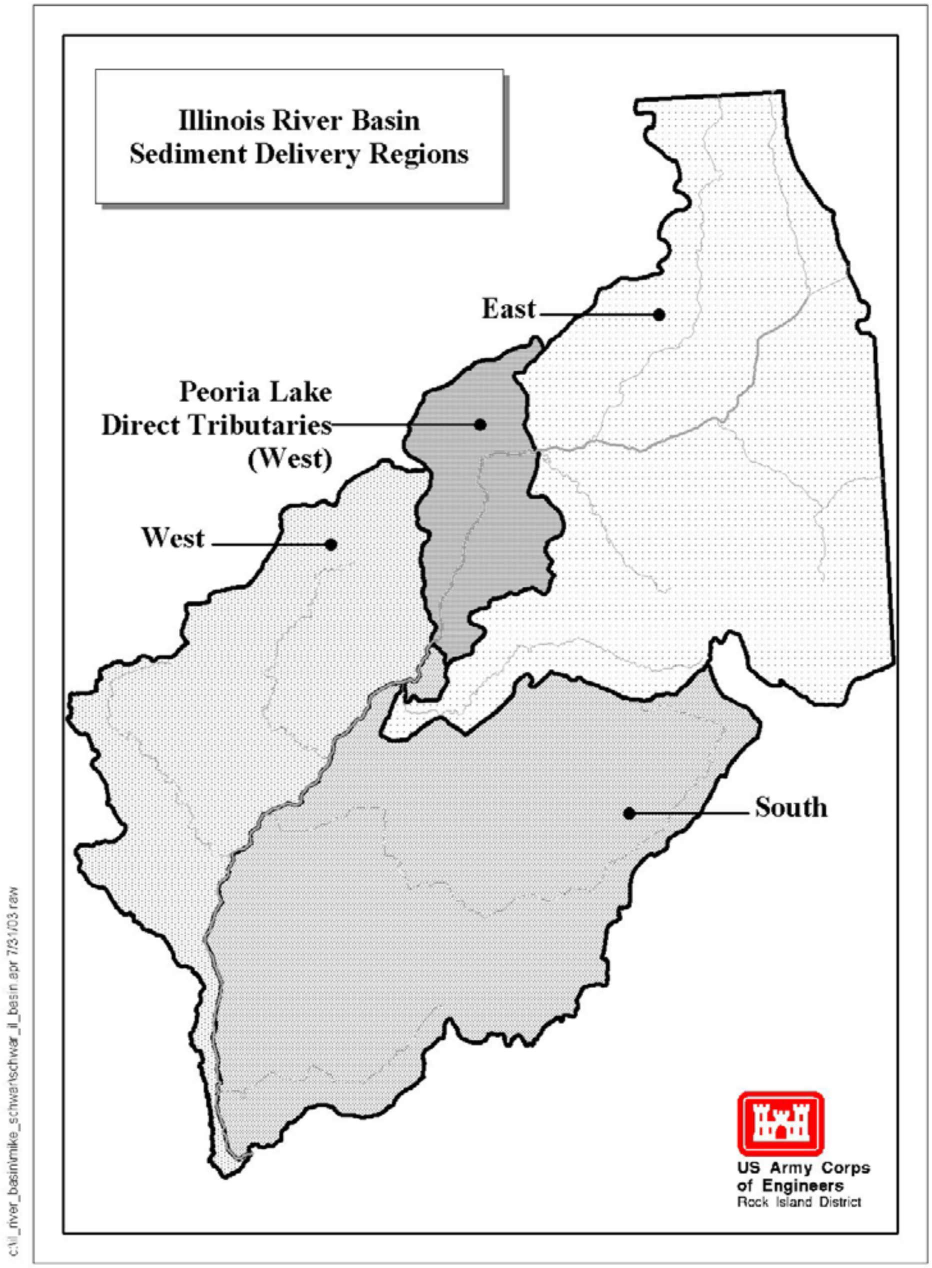


Figure 3-3. Regions Used To Delineate Assumed Tributary Characteristics.
Differing characteristics between regions result in differences in the effectiveness of sediment control measures and thereby differences in the cost to control sediment delivery.

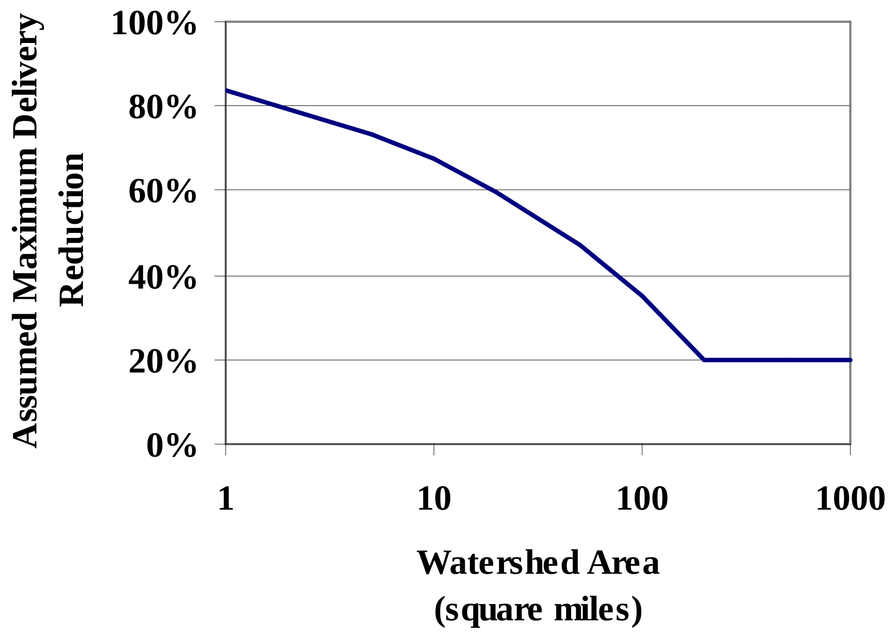


Figure 3-4. Estimated Potential Watershed Sediment Delivery Reduction Relationship

b. Criteria and Constraints. Benefits for this goal are quantified in terms of annual tons of sediment not delivered to the Illinois River main stem, and are sometimes expressed as a percent reduction from current levels. By quantifying the benefits in this way, the inherent assumption is that each increment of sediment reduction provides the same level of benefit; it is probable that there is some variation in incremental benefits of sediment reduction, but the linkages between reductions and ecological benefits are not understood to a sufficient level to justify a different approach so the simple linear relationship was used here.

Because of the interest in maintaining the quality of Peoria Lake, benefits for each alternative have been calculated at both Peoria Lake and at Valley City. Tributary benefits were not specifically quantified but reductions in sediment delivery to the main stem Illinois River necessitate significantly larger percent reductions at some upstream points in its tributaries. Stabilization of eroding channels has been shown to provide ecological benefits within those channels (Shields et al. 1997) and watershed-based sediment control strategies can be expected to provide significant benefits to areas some distance downstream. Because of this, it is reasonable to expect that significant benefits would also accrue in the tributary systems.

Site-specific conditions will have a large effect on the potential for particular measures to provide benefits, the extent that those measures provide additional ecological benefits, and the cost of implementation. For example, in developing watershed plans, local support and involvement will play a large role in the scope of project implementation. Also, sediment control projects located upstream of vulnerable habitat areas would provide more ecological benefits than the same projects downstream of the same areas. The estimates of costs and benefits developed here attempt to reflect a representative average of a number of projects placed over a large area and so balancing overall effects of site-specific conditions.

c. Measures. Although the precise mix of measures to be applied throughout the Illinois River Basin will be developed on a watershed basis, representative project scenarios were developed based on several potential combinations of an abbreviated suite of cost-effective measures. For the purpose of programmatic estimates, it was assumed that incising channels would be treated with rock riffle structures if possible; otherwise, sheet-pile grade control structures would be used. It was assumed that the preferred method of treating bank erosion was stone barbs, then stone toe, or finally a stone armor blanket if necessary. Bioengineering was incorporated in most of the bank erosion stabilization measures. Upland sediment control measures were assumed to be dry basins for costing purposes. Other measures are likely to be used, but it is assumed that overall cost estimates should not greatly change.

Sediment benefits were defined based on the total quantity trapped or from the reduction in sediment generation. Sediment trapping in upland facilities was estimated using an average capacity of similarly sized sediment basins. Sediment generation from unstable streams was estimated using average stream characteristics and rate of channel movement. Stable streams do transport sediment; for purposes of estimating benefits, it is assumed that sediment delivery from stabilized stream banks or beds would be 25 percent of unstabilized levels. Benefits were annualized as necessary to evaluate the yearly delivery reduction after construction of each suite of projects.

d. Alternatives. Three acceptable geographic distributions of projects were developed:

- The alternatives in the first distribution (Alternatives 1A through 1D, table 3-2) were designed to provide equal treatment to the entire Illinois River Basin by focusing on treating “hot spots” in each watershed.
- The alternatives in the second distribution (Alternatives 1E through 1G, table 3-2) identifies Peoria Lake as a focus and concentrates on reducing inputs equally from the entire area contributing flow to Peoria Lake while addressing sediment delivery from downstream watersheds to a lesser extent.
- The alternatives in the third distribution (Alternatives 1H through 1W, table 3-2) were designed to focus sediment delivery reduction measures in the direct tributary watersheds to Peoria Lake, while treating the rest of the basin, both upstream and downstream of Peoria Lake, to lesser extents. Due to their small watersheds, it should be possible to reduce sediment delivery from Peoria Lake direct tributaries by a higher percentage than is possible in the larger tributary systems. Two levels of treatment for the direct tributaries to Peoria Lake are evaluated: those necessary to reduce sediment delivery rates by 20 percent (Alternatives 1H through 1O) and by 40 percent (Alternatives 1P through 1W) below current levels.

It is important to note that although sediment reduction benefits may accrue from projects designed to meet other goals, most notably Goal 5, those benefits are not incorporated into this analysis.

Table 3-2. Alternatives

Alternative	Total Sediment Delivery Reduction (%)	Sediment Delivery Reduction to Peoria Lake (%)	Sediment Delivery Reduction from Watersheds Upstream of Peoria Lake (%)	Sediment Delivery Reduction from Watersheds Downstream of Peoria Lake (%)	Sediment Delivery Reduction from Direct Tributaries to Peoria Lake (%)
1-0	No Action				
First Distribution – Equal Treatment to the Entire Basin					
1A	5.00	5.00	5.00	5.00	5.00
1B	7.50	7.50	7.50	7.50	7.50
1C	10.00	10.00	10.00	10.00	10.00
1D	20.00	20.00	20.00	20.00	20.00
Second Distribution – Focus on Direct Tributaries to Peoria Lake and Upstream Inputs					
1E	5.00	10.00	10.00	2.00	10.00
1F	7.50	15.00	15.00	3.00	15.00
1G	10.00	20.00	20.00	4.00	20.00
Third Distribution – Focus on Direct Tributaries to Peoria Lake					
1H	5.00	10.00	5.50	2.00	20.00
1I	7.50	10.00	5.50	6.00	20.00
1J	10.00	10.00	5.50	10.00	20.00
1K	10.00	12.50	9.10	8.50	20.00
1L	7.50	15.00	12.80	3.00	20.00
1M	10.00	15.00	12.80	7.00	20.00
1N	2.30	6.30	0.00	0.00	20.00
1O	5.00	6.30	0.00	4.25	20.00
1P	5.00	12.50	0.00	0.50	40.00
1Q	10.00	12.50	0.00	8.50	40.00
1R	7.50	15.00	3.60	3.00	40.00
1S	10.00	15.00	3.60	7.00	40.00
1T	4.27	12.50	0.00	0.00	40.00
1U	10.00	20.00	11.00	4.00	40.00
1V	20.00	20.00	11.00	20.00	40.00
1W	22.00	26.00	20.00	20.00	40.00

3. Evaluation and Comparison of Plans. Depending on the particular watershed conditions, a variety of combinations of sediment reduction measures may be applied within the different watersheds. To estimate the programmatic cost, a representative range of potential project combinations was evaluated, including a number of different project combinations for differing treatment strategies and watershed geomorphic conditions. It is expected that sediment control through in-channel work will account for at least 50 percent of the reduction attained; upland projects are generally not considered to be sufficient to control destabilized channels within an acceptable time period without some in-channel remediation, and it is anticipated that restoring such channels would be a major portion of the sediment control undertaken. The range of potential measures assumed different extents of incision, different project locations (small stream vs. large stream vs. upland) and different combinations of upland vs. in-stream measures. Each strategy was standardized to develop the range of costs required to reduce sediment delivery by one ton per year.

From this analysis, estimates of delivery reduction cost were developed for the three watershed regions from figure 3-3. Among the key assumptions of these estimates are:

- The incremental cost for sediment delivery reduction is the same for all units; that is, the first ton costs same as final ton for the range analyzed, and
- Corps construction costs include a 35 percent contingency, an additional 30 percent for engineering and design, and 9 percent for supervision and administration. Real estate costs include a 35 percent contingency as well.
- The cost estimates provided in table 3-3 are the initial (not annual) costs for sediment control measures (e.g. rock riffle structures, stone barbs, etc.) that would be designed to reduce sediment delivery to the Illinois River by one ton per year.

The range of cost estimates for the various watershed alternatives is shown in table 3-3. Please note that the initial project costs (also referred to as the initial costs) identified are the cost of construction plus the cost for real estate and as such are not an annual cost of the project. The initial costs were developed with the goal of reducing sediment delivery by one ton per year. Due to the higher levels of sediment delivery arising out of channel erosion in southern and western tributary watersheds, in-channel treatments were much more cost effective in those areas and overall delivery reduction was possible at a lower cost than reduction in eastern tributaries.

Table 3-3. Cost Estimates To Reduce Sediment Delivery to the Illinois River by One Ton Per Year, by Tributary Region

	Average Costs ($/ton)		Initial Project Costs ($/ton)	
	Construction	**Real Estate**	**Average**	**Range**
In-channel only				
East	623	26	649	502 - 776
West	149	7	156	133 - 185
South	138	6	144	125 - 162
Mixed focus (75% in-channel work)				
East	667	46	713	633 - 778
West	312	32	344	295 - 396
South	357	39	396	296 - 596
Mixed focus (50% in-channel work)				
East	708	66	775	721 - 828
West	472	56	528	452 - 607
South	413	48	461	311 - 587

Although in-channel work is the most cost-effective way to reduce sediment delivery, it is likely that there will be some distribution of in-channel and watershed measures, therefore, the average costs for 75/25 mixes of channel/upland projects were used to develop the cost estimates for each of the 24 alternatives identified in table 3-2. The estimated initial cost to reduce sediment delivery in eastern watersheds by one ton per year is approximately $713in western watersheds it is $344, and in the south it is $396. It is apparent that the geographical location of the watersheds chosen for reduction efforts will have a large effect on the overall project costs. Estimates of sediment delivery to the Illinois River were developed for the tributaries flowing directly into Peoria Lake, the area upstream of Peru, and the area downstream of Peoria Lake. These estimates are as follows:

- Approximately 1.4 million tons per year of sediment is delivered to the Illinois River from the direct tributaries to Peoria Lake (all watersheds are located in the western region).
- Approximately 3.1 million tons per year of sediment is delivered to the Illinois River from the area upstream of Peru (all watersheds are located in the eastern region).
- Approximately 7.6 million tons per year of sediment is delivered to the Illinois River from the area downstream of Peoria Lake. Approximately 0.6, 3.8, and 3.1 million tons per year originate in the eastern, western, and southern regions, respectively.

The initial costs estimates were used to develop cost estimates for each of the alternatives identified in table 3-2. Table 3-4 summarizes the estimated benefits and costs for each alternative considered.

Table 3-4. Alternative Comparison

Alternative	Delivery Reduced (100,000 tons/year)						Reduced Delivery (%)		Initial Cost ($ Million)
	Tributaries Upstream of Peru	Peoria Lake Direct Tributaries	Tributaries Downstream of Peoria Lake				to Valley City	to Peoria Lake	
			East Region	West Region	South Region	Total			
1-0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0
First Distribution									
1A	1.6	0.7	0.3	1.9	1.6	3.8	5.00	5.00	288
1B	2.3	1.1	0.5	2.9	2.3	5.7	7.50	7.50	425
1C	3.1	1.4	0.6	3.8	3.1	7.6	10.00	10.00	573
1D	6.2	2.8	1.3	7.6	6.2	15.1	20.00	20.00	1138
Second Distribution									
1E	3.1	1.4	0.1	0.8	0.6	1.5	5.00	10.00	328
1F	4.7	2.1	0.2	1.1	0.9	2.3	7.50	15.00	499
1G	6.2	2.8	0.3	1.5	1.2	3.0	10.00	20.00	662
Third Distribution									
1H	1.7	2.8	0.1	0.8	0.6	1.5	5.00	10.00	276
1I	1.7	2.8	0.4	2.3	1.9	4.5	7.50	10.00	400
1J	1.7	2.8	0.6	3.8	3.1	7.6	10.00	10.00	521
1K	2.8	2.8	0.6	3.2	2.6	6.4	10.00	12.50	555
1L	4.0	2.8	0.2	1.1	0.9	2.3	7.50	15.00	473
1M	4.0	2.8	0.5	2.7	2.2	5.3	10.00	15.00	590
1N	0.0	2.8	0.0	0.0	0.0	0.0	2.30	6.30	96
1O	0.0	2.8	0.3	1.6	1.3	3.2	5.00	6.30	228
1P	0.0	5.7	0.0	0.2	0.2	0.4	5.00	12.50	211
1Q	0.0	5.7	0.6	3.2	2.6	6.4	10.00	12.50	452
1R	1.1	5.7	0.2	1.1	0.9	2.3	7.50	15.00	362
1S	1.1	5.7	0.5	2.7	2.2	5.3	10.00	15.00	487
1T	0.0	5.7	0.0	0.0	0.0	0.0	4.27	12.50	196
1U	3.4	5.7	0.3	1.5	1.2	3.0	10.00	20.00	559
1V	3.4	5.7	1.3	7.6	6.2	15.1	20.00	20.00	1038
1W	6.2	5.7	1.3	7.6	6.2	15.1	22.00	26.00	1238

Alternative cost estimates were developed using the following methodology. Alternative 1V—which plans to reduce delivery from Peoria Lake direct tributaries by 40 percent, from the rest of the upstream basin by 11 percent, and from the areas downstream of Peoria Lake by 20 percent—is used as an example.

$$TC_{PT} = R_{PT} \times S_{PT} \times C_W$$
$$0.4 \times 1.4\text{ M} \times \$344 = \$195\text{ M}$$

$$TC_U = R_U \times S_U \times C_E$$
$$0.11 \times 3.1\text{ M} \times \$713 = \$243\text{ M}$$

$$TC_D = R_D \times (S_{D\text{-}E} \times C_E + S_{D\text{-}W} \times C_W + S_{D\text{-}S} \times C_S)$$
$$0.2 \times (0.6\text{ M} \times \$713 + 3.8\text{ M} \times \$344 + 3.1\text{ M} \times \$396) = \$600\text{ M}$$

$$TC = TC_{PT} + TC_U + TC_D$$
$$\$195\text{ M} + \$243\text{ M} + \$600 = \$1038\text{ M}$$

where:
TC_{PT} = total initial cost of reducing sediment delivery from the direct Peoria tributaries
TC_U = total initial cost of reducing sediment delivery from the area upstream of Peru
TC_D = total initial cost of reducing sediment delivery from the area upstream of Pekin
TC = total initial cost of the alternative
R_{PT} = reduction from the direct Peoria tributaries
R_U = reduction from the area upstream of Peru
R_D = reduction from the area downstream of Peoria Lake
S_{PT} = sediment contributed by the direct Peoria tributaries in tons per year
S_U = sediment contributed by the area upstream of Peru in tons per year
$S_{D\text{-}E}$ = sediment contributed by the area downstream of Peoria Lake from the eastern region in tons per year
$S_{D\text{-}W}$ = sediment contributed by the area downstream of Peoria Lake from the western region in tons per year
$S_{D\text{-}S}$ = sediment contributed by the area downstream of Peoria Lake from the southern region in tons per year
C_W = cost of reducing sediment delivery by one ton per year for the western region
C_E = cost of reducing sediment delivery by one ton per year for the eastern region
C_S = cost of reducing sediment delivery by one ton per year for the southern region
M = million

4. Plans Recommended for System Analysis

a. Restoration Alternatives. The alternatives were compared for cost-effectiveness to achieve sediment reduction benefits at Peoria Lake and Valley City (table 3-4). Two cost-effectiveness analyses were performed, one assuming that the maximum delivery reduction anywhere in the basin would be 20 percent (table 3-5), and the other assuming that it would be possible to effect a 40 percent reduction from the smaller watersheds of the direct tributaries to Peoria Lake (table 3-6). In the first comparison, 1A through 1C and 1E and 1F were found to be not cost effective because the same sediment reduction benefits at both Peoria Lake and the Illinois River can be achieved at lower costs by one of the alternatives 1H through 1L (table 3-5). This emphasizes that under the assumed conditions the most cost-effective way to develop benefits is by maximizing the focus on the direct tributaries to Peoria Lake. If larger reductions were possible on these particular tributaries, the cost-effectiveness would increase further; table 3-6 demonstrates that, by concentrating on those tributaries to maximize their potential reduction, Alternatives 1P through 1S are better buys than Alternatives 1I through 1M and 1O.

Alternatives 1U and 1V increase the efficiency of reducing the load to Peoria Lake, so they are also better buys than Alternatives 1G and 1D, which would concentrate half as much effort on the direct tributaries to Peoria Lake.

Table 3-5. Cost-effective Alternatives
Assumes 20% maximum reduction possible for Peoria Lake direct tributaries

	Reduced Delivery (%)		
Alternative	**to Valley City**	**to Peoria Lake**	**Initial Cost ($ Million)**
1-0	0.00	0.00	0
1N	2.30	6.30	96
1O	5.00	6.30	228
1H	5.00	10.00	276
1I	7.50	10.00	400
1L	7.50	15.00	473
1J	10.00	10.00	521
1K	10.00	12.50	555
1M	10.00	15.00	590
1G	10.00	20.00	662
1D	20.00	20.00	1138

Table 3-6. Cost-effective Alternatives
Assumes 40% maximum reduction possible for Peoria Lake direct tributaries

	Reduced Delivery (%)		
Alternative	**to Valley City**	**to Peoria Lake**	**Initial Cost ($ Million)**
1-0	0.00	0.00	0
1N	2.30	6.30	96
1T	4.27	12.50	196
1P	5.00	12.50	211
1R	7.50	15.00	362
1Q	10.00	12.50	452
1S	10.00	15.00	487
1U	10.00	20.00	559
1V	20.00	20.00	1038
1W	22.00	26.00	1238

Three key assumptions should be kept in mind when evaluating this alternatives analysis. The first is that the benefits are only accounted at two locations, Peoria Lake and Valley City. Work within each tributary will have specific local benefits that are not considered in this analysis. In some areas, these local benefits will be significantly higher than those accrued from work in other areas, but it is expected that the high-value areas are probably spread throughout the Illinois River Basin and would not change the ranking of the alternatives. Also, because the most upstream point analyzed is Peoria Lake, potential benefits (or lack thereof) to river reaches upstream are not considered in the analysis. The second assumption is that the incremental cost of sediment reduction does not change. Since it is likely that there are some relatively straightforward projects that would reduce sediment delivery, the incremental cost probably increases as the percent reduction increases. By not accounting for this, some bias is introduced into the analysis that somewhat overestimates the cost-effectiveness of concentrating projects in one area, specifically the direct tributaries to Peoria Lake. Finally, this analysis does not differentiate between the effects of silt and sand. For this analysis, the benefit is related only to the quantity of sediment reduced and not to the particle size.

b. Selected Alternatives. By consensus of the project study team, it was decided that it should be possible to reduce sediment entering the river from the direct tributaries to Peoria Lake by 40 percent. From the list of cost-effective alternatives (table 3-6), four were chosen as pieces of the seven system plans. Alternative 1N was chosen as the minimum level of effort necessary to show regional benefits for this goal, Alternative 1P was the minimum necessary to maintain current system function, and Alternative 1U was the minimum required to begin to show system-wide improvements. These were included in the system plans as shown in table 3-7. Alternative 1V is the minimum level of effort necessary to fully meet the objectives of this goal and was chosen as part of Plans 6 and 7.

i. Implementation. Although quantifying the sediment control benefits of a particular project will assess how well it addresses the numerical objectives of this goal, prioritization and implementation will help determine how these projects fit into the overall goal of improved ecosystem function. As an ecosystem restoration project, it is envisioned that the measures implemented to meet this goal will be those that best improve overall function, are cost effective, and will not have significant adverse impacts themselves. The following characteristics should be considered when prioritizing which measures to implement:

- Measures that address sources that directly affect vulnerable resources (for example, unstable streams filling backwater lakes) should be given highest priority.
- Significant consideration should be given to reduction measures that provide additional benefits, specifically improvement of stream habitat.
- Delivery is often inversely related to distance from the Illinois River, so proximity to the river should be taken into account.
- Delivery of fines (silts and clays) is problematic system-wide. Projects affecting silts and clays can be generally assumed to have benefits for downstream portions of the Illinois River.
- Delivery of bed material load (sand) can also be a major issue at local or regional levels, specifically the mouths of tributaries (i.e., backwater lakes or Peoria Lake), and should be considered on a case-by-case basis.

A primary assumption of this goal is that future sediment loads remain at approximately the same levels without the project and that the actions taken for the project will result in a net reduction in sediment load. This implies that any existing sediment controls would remain functioning and that the loading from any new sources would be offset by reductions due to other measures. Measures undertaken for this project are expected to have minimal maintenance requirements, and their project lives would be sufficient so that they would all be functioning at the end of the program (50 years). However, at that point the earliest projects would begin to exceed their design life and their sediment reduction capability might decline if they were not maintained. Therefore, the sediment reduction goal would be met in the later stages of the program life, but this success would not necessarily be permanent. Additional maintenance efforts would extend the time that delivery reduction could be maintained, and may also increase the degree of reduction possible (for example, emptying sediment traps would allow more capture).

ii. Systemic Benefits - Benefit Quantification. The benefits for Goal 1 were quantified for each alternative in terms of percent reduction of sediment delivery with an overall goal of a 20 percent reduction (2.4 million tons per year). This target was set based on experience on the Delta Headwaters Project in Mississippi and profession judgment of ERDC and Colorado State University staff. In addition to the percent of goal attainment, these benefits have been adapted to stream miles by considering the practices that would be used to reduce sediment delivery and making assumptions, based on engineering expertise, as to the length of stream that would be affected from these practices. Table 3-8 shows the quantity of stream miles with direct benefits (the length of stream immediately adjacent to the construction activity) and the area of influence (the length of stream, including those areas upstream and downstream, anticipated to benefit from the stabilized reach or sedimentation retention structure) for each alternative, and for the assumptions used to develop those quantities.

The direct benefits and the length of stream influenced from the proposed measures for each of the alternatives were calculated based on engineering expertise as described in the following text. Table 3-9 includes the number of measures proposed for each alternative. It is assumed that riffle structures, drop structures, and sills will be used for grade control. Riffle structures will be built, in most instances, such that there will be three riffles in series separated by a distance (X) equal to the height of the riffle (H) divided by the channel slope (S_o) ($X = H/S_o$). It is also assumed that for a series of riffle structures, the length of stream realizing direct benefits associated with the riffles will extend a distance of X upstream from the most upstream riffle and a distance of 3X downstream from the most downstream riffle. For other types of grade control structures, it is assumed that the length of stream realizing direct benefits will extend a distance of X upstream and 5X downstream from the structure. It is assumed that Direct Structural Measures (i.e. Riprap) and Indirect Structural Measures (i.e. Bendway Weirs, Barbs, Groins, and Spurs) will be used for Bank Stabilization. The length along the stream where riprap is placed is considered to be the stream length with direct benefits. Riprap may be used alone or in conjunction with bioengineering. The length along the stream where bioengineering is placed is considered to be the stream length with direct benefits. Indirect Structural Measures will be applied at frequency of 1 per 100 feet of stream; therefore, it is assumed that the direct benefits for each structure extend 50 feet upstream and 50 feet downstream from the structure. The relationship between Sediment Retention Structure size and stream miles with direct benefits is based on the following assumptions: (1) each acre of sediment retention built will affect 20 acres of watershed and (2) the percentage of total watershed area benefited is equivalent to the percentage of total (perennial and ephemeral) stream miles benefited.

As the streams are stabilized (through the placement of riprap, bendway weirs, etc.), upstream segments of stream will experience reduced downcutting and widening due to erosive forces. Over the 50-year life of this project, it is anticipated that for Alternatives 6 and 7 sediment reduction measures will be installed in half of the sub-basins of the Illinois River Basin; therefore, up to half of the stream miles in the basin (5,500 perennial stream miles and 11,250 ephemeral stream miles, 16,750 total stream miles) will be beneficially influenced through the project measures. The quantity of stream miles influenced for Alternatives 1 through 5 were determined by prorating the previous total (16,750 stream miles) by the ratio of the stream miles with direct benefits for each alternative to the stream miles with direct benefits for Alternatives 6 and 7. The quantities of stream miles influenced are estimates of the maximum benefits that could be realized over the 50-year life of the project.

iii. Ancillary Benefits. Additional sediment delivery benefits are likely to accrue from projects undertaken for other goals. These include:

- Reductions due to reduced transport and sediment trapping in stream and riparian restoration projects **(Goal 3)**
- Reductions from reduced stream power under naturalized hydrologic regimes **(Goal 5)**
- Sediment trapping in water quality facilities **(Goal 6)** and flood storage areas **(Goal 5)**

However, there could also be negative impacts from actions that may release sediment, such as some dam removal projects (Goal 4). It is assumed that the sediment delivery benefits or detriments due to those goals will be addressed within the project design.

In addition, the projects enacted under this goal are likely to have ancillary benefits for other goals. Habitat benefits to support Goal 3 will be provided by riffle-pools, stone structures and vegetated banks, although there is a broad range of potential benefits due to the unknown configuration of the eventual watershed projects.

Additional benefits will accrue to Goal 6 as reduced sediment delivery will reduce the transport of nutrients associated with the sediment, most notably phosphorus, into the aquatic systems. Hubbard et al. (2003) cited chemical analyses indicating that soils in the Mississippi contained approximately 200 parts per million phosphorus; assuming that soils in Illinois are comparable, each ton of sediment reduction would amount to a reduction of approximately 0.4 pounds of phosphorus delivery to the river. Other unquantified ecosystem benefits of reduced sediment delivery include:

- Improved aquatic habitat quality in tributaries and backwater areas due to reduced turbidity and sedimentation effects **(Overarching Goal and Goals 2 and 3)**
- Increased backwater longevity **(Goal 2)**
- Connectivity benefits in certain riffle-pools **(Goal 4)**
- Lower flood stages due to stabilized sediment regime **(Goal 5)**

Non-ecosystem benefits that can also be attributed to reduced sediment delivery are reduced dredging costs and beneficial use of the sediment removed from traps and/or mined deltas. These benefits were not quantified for this study.

Finally, there will be the potential to incorporate additional features into the sediment projects to support other goals. For example, the design of upland measures can be modified to attenuate peak flows or increase baseflows (Goal 5). There is also the potential to incorporate water quality features into upland facilities and bank stability measures (Goal 6). These types of added benefits would generally require additional costs as they require features that would not otherwise be included in the sediment reduction projects.

Table 3-7. Characteristics of Alternatives Selected as Part of System Plans

		Reduced Delivery (%)		Delivery Reduced (100,000 tons/year)				Initial Cost ($ Million)		
System Plan	**Alternative**	**to Valley City**	**to Peoria Lake**	**Tributaries Upstream of Peru**	**Peoria Lake Direct Tributaries**	**Tributaries Downstream of Peoria Lake**	**Total**	**Construction**	**Real Estate**	**Total**
1	1N	2.30	6.30	0.0	2.8	0.0	2.8	87	9	96
2	1P	5.00	12.50	0.0	5.7	0.4	6.0	191	20	211
3,4,5	1U	10.00	20.00	3.4	5.7	3.0	12.1	514	45	559
6,7	1V	20.00	20.00	3.4	5.7	15.1	24.2	950	88	1038

Table 3-8. Benefit Quantification for Goal 1

System Plan	Alternative	Effectiveness (% of desired future conditions)	Stream Length with Direct Benefits Resulting from the Proposed Measures (miles)	Stream Length Influenced by the Proposed Measures (miles)
1	1N	12	106	1,700
2	1P	25	201	3,220
3,4,5	1U	50	598	9,570
6,7	1V	100	1,047	16,750

Table 3-9. Quantity of Features To Be Installed for the Cost-Effective Alternatives

		Feature Quantities			
System Plan	**Alternative**	**Riffle (ea)**	**Bioengineering (mi)**	**Stone Toe (mi)**	**Stream Barbs (ea)**
	1-0	0	0	0	0
1	1N	13-110	7.3-26	4.6-15	200-870
2	1P	28-240	16-57	10-32	450-1900
3,4,5	1U	47-480	60-230	36-120	1800-7600
6,7	1V	91-880	98-370	60-200	2900-12000

c. Risk and Uncertainty. The measures selected for this goal, when correctly designed and applied, are known to effectively reduce the downstream delivery of sediment. The actual sediment delivery reduction for each individual project will vary widely based on site conditions, but it is likely that the assumed benefits for the proposed levels of project implementation are somewhat underestimated. Benefits were based on "average" conditions, while it is expected that most projects will be applied to sites with higher than average sediment delivery and thus greater potential reductions. Thus, it is fairly certain that project implementation as proposed here will in fact reduce sediment delivery to the Illinois River to the expected degree (tons per year). By using the complete time period of 1981-2000 as the baseline, including the extreme year of 1993, there is confidence that the sediment reduction goals, 1.2 million tons per year after 20 years and 2.4 million tons per year after 50 years, represent a conservative estimate of the requirements necessary to enact 10 percent and 20 percent reductions, respectively, from existing conditions.

One item of significant uncertainty is the net effect of outside influences on the sediment regime of the Illinois River in the future. Factors that will affect future sediment conditions are climate, land use, and land cover conditions. Changes in any of these factors could mask the change, or lack of change, brought about by project implementation. The uncertainty regarding this item can be addressed by incorporating monitoring results into evaluations of program effectiveness; by separating project effects from those of outside influences it will be possible to correctly assess project benefits and adapt to changing conditions. The monitoring will have to be sufficient to determine whether background sediment loads have remained at the same level (as assumed for this document), increased, or decreased over the life of the project. It must also inform regarding the influence of any extreme events encountered and allow determination of the ongoing success of the project independent of those extreme events.

Finally, an additional item of uncertainty is the ecological response from the proposed level of sediment delivery reduction. The team is confident that the proposed objectives will provide significant and measurable benefits and that the physical changes will have significant ecological benefits. However, without an adequate framework to relate sediment transport to ecosystem integrity, it cannot be confidently assumed that any particular reduction will be sufficient to maintain a specific level of integrity. Further work is necessary to move beyond the qualitative understanding of system function so that quantitative predictions of ecosystem response are possible, and that the initial target reductions may be revised if necessary.

d. Information and Further Study Needs

- Must define and quantify "excessive" on a system-wide basis (excessive sediment for a given stream may be definable by site-specific project studies).
- Research to determine the quantity of "excessive" sediment loads and sources of sediment in the main stem Illinois and its major tributaries.
- Stream surveys, sediment monitoring, and evaluation of installed practices.
- Basin-wide hydrologic and sediment models.
- Ecosystem response model for sediment.
- Quantitative understanding of the geomorphological evolution of streams in the Illinois River Basin and their response to altered sediment supply and hydrology.

G. GOAL 2: BACKWATERS AND SIDE CHANNELS. Restore aquatic habitat diversity of side channels and backwaters, including Peoria Lakes, to provide adequate volume and depth for sustaining native fish and wildlife communities

Problem. A dramatic loss in productive backwaters, side channels, and islands due to excessive sedimentation is limiting ecological health and altering the character of this unique floodplain river system. In particular, the Illinois River has lost much of its critical spawning, nursery, and overwintering areas for fish, habitat for diving ducks and aquatic species, and backwater aquatic plant communities. A related problem is the need for timely action. If restoration is not undertaken soon, additional productive backwater and side channel aquatic areas will be converted to lower value and increasingly common mudflat and extremely shallow water habitats.

Objectives

- Restore and rehabilitate 19,000 acres of habitat in currently connected areas (1989 data shows approximately 55,000 acres of backwaters during summer low water). Restoration should result in a diversity of depths. For restored backwaters, a general target would be to have the following distributions of depths: 5% > 9 feet; 10% 6 to 9 feet; 25% 3 to 6 feet; and 60% < 3 feet.
- Restore and maintain side channel and island habitats.
- Maintain all existing connections between backwaters and the main channel. (connections at the 50% exceedance flow duration).
- Identify beneficial uses of sediments.
- Compact sediments to improve substrate conditions for aquatic plants, fish, and wildlife.

Anticipated Outputs

Anticipated project outputs include immediately addressing the system limiting lack of overwintering aquatic habitat (UMR-EMP Habitat Needs Assessment, 2000). These effects will benefit the system's fish (paddlefish, bass, bluegill, catfish, and mooneye), diving ducks (canvasback and greater and lesser scaup), invertebrates (mayflies and fingernail clams), aquatic plants, mussels, and other native species. At a completed side channel and backwater restoration project, a comparison of pre- and post-project construction monitoring data showed a dramatic increase in the number and diversity of fish and waterfowl species as well as an increased total number of individuals. This success is anticipated for similar projects. System quality would increase as the number of restored backwaters reaches the desired spacing of a high quality backwater approximately every 5 miles.

1. Inventory Resource Conditions

a. Historic Conditions. Historically, the complexes of backwaters and side channels along the main stem Illinois River have provided incredibly rich habitat for fish and wildlife. Numerous small lakes and ponds rather than large lakes, dominated the floodplain (Bellrose et al. 1983). Early accounts record abundant beds of aquatic plants, attesting to the water clarity and suitable substrates. The fishery was exceptional, with a 200-mile reach of the Illinois River producing 10 percent of the total U.S. catch of freshwater fish in 1908, more than any other river in North America (Sparks 1992).

Glacial history directly shaped the geomorphic conditions of the Illinois River. This history can be used to illustrate the differences between two sections of the Illinois River, the upper and lower river, which are roughly separated at Hennepin, Illinois.

The upper river has an average width of 400 feet and a relatively steep slope of approximately 1 foot per mile. This reach does not contain significant backwater areas. In contrast, the lower river that occupies the former channel of the ancient Mississippi River has a width approaching 1,400 feet near Grafton, Illinois, a much wider natural floodplain, and a very flat slope of 0.1 foot per mile. Since glacial retreat, sediments eroded from steep tributaries have built large alluvial fans and deltas into the lower Illinois River valley, causing the formation of natural constrictions, lakes, and backwaters. The lower Illinois River is characteristically low gradient, aggradational, and has large backwater areas. The sedimentation occurring within this reach has increased significantly since settlement and threatens to convert the backwater areas into mudflats and extremely shallow water areas with decreased habitat value due to hydrologic regimes and turbidity, which essentially exclude vegetation from these areas.

i. Backwaters. Sedimentation of the Illinois River and its backwater areas has been the subject of numerous studies (Lee and Stall 1976; Bellrose et al. 1983, Demissie and Bhowmik 1986, Demissie et al 1992, WEST Consultants, Inc. 2000, Demissie et al. 2004, USACE 2003a, and USACE 2003b). Lee and Stall (1976) concluded that the backwater lake volume was being lost at an annual rate ranging from 0.6 to 1.1 percent over the period of 1903 to 1975.

Recently, the amount of backwater areas has fluctuated significantly. Following significant increases in the backwater surface acreage associated with diversion and dam construction, relatively steady declines have followed. The earliest recorded data comes from a survey conducted by J. W. Woermann between 1902 and 1904 for the U.S. Army Corps of Engineers. However, even by this time the survey reflects an altered system. The construction of dams and flow diversion from Lake Michigan had already raised water levels and increased the area covered by water relative to prior conditions.

Bellrose et al. (1983) estimated total surface acreage of backwaters at approximately 55,000 acres in 1903. Backwater area calculations were based on the 1903 tree line; this corresponds to lower elevations than current conditions. Ultimately, levee construction resulted in the loss or isolation of 31 lakes and approximately 22,000 acres of the original 55,000 acres of backwater area (Bellrose et al. 1983). As water levels on the system were raised through increased diversions of water from Lake Michigan and construction of dams, the total surface area also increased. At the peak of diversion, and prior to levee construction, the total acreage of backwaters is estimated to have exceeded 110,000 acres (Bellrose et al. 1983). By 1969, however, there was a relatively dramatic reduction to approximately 68,000 acres due to the combined effects of levee building, reduction in diversion, and sedimentation. The 1969 calculations were again based on the existing tree line, which were higher than the 1903 elevations due to improvements. Table 3-10 summarizes findings from the analysis. Bellrose et al. (1983) assessed potential future effects associated with sedimentation by estimating that the number of years required for selected lakes to lose half their average depth ranged from 24 to 127 years.

Table 3-10. Estimated Historic Surface Acreage of Connected Backwater Areas

Backwaters	River Mile	Estimated # of Backwaters	1903 Surface Acreage	Actual # of Backwaters	1969 Surface Acreage
Lower 3 Pools					
Peoria Pool		34	17,419	32	32,831
La Grange Pool	73	67	27,877	52	26,981
Alton Pool	77	35	10,366	21	7,881
Total Lower 3 Pools	**80**	**136**	**55,661**	**105**	**67,693**
Total Upper Pools (Dresden, Marseilles, Starved Rock)				**11**	**2,956**

Source: The Fate of Lakes in the Illinois River Valley, Bellrose et al. (1983)

Demissie and Bhowmik (1986) conducted an investigation of the sedimentation characteristics of Peoria Lake, the largest and deepest lake on the Illinois River. Their comparison of limited historic cross sections of the lake demonstrated sediment accumulation of up to 14 feet in various locations of the lake while the navigation channel was relatively stable over the period of record. As of 1985, the lake was estimated to have lost about 68 percent of its 1903 volume. The study concluded that, if sediment input continued at current rates, within 10 to 15 years, the river and lake would reach dynamic equilibrium and net accumulation of sediment in the lake would be zero. They predicted that most of the area outside the channel would become either a mudflat or a marshy wetland area, depending on the ability of vegetation to grow in the lake sediment.

A more recent study of the Peoria Lakes by the USACE (2003b) using data from 1903, 1930s, 1965, 1976, 1988, 1996 and 1999, shows that the off-channel areas (lake area outside of the navigation channel) experienced a volume loss of 60 percent from 1930 to 1999. These reductions correspond to average annual volume losses of approximately 0.87 percent. Over this same time period, the lake surface area decreased by approximately 10 percent, a 0.15 percent annual loss. This relatively slow rate of change in surface area for this large riverine lake likely does not reflect the rate of change occurring in the more isolated backwater lake areas, which probably lose surface area at a much higher rate.

Sedimentation and the related reductions in lake volume have dramatically altered habitat values. As the lake cross sections (Figures 3-5a and 3-5b) and plan view (Figure 3-6) show, lake depth diversity has been greatly simplified. While water levels currently are somewhat higher, the overall effect has been the loss of depth and dramatic reduction in habitat diversity. The lake historically had a mix of shallow and deepwater off-channel areas serving as aquatic habitat. Even the relatively shallow areas are reported to have had firm substrates and been home to large aquatic plant beds.

Demissie (1992) calculated the average capacity loss for selected backwater lakes from 1903 to 1975 (table 3-11). Their study showed an average capacity loss of 72 percent. Higher flow velocities and tow traffic in the channel keep finer sediments suspended in the vicinity of the navigation channel, but low velocities allow sediment to drop out in calmer areas.

This is consistent with results of the Cumulative Effects Study (WEST Consultants, Inc. 2000), which compared 1930s data with 1980s data and found that the main channel of the Illinois River has not changed significantly since the 1930s, even in the downstream reaches of the Illinois River. However, they noted changes in the backwater areas and anticipated further filling.

Table 3-11. Estimated Sedimentation in Selected Backwater Lakes in the Illinois River Valley

Pool	Lake Name	River Mile	Capacity (acre-feet) 1903	1975	1990 [1]	Rate inches/yr	Loss Percent
Alton							
	Swan Lake	5	4,816	2,783	2,359	0.18	51
	Lake Meredosia	72	7,791	4,207	3,460	0.43	56
La Grange							
	Muscooten Bay	89	1,459	184	0	3.12	100
	Patterson Bay	107	271	165	143	0.31	47
	Lake Chautauqua	125	14,293	11,679	11,134	0.33	22
	Rice Lake	133	3,064	1,119	714	0.32	77
	Pekin Lake	153	323	226	206	0.08	36
Peoria							
	Peoria Lake	162	120,000	56,600	29,150	0.79	76
	Babb's Slough	185	1,377	625	468	0.14	66
	Weis Lake	191	450	110	39	0.15	91
	Sawmill Lake	197	2,110	381	21	0.47	99
	Lake Senachwine	199	9,240	2,468	1,057	0.30	86
	Lake DePue	203	2,837	778	349	0.59	88
	Huse Slough	221	253	51	9	0.96	96
Marseilles							
	Ballard's Slough	248	142	36	14	0.91	90

[1]1990 capacity estimated based on sedimentation rate for the period from 1903-1975(Demissie 1992).

A sediment analysis conducted for Pekin Lake, in La Grange Pool, was conducted as part of work on the Pekin Lake Critical Restoration project. This backwater has experienced significant sedimentation during the last century. The earliest detailed survey of Pekin Lake was completed about 1903 by J. W. Woermann. The maps created from that survey depict the lake when the Illinois River was at low water conditions (approximately 432.5 feet NGVD, 1929). Under these conditions, some areas of the lake exhibited water depths in excess of 6 feet. Today, when the river falls to normal summer low-flow levels, what little open water exists is only 0 to 2 feet deep. Rates of sedimentation over the last 100 years were computed for the Pekin Lake area. The average annual sedimentation rate based on the amount of sediment that has deposited between 1903 and the present is 0.23 inches per year in the upper lakes and 0.3 inches per year in the lower lakes and 0.26 inches per year for the entire lake complex.

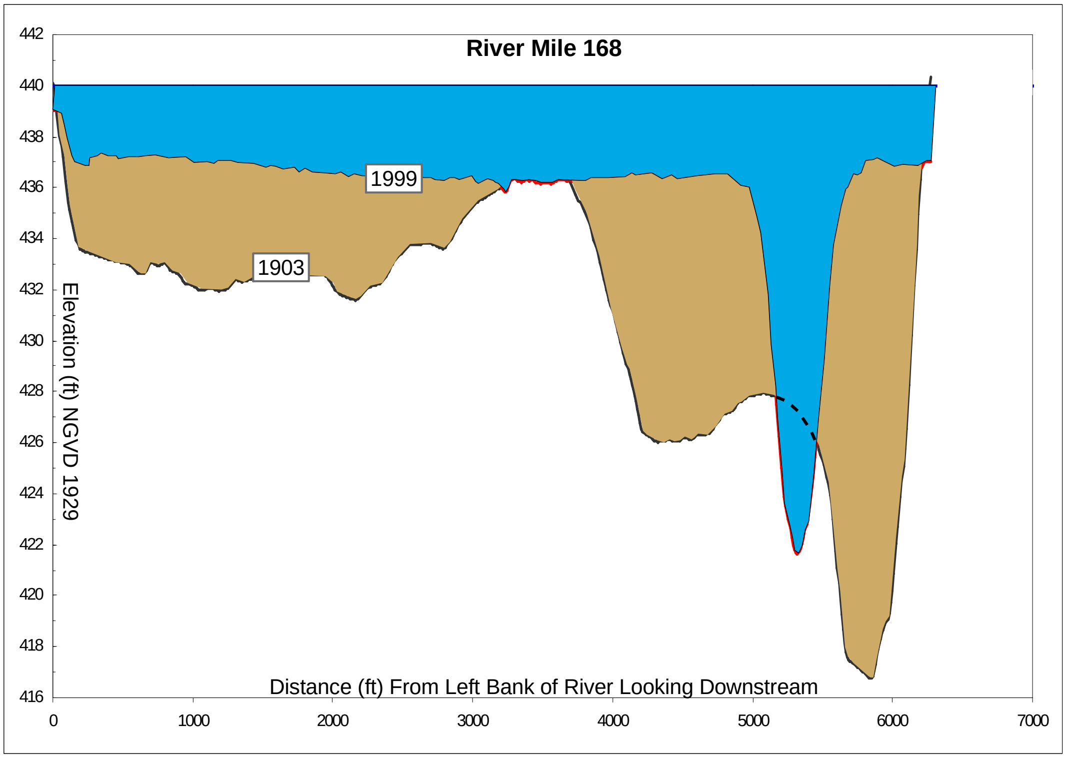


Figure 3-5a. Typical Cross Sections from Peoria Lakes Showing Dramatic Sedimentation Between 1903 and 1999, RM 168

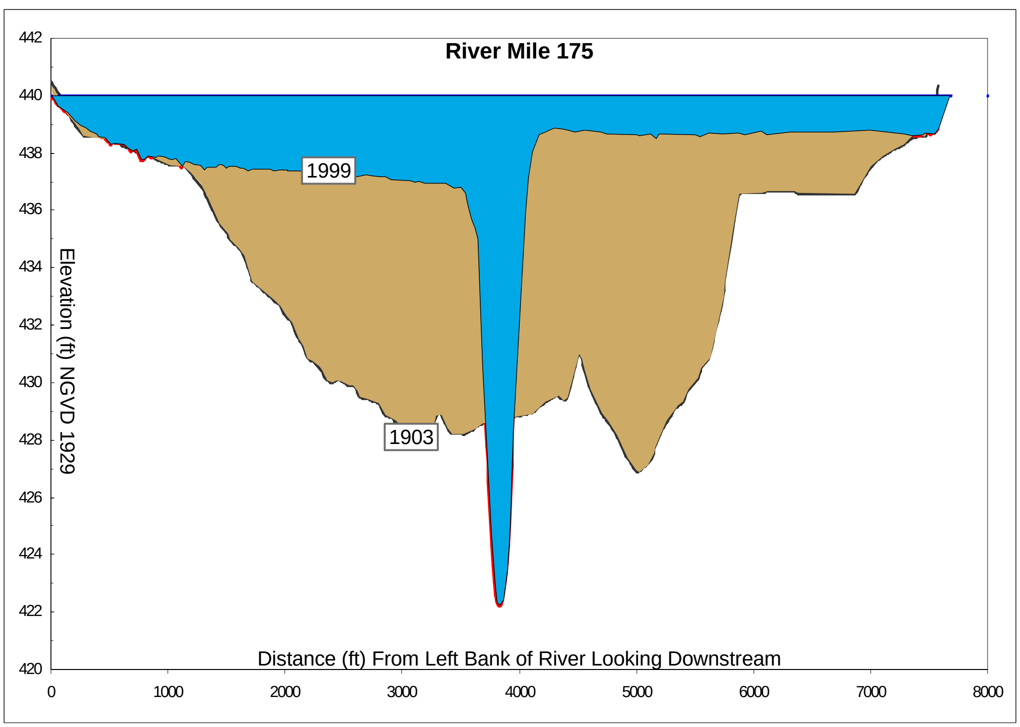


Figure 3-5b. Typical Cross Sections from Peoria Lakes Showing Dramatic Sedimentation Between 1903 and 1999, RM 175

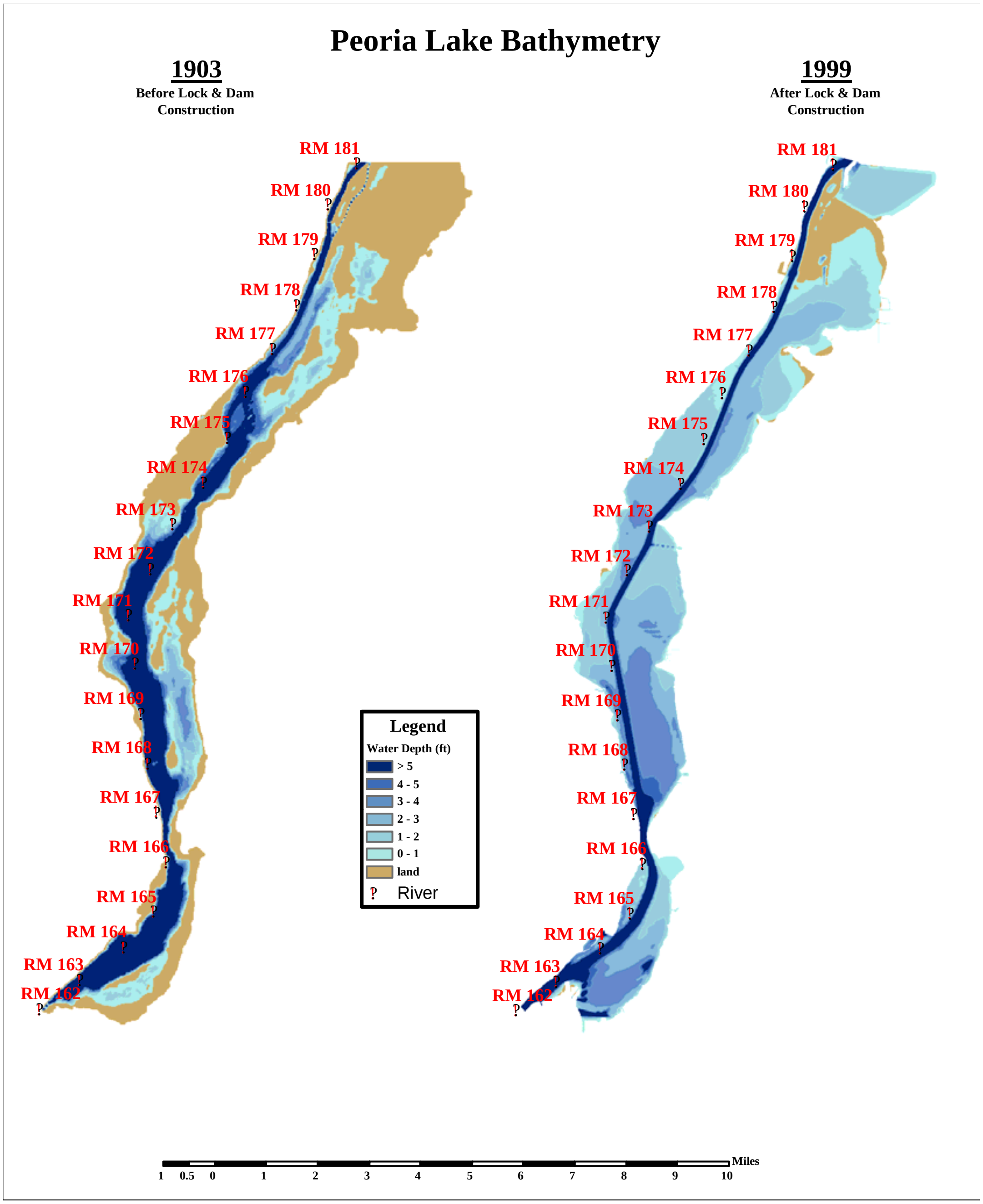


Figure 3-6. Peoria Lake 1-Foot Water Depth Contours
Note loss of numerous islands and side channels between 1903 and 1999. Also, water depths >5 feet currently are only found in the very narrow navigation channel. This loss of bathymetric diversity greatly limits the value of existing habitat within Peoria Lake.

The Corps of Engineers (2003a) conducted an analysis of the rate of loss of backwater capacity and surface area for three backwaters (Babb's Slough-Sawyer Slough, Meadow Lake, and Wightman Lake) in the Peoria Pool (tables 3-12 to 3-14). This analysis was based on the comparison of 2001 bathymetry data to data from 1903. Sedimentation rates between 1903 and 2001 for these backwaters ranged from 0.18 inches/year to 0.37 inches/year and the percentage reduction in storage capacity varied from 77.2 percent (0.78 percent/year) to 97.0 percent (0.99 percent/year). In general, deeper areas have filled more quickly than shallow areas resulting in a higher and more uniform bottom surface in 2001 as compared to 1903. The annual rates of capacity loss and sedimentation calculated between 1903 and 2001 compare closely to rates calculated in other publications for the timeframe between 1903 to the mid 1970s, indicating that sedimentation rates and rates of annual percent capacity loss have remained nearly constant in the timeframe since 1975. These recent rates are higher than expected given that the bottom surface has been progressively rising, which would be expected to result in decreased rates of sedimentation. Water elevation duration curves for the 1903 through 1975 timeframe and the 1975 through 2001 timeframe show that more recent water flow rates and corresponding water surface elevations have been higher, promoting continued high rates of sedimentation.

Table 3-12. Change in Storage Capacity of Backwater Lakes [1]

	1903	2001	1903 to 2001	1903 to 2001
Backwater Lake	**Capacity (acre-feet)**	**Capacity (acre-feet)**	**Capacity Loss (%)**	**Capacity Loss (%/Yr)**
Combined Babb's and Sawyer Sloughs	4687	544	88.4	0.90
Meadow Lake	2080	37	97.0	1.00
Wightman Lake	2134	285	87.0	0.89

[1] Capacity based on elevation 440 msl

As would be expected, the changes in depth roughly mirror the loss in capacity (table 3-13). Depths have decreased dramatically, to the point where all four lakes average only a few inches.

Table 3-13. Change in Depth of Selected Backwater Lakes

	1903 [1]	2001	1903 to 2001
Backwater Lake	**Average Depth (feet)**	**Average Depth (feet)**	**Depth Loss (inches/Yr)**
Combined Babb's and Sawyer Sloughs	2.05	0.6	0.18
Meadow Lake	3.2	0.16	0.37
Wightman Lake	3.8	0.59	0.39

[1] 1903 capacity based on elevation 440 msl

The change in surface area has been somewhat less dramatic over time in all but one backwater. The percentage reduction surface area varied from 12.6% (0.13%/year) to 65.3% (0.67%/year) (table 3-14). It is likely that the rate of loss of surface area will increase in the future since little depth remains.

Table 3-14. Change in Surface Area of Selected Backwater Lakes

	1903 [1]	2001	1903 to 2001	1903 to 2001
Parameter	**Surface Area (acres)**	**Surface Area (acres)**	**Surface Area Loss (%)**	**Surface Area Loss (%/Yr)**
Combined Babb's and Sawyer Sloughs	2276	875	61.5	0.63
Meadow Lake	652	226	65.3	0.67
Wightman Lake	557	487	12.6	0.13

[1] 1903 capacity based on elevation 440 msl

ii. Side Channels and Islands. While considerably less documentation has been assembled on the side channel and island habitats of the Illinois River, a review of the Woermann Maps (1903) revealed the following estimates of 94 islands with a total length of approximately 75 miles (table 3-15). Since islands separate the main channel from side channels, the island length provides a rough estimation of the amount of side channel habitat.

Table 3-15. Estimated Historic Islands and Side Channels By Pool (Woerman 1903)

Pool	Number of Islands	Length in Miles
Dresden	4	1.5
Marseilles	12	4.5
Starved Rock	8	6.0
Peoria	23	14.5
La Grange	24	25.0
Alton	23	23.0
Total	**94**	**74.5**

b. Existing Conditions. The existing resource conditions related to backwaters and side channels were estimated using available data and are summarized below.

i. Backwaters. Due to the absence of recent survey data of backwater acreage and volume, existing backwaters conditions were estimated using the USGS 1989 Aerial Photo Interpretation. This dataset is the most recent fully analyzed and readily available information, but several features should be kept in mind when comparing these results to historic data.

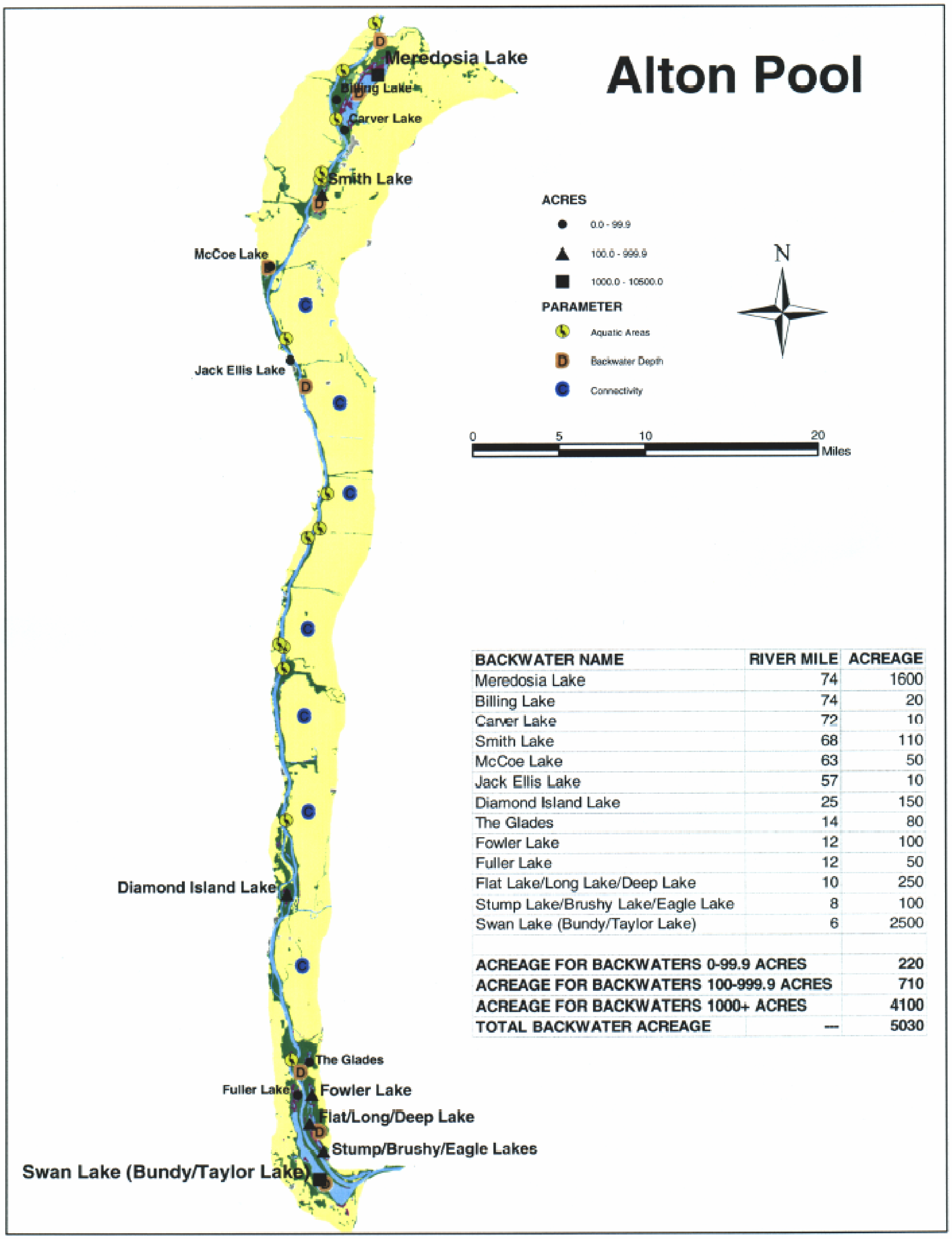
The analysis showed that in the three lower pools of the Illinois River there were approximately 54,000 acres of backwaters during summer low water periods. Table 3-16 and Figures 3-7, 3-8, and 3-9 show the numbers of backwaters and total acreage by pool.

Table 3-16. Estimated Existing Surface Acreage of Connected Backwater Areas (USGS 1989 Aerial Photo Interpretation)

Reach	**Number of Back waters**	**Surface Acres**
Peoria Pool	32	30,325
La Grange Pool	46	18,537
Alton Pool	18	5,030
Total	**96**	**53,892**

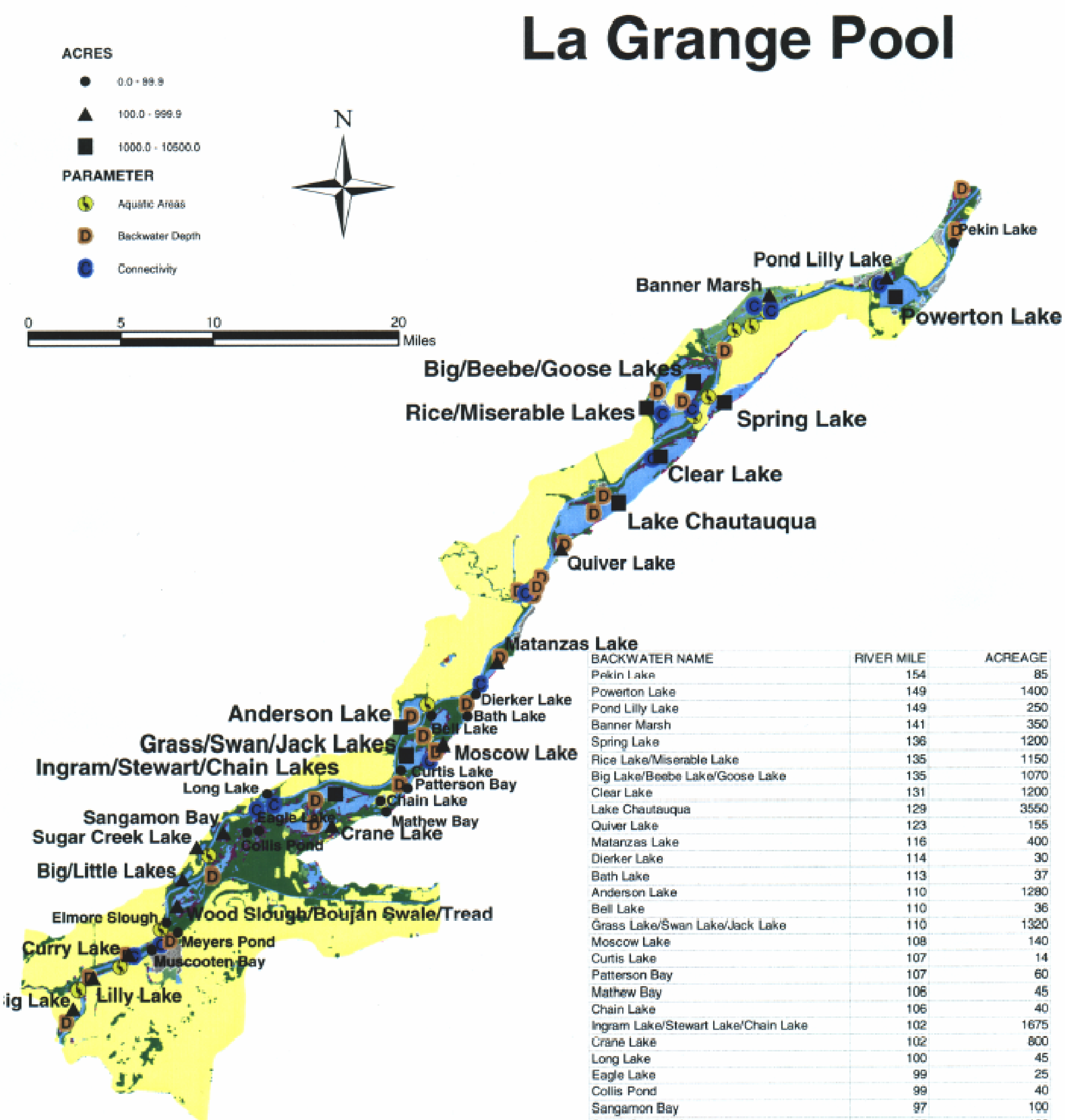
The current quality of the existing backwaters is low due to the relatively shallow depths (less than 1 foot) and relatively uniform bottom surface lacking depth diversity. The near absence of aquatic plants due to current water level regime, turbidity, and unconsolidated sediments further limits habitat values. Sediment accumulation has eliminated most deep water outside the navigation channel. This limits fish overwintering habitat to the channel, which is subject to year-round navigation and higher flow velocities.

Figure 3-10 shows the Upper Illinois River Basin backwaters and total acreage. Although this information is not directly comparable to historic measurements, it provides a baseline of relatively current conditions. While existing volumes for the system have not been surveyed in recent years, the four backwaters surveyed in 2001 and evaluated for filling rates since 1903 showed dramatic losses over time and losses continuing even in recent periods. These are believed to be fairly representative of other backwater areas.



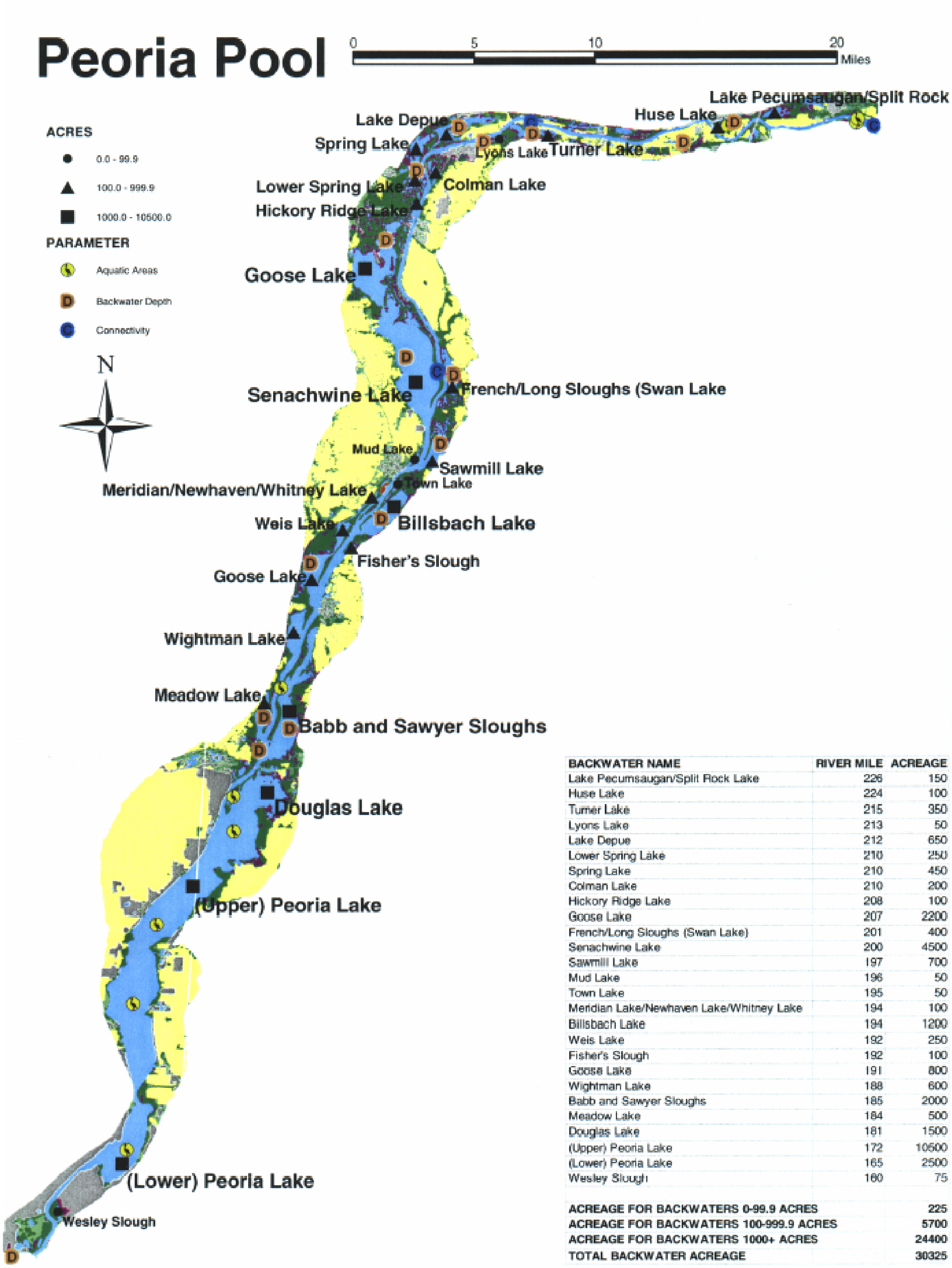
BACKWATER NAME	RIVER MILE	ACREAGE
Meredosia Lake	74	1600
Billing Lake	74	20
Carver Lake	72	10
Smith Lake	68	110
McCoe Lake	63	50
Jack Ellis Lake	57	10
Diamond Island Lake	25	150
The Glades	14	80
Fowler Lake	12	100
Fuller Lake	12	50
Flat Lake/Long Lake/Deep Lake	10	250
Stump Lake/Brushy Lake/Eagle Lake	8	100
Swan Lake (Bundy/Taylor Lake)	6	2500
ACREAGE FOR BACKWATERS 0-99.9 ACRES		220
ACREAGE FOR BACKWATERS 100-999.9 ACRES		710
ACREAGE FOR BACKWATERS 1000+ ACRES		4100
TOTAL BACKWATER ACREAGE	---	5030

Figure 3-7. Alton Pool Backwaters and Total Acreage



BACKWATER NAME	RIVER MILE	ACREAGE
Pekin Lake	154	85
Powerton Lake	149	1400
Pond Lilly Lake	149	250
Banner Marsh	141	350
Spring Lake	136	1200
Rice Lake/Miserable Lake	135	1150
Big Lake/Beebe Lake/Goose Lake	135	1070
Clear Lake	131	1200
Lake Chautauqua	129	3550
Quiver Lake	123	155
Matanzas Lake	116	400
Dierker Lake	114	30
Bath Lake	113	37
Anderson Lake	110	1280
Bell Lake	110	36
Grass Lake/Swan Lake/Jack Lake	110	1320
Moscow Lake	108	140
Curtis Lake	107	14
Patterson Bay	107	60
Mathew Bay	106	45
Chain Lake	106	40
Ingram Lake/Stewart Lake/Chain Lake	102	1675
Crane Lake	102	800
Long Lake	100	45
Eagle Lake	99	25
Collis Pond	99	40
Sangamon Bay	97	100
Sugar Creek Lake	95	100
Big Lake/Little Lakes	93	180
Wood Slough/Boujan Swale/Treadway Lake	91	900
Elmore Slough	90	35
Muscooten Bay	89	20
Meyers Pond	89	70
Curry Lake	87	425
Lilly Lake	84	180
Big Lake	82	130
ACREAGE FOR BACKWATERS 0-99.9 ACRES		582
ACREAGE FOR BACKWATERS 100-999.9 ACRES		4110
ACREAGE FOR BACKWATERS 1000+ ACRES		13845
TOTAL BACKWATER ACREAGE		18537

Figure 3-8. La Grange Pool Backwaters and Total Acreage



BACKWATER NAME	RIVER MILE	ACREAGE
Lake Pecumsaugan/Split Rock Lake	226	150
Huse Lake	224	100
Turner Lake	215	350
Lyons Lake	213	50
Lake Depue	212	650
Lower Spring Lake	210	250
Spring Lake	210	450
Colman Lake	210	200
Hickory Ridge Lake	208	100
Goose Lake	207	2200
French/Long Sloughs (Swan Lake)	201	400
Senachwine Lake	200	4500
Sawmill Lake	197	700
Mud Lake	196	50
Town Lake	195	50
Meridian Lake/Newhaven Lake/Whitney Lake	194	100
Billsbach Lake	194	1200
Weis Lake	192	250
Fisher's Slough	192	100
Goose Lake	191	800
Wightman Lake	188	600
Babb and Sawyer Sloughs	185	2000
Meadow Lake	184	500
Douglas Lake	181	1500
(Upper) Peoria Lake	172	10500
(Lower) Peoria Lake	165	2500
Wesley Slough	160	75
ACREAGE FOR BACKWATERS 0-99.9 ACRES		225
ACREAGE FOR BACKWATERS 100-999.9 ACRES		5700
ACREAGE FOR BACKWATERS 1000+ ACRES		24400
TOTAL BACKWATER ACREAGE		30325

Figure 3-9. Peoria Pool Backwaters and Total Acreage

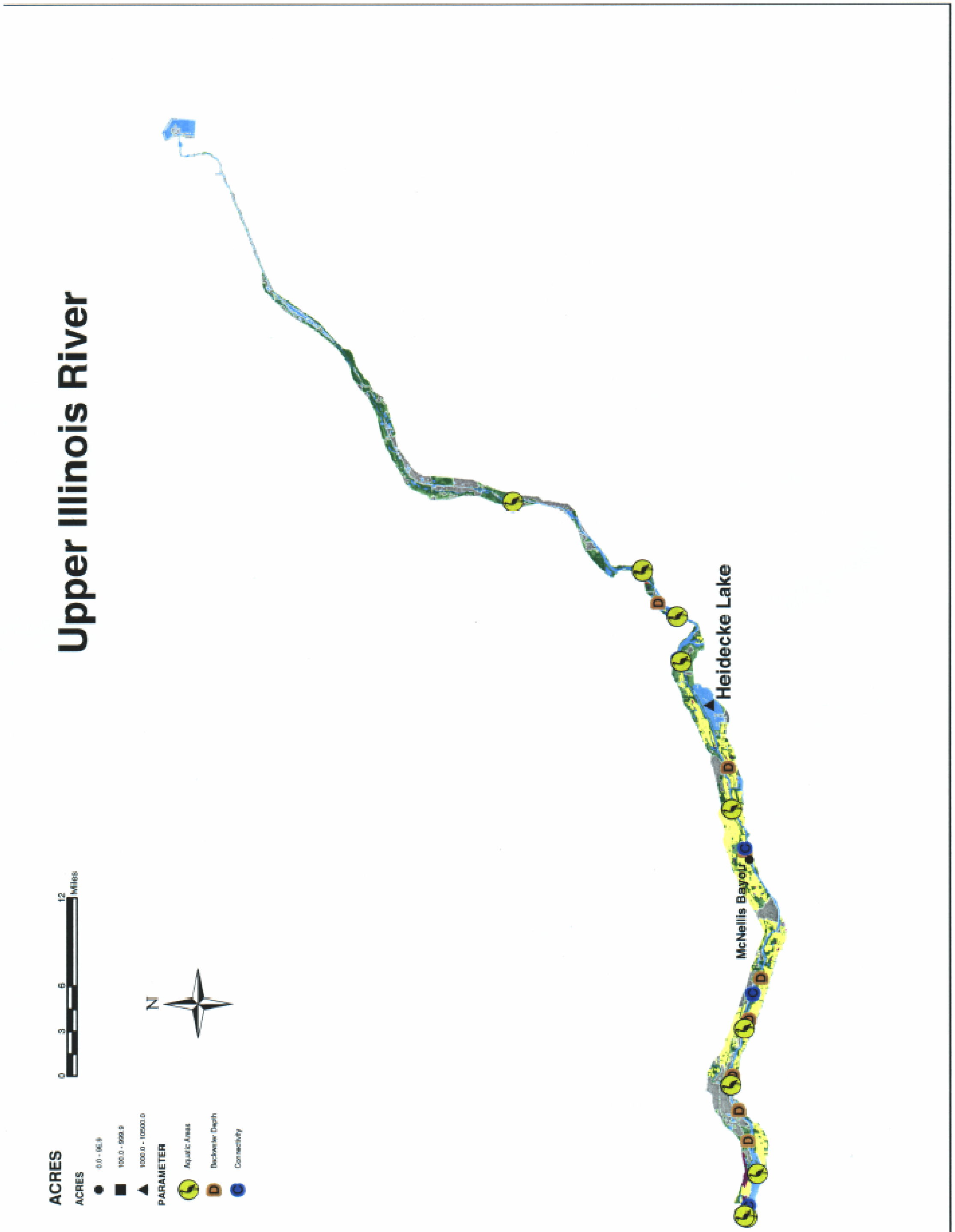


Figure 3-10. Upper Illinois River Backwater Acreage

ii. Side Channels and Islands. ***A***reas sheltered from the main river flows provide beneficial resting habitat for aquatic animals. Islands often provide such protection to their side channels, so protection of side channel habitat is tied to the protection of islands. For this study, the amount of side channel habitat was estimated using the Illinois River Navigation Charts. Based on this information, there are approximately 57 islands on the Illinois River that create approximately 54 miles of side channel (table 3-17). While the size and shape vary considerably, on average Illinois River side channels are approximately 1 mile long with widths of roughly 100 feet. This current total represents a relatively dramatic decline from the 94 islands with a total length of approximately 75 miles in 1903. While increases in water level elevations associated with impoundments and diversion are likely a primary cause, it does point to concerns over continued loss.

Table 3-17. Estimated Existing Side Channels by Pool

Pool	Number of Side Channels	Length in Miles
Dresden	3	1.9
Marseilles	6	4.7
Starved Rock	5	5.0
Peoria	12	7.6
La Grange	13	17.7
Alton	18	17.2
Total	**57**	**54.0**

In 2001, Mike Cochran, Illinois DNR (retired), and T. Miller, USACE - St. Louis District conducted a detailed evaluation of the side channels and islands in Alton Pool, the 80 mile reach upstream of the mouth. They found that many of the side channels on the system still provide relatively good habitat value and some have depths reaching 6 to 15 feet. In particular, they found that 14 of 18 islands in Alton Pool (approximately 80 percent) required bank protection to reduce excessive island erosion and loss of island/side channel length. They also found 3 of 18 side channels (approximately 17 percent) filling with sediment to the point that the channels may close completely. The side channels in jeopardy of closing had been reduced to only a few feet of depth on average.

While not directly evaluated as part of the study, Corps of Engineers channel maintenance staff observe that the loss of side channel depths due to sedimentation is a much greater concern in the La Grange Pool. In general, the quality of side channels is diminished from historic levels due to loss of depth diversity and lack of aquatic structure, such as woody debris.

c. Future Without-Project Conditions. The future without geomorphic conditions were evaluated by WEST Consultants, Inc. (2000) as part of the Upper Mississippi River and Illinois Waterway Cumulative Effects Study. The following paragraphs summarize the findings of their evaluation:

> Overall, the future geomorphic conditions of the Illinois River are well defined. The geologic history of the Illinois River created conditions where sedimentation is and will continue to be the predominant geomorphic process. More sediment supplies from tributary areas are deposited within the river valley than are transported through it. However, the rate at which sediments are supplied to the Illinois River and sedimentation occurs is undoubtedly influenced by human activities, such as land use, water regulation, and dredging.

Most of the investigators of the Illinois River agree that significant sedimentation is occurring under current conditions and most backwater areas will be filled with fine sediment within the foreseeable future. According to Demissie and Bhowmik (1986), equilibrium between the sediment supply and transport out of Peoria Lake, the largest and deepest pool along the Illinois River, will be reached within the next few years. The navigation channel has not changed significantly in plan form over the period of record. Higher flow velocities and maintenance dredging along the channel effectively prevent significant change along its length.

In summary, according to previous studies, by the year 2050 the Illinois River is predicted to lose a significant portion of its off-main channel backwater areas under current conditions of sediment supply. The affected contiguous and isolated backwater areas are expected to convert to mud flats (photograph 3-2). The location and area of the main channel is expected to remain relatively constant with the exception that it will become more defined within the various pools along the Illinois River.

Photograph 3-2. Backwater Conversion to Mudflat During Low Water Conditions

i. Backwaters. In the without-project future, it is expected that there would continue to be further loss of both surface area and volume of backwaters and continued low aquatic habitat quality. This will further limit off-channel habitat for fish and other aquatic species. The following tables look at the potential loss of acreage based on various loss assumptions. The consensus of a number of scientists working for the State of Illinois was that due to the increasingly shallow condition of existing areas, even more rapid losses are expected in the future. This resulted in the estimation of a 1 percent loss rate per year as the most likely future condition. If this rate were to continue throughout the 50-year project life, the acreage of backwaters would drop to just 32,605 acres, or a 40 percent loss.

Table 3-18 shows the anticipated future backwater acreages assuming the 1 percent rate of loss and others.

Table 3-18. Estimated Future Without Surface Acres of Backwaters in 2054 at Low Water Conditions Assuming Various Annual Loss Rates of 1989 Area

		Future Without Estimated 2054 Acres			
Pool	**1989 Surface Acres**	**0.50% loss/yr**	**1% loss/yr**	**1.50% loss/yr**	**2% loss/yr**
Peoria Pool	30,325	23,602	18,347	14,243	11,043
La Grange Pool	18,537	14,428	11,215	8,707	6,751
Alton Pool	5,030	3,915	3,043	2,363	1,832
Total Lower 3 Pools	**53,892**	**41,945**	**32,605**	**25,313**	**19,626**

The physical quality of backwaters was also assessed as part of the evaluation process. The assessment was based on an evaluation of the physical parameters, topographic diversity, etc. and did not make assumptions regarding recolonization by aquatic plants, which is dependent on other systemic improvements. Despite continued sedimentation, the increasingly shallow areas are not expected to be able to establish marsh vegetation due to current levels of water level fluctuations, unconsolidated substrates, and turbidity. It was the consensus of an interagency panel that the existing backwaters, which average roughly 500 surface acres and in many cases a depth of less than 1 foot, have a very low level of quality during summer low water and overwintering periods (tables 3-19a and 3-19b). On a scale of 0 to 1, an interagency group rated existing backwaters as having an overall habitat value of 0.1 considering value to all species. This relatively low habitat value was estimated to decrease slightly over time to an estimated value of 0.07 in 50 years. Future habitat value was estimated assuming a 1.0% annual loss in habitat quality for years 1 through 25, and a 0.5% years 26 through 50.

ii. Side Channels and Islands. Some side channel areas are experiencing sedimentation and are anticipated to be lost in the future (approximately 17 percent in the Alton and Peoria Pools and greater in La Grange Pool). Another widespread threat to the side channels is their loss due to erosion of the protective islands photograph 3-3). Based on data collected as part of this study, it is anticipated that without any action some continued loss of side channel length will occur at the rate of approximately 0.25 percent per year if it follows trends from 1903 to the present. This would result in a loss of approximately 6.5 additional miles of side channel habitats if no action were taken (table 3-19).

In the future without, it is anticipated that the quality of side channel areas will continue to remain at relatively low levels. In many areas, there will continue to be further losses of depth diversity due to sedimentation and a lack of adequate structure (woody debris, rock, etc.).

d. Desired Future Conditions. The desired future conditions or objectives resulted from a series of interagency meetings aimed at identifying the restoration needs of the system. The restoration needs were determined largely by looking at the likely future without-project conditions and assessing needs to restore aquatic habitats for fish spawning, nursery, and overwintering habitats.

Photograph 3-3. Erosion of Upstream End of Illinois River Island

Table 3-19. Estimated Future Without Miles of Side Channels in 2054 Given an Approximate Annual Loss Rate of 0.25% Loss/Year

Name	**Current Miles**	**Estimated Miles in 2054**
Dresden	1.9	1.7
Marseilles	4.7	4.1
Starved Rock	4.95	4.4
Peoria	7.6	6.7
La Grange	17.7	15.6
Alton	17.15	15.1
Total	**54**	**47.6**

The backwater restoration objective of restoring 19,000 acres had previously been identified in the Habitat Needs Assessment. An interagency team assessing the restoration needs of the entire Upper Mississippi River System, including the Illinois River, conducted the assessment and set the restoration target. Resource managers further identified a general target of depths for backwater restoration by recommending the following distributions of depths: 5% >9 feet; 10% 6 to 9 feet; 25% 3 to 6 feet; and 60% < 3 feet. Since virtually all areas are currently less than 3 feet, restoration of the 19,000 acres could be focused on restoring the relative depth diversity associated with the other three depth categories.

One of the major concerns on the river system is the potential loss of connected off-channel areas. The desired future includes the restoration and maintenance of side channel habitats and the maintenance of all existing connections between backwaters and the main channel (connections at the 50 percent exceedance flow duration).

Backwater restoration success is also related to the quality of sediments. Options should be explored to compact sediments or remove unconsolidated material to improve substrate conditions for aquatic plants, fish, and wildlife. Due the potential for substantial amounts of dredging, additional beneficial uses of sediment should be investigated.

2. Formulation of Alternative Plans

a. Approach/Assumptions. The formulation of alternative plans involves identifying measures and creating alternative plans by using combinations of measures. A range of alternative plans was developed to look at potential ways to reach the desired future conditions identified in the study process. The approach for backwaters included the use of an expert panel to incorporate an assessment of area (including predicted loss rates) and quality into the assessment of various options. The assessment of side channels and island protection focused more directly on various levels of effort associated with previously identified cost-effective approaches to restoration. The formulation of measures and alternatives for the restoration of backwaters and side channels was aided considerably by the fact that a number of projects were previously evaluated and constructed in the Midwest.

b. Criteria and Constraints. The following criteria and constraints were developed for consideration in future issues associated with implementation. The following criteria should be refined and utilized during the implementation process to best identify locations for restoration:

- Proximity to other high quality areas.
- Geographic spacing to maximize benefits to river system should be approximately every 5-10 miles to support fish populations.
- Site selection and design should consider sustainability and anticipated sedimentation rates for particular backwaters and effects of direct tributaries.
- Availability of placement areas near site (land based, island creation, shipments).
- Maintain desirable water quality (DO, turbidity, temperature, ammonia).
- Design projects for habitat diversity (including a range of depths, structure, and plant and animal communities).

The following constraints, which could limit restoration success, were identified:

- Continued excessive sediment delivery and sedimentation.
- Cost limitations of Federal and State partners.
- Corps traditional approach to projects with one time construction and then sponsor O&M. Adaptive management/continuing construction may be needed to make restoration viable.
- Resuspension of sediments by wind, wave action, and rough fish.
- Time – need action soon or additional areas may transition from aquatic to terrestrial.
- Placement locations for material removed.
- A final legal determination has not been made as to the ownership of submerged lands in the Illinois River Basin.
- Potential for areas to contain contaminated sediments.
- Project life.
- Placement in floodplain cannot affect flood heights.
- Habitat values may continue to be limited by other factors (e.g., potential for continued limitations in aquatic plant due to effects of water level fluctuations and turbidity).

c. Measures. The first step in the formulation process was to identify the range of measures to be investigated. Measures were separately identified for backwaters and side channels and are presented in this section. A key consideration in the selection of measures was sustainability. Due to the nature of the system, no backwater dredging will be fully sustainable, instead the intent is to restore habitats in ways that maximize sustainability. Although the descriptions of measures below are relatively generic given the system aspects of the study, the specifics of measures used in implementation will be based on lessons learned from previous projects, analysis using models, and monitoring and adaptive management. These types of information will be used to maximize the sustainability and cost effectiveness of the projects.

Examples of sustainable design considerations include:

- locating dredge cuts away from sediment sources (i.e. tributaries) and secondary channels;
- reducing the sediment load to the dredge cuts by reducing the inflow of sediment-laden water;
- altering local hydrodynamic conditions so that sediment is transported through and out of dredge cuts (addition of rock or timber structures, etc.);
- constructing islands to reduce sediment resuspension due to wind-driven wave action;
- establishing a reoccurring dredging cycle for implementation as a way to address ongoing sedimentation and maintain areas with firm substrates, and
- arranging features to slow conversions of habitat types (i.e. increased depth closer to bank to slow conversion to terrestrial habitats and plant colonization moving in from edges).

i. Backwaters

Sediment Removal (Dredging). The study team looked at various scales of potential restoration for particular backwaters. Based on desires for increased depths, the restoration levels were based on varying percentages of dredging. For restored backwaters, a general target identified by resource managers to provide more optimal habitat for a wide range of species would be to have the following distributions of depths: 5% >9 feet; 10% 6 to 9 feet; 25% 3 to 6 feet; and 60% < 3 feet. For formulation purposes, an average size of 500 acres was assumed per backwater (calculated based on acreage and number of backwaters), but the information is applicable to all sizes based on a percentage basis. The approximate costs are based on a 500-acre backwater lake.

- **Level 1 -** Dredge 2 percent - Maintain connection to main stem and create deep entrance channels estimated cost $910,000
- **Level 2 -** Dredge 10 percent - Configuration approximating ¼ targets established in objectives estimated cost $4.9 million
- **Level 3 -** Dredge 20 percent - Configuration approximating ½ targets established in objectives estimated cost $9.6 million
- **Level 4 -** Dredge 40 percent - Configurations following general target established in objectives estimated cost $19.6 million
- **Level 5 -** Dredge 60 percent - Configuration exceeding targets established in objectives estimated cost $29.5 million

Sediment Placement. Various placement options follow. However, due to the system scale of the analysis, specific differences were not calculated. It is further assumed that the actual placement option chosen will vary based on site-specific conditions related to placement opportunities and costs. Cost estimates for placement are included with the dredging costs shown above, for placement options near the dredging, additional costs would be incurred for placement options more removed from the dredging area.

- on existing islands (increase elevations in selected areas to increase vegetation diversity and potential for mast trees)
- creation of new islands (create habitat and potentially reduce sediment resuspension from wind and waves)
- on adjacent agricultural lands
- beneficial reuse on brownfields, former mined lands, stockpile, gravel pits, etc.

Technologies

- hydraulic, mechanical, and high solids dredging
- dewater backwater areas and use conventional equipment
- reconnect currently isolated backwater areas that have adequate depth

Construction Approach

- traditional staging (one backwater at a time)
- multiple backwaters at one time
- continuous construction (ongoing construction/O&M to address sedimentation)

ii. Side Channels and Islands

Protect Islands. Based on the analysis of Alton Pool that highlighted the loss of island/side channel length, some measures were proposed that would protect the upstream ends and banks of existing islands to maintain and possibly restore some of their historic length. Rock off-bank revetments are more costly, as shown by the cost data for an average 2,100 foot section (protecting 20 percent of the perimeter of a typical 1 mile long island). However, they create unique habitat conditions between the revetment and island. Habitat benefits would be used to evaluate their cost versus benefit relative to the other measures.

- Rock Off-bank revetments – cost estimate $2 million per island.
- Rock Bank protection – cost estimate $745,000 per island
- Timber Off- bank revetments **–** cost estimate $675,000 per island

Another innovative technique that will be considered as part of future critical restoration projects is *seed islands.* Seed islands are started by placing stones in such a way that the natural sedimentation processes create an island in the desired location downstream of the stones. This technique has been used successfully by the Corps on the Upper Mississippi River and could serve as a method to reestablish islands. Depending on the size of the desired islands the cost would be similar to Rock Off-bank revetments or bank protection.

Create Varying Depths/Maintain Scour. Other options to restore some of the historic depth diversity; to help maintain deep holes and areas for fish; and increase the sustainability of side channels following potential dredging activities included the following types of wood and rock structures that could be placed in side channel areas. Assumes the need for 7 structures per average side channel (approximately 1 mile long). Estimated cost is $127,000 for structures in one side channel.

- Stub dikes/wing dams
- Log piles
- Pile dikes
- Notching existing closing structures

Dredge. In side channel areas that are experiencing sedimentation, typically only a portion is most heavily affected by sediment. It is estimated that in many cased, dredging would only be required for approximately 1/3 of the side channel length to restore historic flow and off-channel aquatic conditions. The estimated cost assuming the dredging of a 1/3 mile, 6 foot deep, 50 foot wide channel was $265,000 per side channel.

d. Alternatives. The following section reviews and discusses the various alternatives developed for the backwater and side channel alternatives.

i. Backwaters. Two interagency assessment meetings were held on May 22 and June 10, 2003, to study backwaters and side channels in detail. The study team looked at various levels of potential restoration for particular backwaters. The levels were based on varying percentages of dredging. For formulation purposes, an average size of 500 acres was assumed per backwater, but the information is applicable to all sizes based on a percentage basis.

Two areas of primary concern in evaluating the levels were assumptions regarding changes in quantity (acreage) and quality (index values). The following tables relate the assumptions developed regarding changes in quantity and quality assuming a one-time construction sequence. Ongoing construction or active operation and management activities would allow the project to remain at levels similar to year 0 throughout the project life.

Losses in the surface acreage of backwaters were anticipated to be 1 percent loss per year. This was based on observations of the historic loss of backwater volume and area. Level 1, dredging of 2 percent (10 acres of a 500-acre backwater), was assumed to make no measurable change in the rate of loss. The other more extensive levels of dredging 10 to 60 percent of lake area, would have a progressively greater effect on reducing the rate of loss assuming proper configuration. Table 3-20 shows the loss rates assumed to be associated with the proposed restoration levels.

Table 3-20. Assumptions on Backwater Acreage Loss Over Time

	Backwater Areas			
Proposed Level	**Year 0**	**Year 25**	**Year 50**	**Assumptions**
Without-Project	500	389	303	1.00%/year loss
Level 1	500	389	303	1.00%/year loss
Level 2	500	414	343	0.75%/year loss
Level 3	500	441	389	0.50%/year loss
Level 4	500	455	414	0.38%/year loss
Level 5	500	470	441	0.25%/year loss

Note: Example is for a 500-acre backwater

Assessments of quality were made using a physical quality index (PQI). Index values range from 0 to 1, with 0 representing no valuable habitat and 1 optimal habitat. This approach is similar to the U.S. Fish and Wildlife Habitat Evaluation Procedure (HEP) developed to estimate the quality of habitat areas. The index values used for the study were determined by expert opinion of resource managers and scientists with experience in fisheries, waterfowl, wildlife, wetlands ecology, hydrology and sedimentation for the without-project and all levels 1-5 for year 0 (immediately following construction).

A simplified approach to estimate quality was used based directly on the proposed physical footprint. It was agreed that the physical quality index would only assess the physical configuration of the backwaters in terms of configurations of habitat (depth and diversity) to maximize value and use by a broad range of plant, fish, and wildlife species. This assessment is a simplification, since actual quality depends on numerous factors: temperature, dissolved oxygen (DO), plant communities, etc.. However, this approach is appropriate, since the dominate process affecting backwaters along the Illinois River is sedimentation. In many cases, the other factors will benefit directly from dredging and show similar trends. For example, as larger areas are restored with greater depths more desirable temperatures are anticipated. In other cases the quality can be affected at similar costs for various alternatives, such as introducing some flow to increase DO, etc.

The optimal level of restoration, a value of 1, was assigned to level 4 in year 0. This represents the target established to maximize backwater habitat benefits by providing the following distributions of depths: 5% >9 feet; 10% 6 to 9 feet; 25% 3 to 6 feet; and 60% < 3 feet. Since in most of the cases all of the backwater areas are less than 3 feet deep, actual restoration activities would only need to address the 40 percent targeted for deeper depths. For example, taking a 500-acre backwater, work under level 4 (dredging 40 percent or 200 acres) would result in dredging approximately 25 acres >9 feet, 50 acres 6 to 9 feet; 125 acres 3 to 6 feet; and the 300 acres already less than 3 feet would be minimally affected. It should be noted that while level 5 exceeds the target and as such had a lower PQI in year 0, it actually improves over time as sedimentation brings it closer to the desired configuration. The PQI for all subsequent years was calculated based on assumed changes in quality over time (table 3-21shows year 25 and 50 values). It was felt that for all levels the rate of loss would be highest in the years immediately following construction due to initial sedimentation. This matches observed changes in completed dredging projects where the sedimentation rates were greatest in the years immediately following construction. Ongoing dredging through operation and maintenance could be utilized to eliminate or reduce loss in quality over time.

Table 3-21. Assessment of Physical Quality and Changes Over Time

	Physical Quality				Loss Rate/Yr	
Quality	**Year 0**	**Year 25**	**Year 50**	**Loss Assumption**	**Years 1 - 25**	**Years 25 - 50**
Without-Project	0.1	0.08	0.07	Slow reduction	1.00%	0.5%
Level 1	0.11	0.08	0.07	Slow reduction	1.25%	0.5%
Level 2	0.3	0.18	0.14	Higher rate	2.0%	1.0%
Level 3	0.5	0.30	0.23	Higher rate	2.0%	1.0%
Level 4	1.00	0.60	0.47	Higher rate	2.0%	1.0%
Level 5	0.8	0.76	0.59	Higher rate	2.0%	1.0%

Assume sedimentation rates of 2 in/year in first 25 years, approximately 50 inches.
Assume sedimentation rates of 1 in/year in years 25-50, approximately 25 inches.
Level 5 - 11.5 years to get to 1.00, then decreases at rate of others.

Regarding the physical quality index, the study team was not able to identify a system threshold in terms of total acreage needs based on limited data and system understanding. As a result, the full benefits associated with the restoration of each backwater were applied to varying numbers of backwaters on the system without decreasing benefits, fixed at a maximum of 60 backwaters previously identified by resource managers.

Table 3-22 summarizes the alternatives developed for the backwater analysis. The table relates the number of backwaters to be restored in each level category and summarizes the total acreage to be dredged. For example, Alternative 2A is composed of dredging 60 backwaters to level 1 (2 percent) for a total dredging acreage of 600 acres. This level would involve only limited dredging (averaging 10 acres per backwater) in a large number of areas as a way to maintain the low water connections with the main stem and wide distribution of minimal areas for overwintering. Alternative 3B is composed of combinations of four levels for a total dredged area of 1,150 acres:

10 - Level 1
5 - Level 2
2 - Level 3
3 - Level 4

The number of backwaters included in the alternatives were formulated in consideration of a past restoration analysis that identified roughly 60 backwaters in need of restoration.

The maximum number of backwaters to address was set at 60 with some alternatives addressing less. The analysis also considered the resulting spacing and the desire for high quality backwater areas every 5 to10 miles. The total number of backwaters included in each of the alternatives 2A to 2H is shown in table 3-22.

Table 3-22. Backwater Alternatives – Number of Backwaters by Level and Total Acres Dredged

	Number of Backwaters by Category						
Alternative	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Total Number**	**Total**
2A	60	0	0	0	0	60	600
2B	10	5	2	3	0	20	1,150
2C	5	5	5	5	0	20	1,800
2D	10	10	10	10	0	40	3,600
2E	10	20	10	20	0	60	6,100
2F	10	10	0	40	0	60	8,600
2G	0	0	0	60	0	60	12,000
2H	0	0	0	0	60	60	18,000

The costs for the various alternatives are shown in table 3-23. No costs were included for operation and maintenance because approximately 2 feet of overdredging was included and as a result anticipated sedimentation rates will not require additional dredging within the project horizon.

An analysis was made utilizing the estimates of quality and acreage loss over time (table 3-24). For the analysis, it was assumed that implementation of the alterative would take 50 years. As a result, 2 percent of the total restoration was implemented in any given year. The results of this analysis show that for all alternatives, year 0 or the current condition is the existing approximately 55,000 acres and a relatively low quality of 5,500 units (55,000 acres times the quality index value of 0.1). In the without-project condition, acreage is anticipated to be lost at a rate of 1 percent, resulting in 33,275 acres remaining in year 50. The total quality would also be reduced to 2,329 units (33,275 acres multiplied by the reduced quality index value of 0.07). The various alternatives show different reductions in the rate of conversion of backwaters and in many cases dramatic increases in quality based on the number and amount of restoration projects associated with the alternative plan.

For example, the backwater quality units are estimated to be approximately 10 times greater for Alternatives 2G and 2H in year 50, approximately 19,000 – 23,000, versus a value of closer to 2,300 for the without-project.

The values calculated for Alternatives 2A to 2H reflect a gradual 2 percent annual rate of construction of the total restoration proposed. For example, the analysis of Alternative 3G assumed restoration of 12,000 acres over 50 years, 600 acres per year. As the various acreage was restored a higher value of 1.0 was assigned to the restored backwater complexes following construction. The backwater acreage and index value were then lowered following the anticipated loss rates identified by the expert panel.

Table 3-23. Cost of Backwater Restoration Alternatives

Alternative	First Cost Construction 35% Contingency	Planning, Engineering, And Design 30%	Supervision and Administration 9%	Real Estate [1]	Total First Cost
2A	$36,603,000	$10,981,000	$3,294,000	$3,655,000	$54,533,000
2B	$75,173,000	$22,552,000	$6,766,000	$6,988,000	$111,478,000
2C	$117,833,000	$35,350,000	$10,605,000	$10,946,000	$174,734,000
2D	$235,666,000	$70,700,000	$21,210,000	$21,892,000	$349,469,000
2E	$400,823,000	$120,247,000	$36,074,000	$37,053,000	$594,196,000
2F	$567,067,000	$170,120,000	$51,036,000	$52,165,000	$840,389,000
2G	$791,621,000	$237,486,000	$71,246,000	$72,791,000	$1,173,145,000
2H	$1,194,296,000	$358,289,000	$107,487,000	$108,927,000	$1,768,999,000

[1] Real Estate costs do not include acquisition or appraisal costs.

Table 3-24. Summary of Acreage and Physical Quality by Alternative

	Year 0		Year 25		Year 50	
Alternative	Area (ac)	Total Quality	Area (ac)	Total Quality	Area (ac)	Total Quality
2-0	55,000	5,500	42,780	3,422	33,275	2,329
2A	55,000	5,500	42,780	3,622	33,275	2,682
2B	55,000	5,500	42,890	4,315	33,673	3,736
2C	55,000	5,500	42,964	4,874	33,942	4,618
2D	55,000	5,500	43,148	6,326	34,609	6,907
2E	55,000	5,500	43,383	8,432	35,458	10,231
2F	55,000	5,500	43,521	10,766	35,976	14,011
2G	55,000	5,500	43,793	13,831	36,978	18,926
2H	55,000	5,500	44,008	15,237	37,810	22,642

The benefits of the various alternatives were further evaluated by looking at the incremental improvements over the without-project condition and the associated costs, summarized in table 3-25. This analysis revealed that considerable total acreage would be preserved by many of the alternatives ranging from 398 acres with Alternative 2B (33,673 acres in year 50 versus 33, 275 acres in year 50 without the project) to 4,534 with Alternative 2H. This is associated with the fact that restoration activities will slow conversion of many areas to terrestrial habitats. More dramatic than the preservation of backwater acreage is the estimated increase in average annual quality of the remaining acreage. This is generally related to the fact that due to dredging activities remaining acreages will have greater depth and more habitat value and function. The figures in table 3-25 show the average annual amounts, which are the average values over the entire 50-year period of analysis.

Table 3-25. Summary of Incremental Acreage and Physical Quality Changes, Average Annual Total Quality, and Costs by Alternative

	Benefits			Costs ($1,000)	
Alternative	**Area, Year 50 (ac)**	**Total Quality, Year 50**	**Average Annual Total Quality**	**Cost Implementation**	**Cost per Average Annual Quality Unit**
2-0				-	
2A	0	353	185.1	$ 54,500	$294
2B	398	1,407	840.7	$111,500	$133
2C	667	2,289	1,370.2	$174,700	$128
2D	1,333	4,578	2,740.4	$349,500	$128
2E	2,183	7,902	4,730.2	$594,200	$126
2F	2,701	11,681	6,955.6	$840,400	$121
2G	3,702	16,596	9,869.8	$1,173,100	$119
2H	4,534	20,313	11,331.3	$1,769,000	$156

As the analysis shows, the most cost-effective alternative in terms of average annual total quality was 2G. This plan was composed of 60 backwaters restored to the level 4 effort. Based on the assumptions above, a large number of alternatives were run. In general, levels 2 (10 percent), 3 (20 percent), and 4 (40 percent) are relatively equally cost effective. Levels 1 (2 percent) and 5 (60 percent) were less effective. Level 1 did not provide a large enough area of effect to significantly improve the backwater as a whole. Also, based on the small area and proximity to the channel, it would experience relatively rapid loss of much of its depth. Level 5 provided deep-water areas in excess of the optimal targets. This, in essence, represents significant over dredging. While it does provide for higher quality in future years than the other levels, it was not as cost effective.

Traditional cost effectiveness and incremental cost analysis was also preformed on the alternative utilizing Institute of Water Resources (IWR) – Plan software. As figures 3-11 and 3-12 indicate, all plans were cost effective, but cost effectiveness increased and was greatest for plans 2G to 2H Cost effectiveness means that for a given level of benefit, no other plan costs less, and no other plan yields more output for less money. Only alternatives 2G and 2H were identified as best buy plans, which provide the greatest increase in output for the least increase in cost, and received further analysis using incremental analysis.

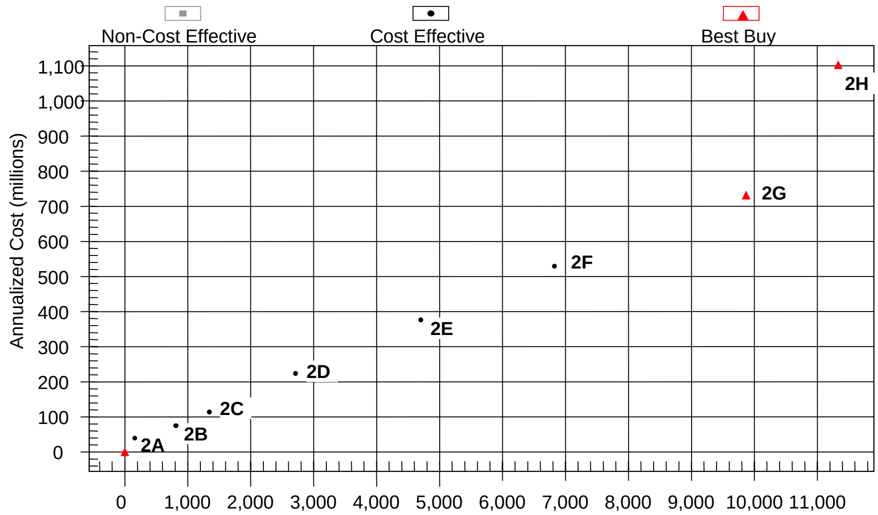


Figure 3-11. Cost Effectiveness of Backwater Restoration Alternative Plans

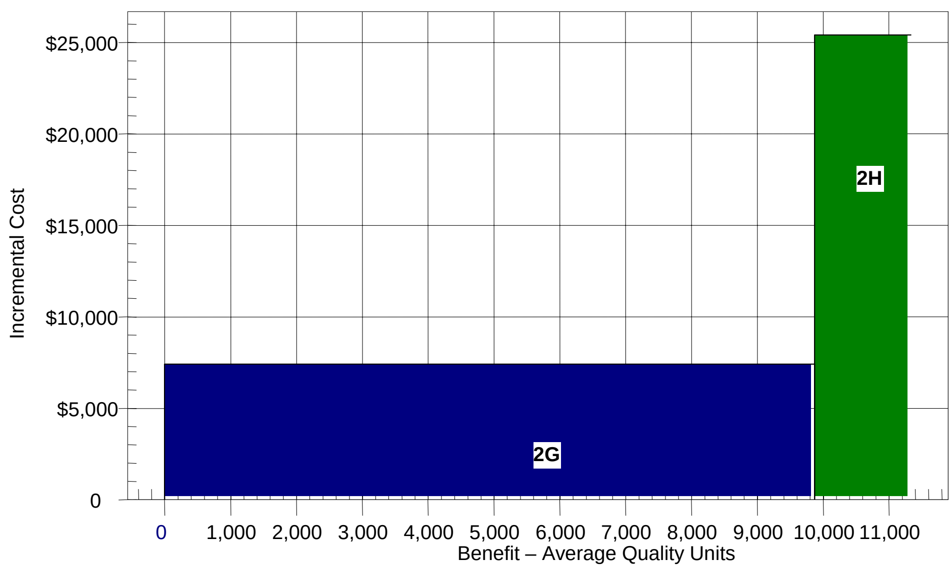


Figure 3-12. Incremental Analysis of Best Buy Plans (Acres of Benefit)

In addition to the analysis of total quality, further analysis was completed to better define the direct and indirect benefit areas. It is widely recognized that the benefits of restoring deep water habitat extend well past the actual dredging footprint. Research has shown benefits to surrounding backwater areas as well as up to a five mile reach of the main stem (Iowa DNR 2000 and Iowa DNR 2003). This is based the travel area of various fish species, which utilized backwaters for spawning, nursery, and overwintering habitat. The areas estimated below are the total indirect benefit area. In these areas the habitat suitability would be improved to varying degrees as a result of the restoration projects. For this analysis the maximum benefit area of an average backwater restoration project was limited to the entire 500 acre backwater, plus up to a five mile reach of the main stem or approximately 515 acres of main stem area (based on an average width of 850 feet). As a result an optimal backwater restoration project could have an indirect benefit area of up to 1,015 acres. The amount of this benefit area associated with each alternative was calculated by multiplying the number of backwaters being worked on, times the percent of the average annual total quality attained by the alternative, times the potential backwater and main stem area. The total backwater and main stem areas where then added together to provide the total indirect benefit area (table 3-26).

ii. Side Channel and Islands Alternative

The study team looked at various scales of potential restoration for side channels and islands. The scales were based on varying amounts of restoration features. For conceptual discussions, a typical 1-mile-long side channel and island was used, but the information is applicable to all sizes based on a percentage basis. Side channel and island widths vary considerably, but average roughly 100 feet.

Island Protection. Island erosion is a natural process that characterizes dynamic rivers; however, it is a problem when it damages important habitats (forested islands and side channels) or archeological resources or under conditions where it occurs at an unsustainable rate (additional natural island creation activity is not keeping pace). Along the Illinois River, island erosion is exacerbated by commercial and recreational boats and by wind-generated waves and in many areas islands are being lost and not replaced by natural processes.

The primary source of information for the analysis was the detailed evaluation of the side channels and islands in Alton Pool, the 80-mile reach upstream of the mouth, conducted by Mike Cochran, Illinois DNR (retired), and T. Miller, U.S. Army Corps of Engineers - St. Louis District. This information was then extrapolated to the rest of the system with the assistance of Rock Island District channel maintenance staff.

Based information from the analysis, restoration measures were proposed for protection of approximately 20 percent of the island perimeter of actively eroding islands to reduce erosion, maintaining island and side channel length. Protection of 20 percent would result in protection of approximately 2,100 feet per average island. Options included constructing these structures from rock as off-bank revetments or bank protection or as timber piles revetments, or a combination of both. For cost purposes, an average of all three costs was utilized. Habitat analysis and adaptive management will be used as part of the site evaluations to determine which of the three methods is preferred.

The protection of existing islands was identified as a relatively low-cost method to maintain existing habitats and avoid future losses of both island and side channel habitats. Island protection projects using off-bank revetments could also provide unique aquatic habitats between the revetments and islands. An additional benefit to the system would be reduced sediment delivery to the river from the island erosion. While island protection would help to reduce sediment delivery to the system, islands are not considered a major source of sediment to the system. As a result of the relative low cost and benefits, just two levels were formulated that would restore a significant portion of the sites identified as degrading/needing protection. Table 3-27 summarizes information on the number of islands protected and the costs involved.

Table 3-26. Summary of Total Benefit Area of Backwater Restoration Projects

Alternative	Number of Backwaters	AA Total Quality	% Quality	Benefit Area Backwaters	Benefit Area Main stem	Total Benefit Area	Cost $1000s	Cost Per Acre
3A	60	185	0.02	90	505	995	$54,500	$54, 800
3B	20	841	0.07	742	764	1,506	$111,500	$74,000
3C	20	1,370	0.12	1,209	1,246	2,455	$174,700	$71,200
3D	40	2,740	0.24	4,837	4,983	9,820	$349,500	$35,600
3E	60	4,730	0.42	12,523	12,903	25,426	$594,200	$23,400
3F	60	6,956	0.61	18,415	18,973	37,388	$840,400	$22,500
3G	60	9,870	0.87	26,130	26,922	53,053	$1,173,100	$ 22,100
3H	60	11,331	1.00	30,000	30,909	60,909	$1,769,000	$29,000

Table 3-27. Potential Island Protection Alternatives

Alternative	Number of Islands Protected	Construction	Real Estate [1]	Total First Cost	Annual O&M
2M	10	$11,449,000	$128,000	$11,577,000	$12,000
2N	15	$17,174,000	$192,000	$17,366,000	$18,800

[1]Real Estate costs do not include acquisition or appraisal costs

The actual direct and indirect benefit area was also calculated to provide an estimate of the area of island and side channel restored by the project. Three separate types of areas would benefit from island protection: reduced loss of island habitat, reduced loss of side channel (which would be lost if the island was eliminated), and reduced loss of habitat value of main channel and main channel border habitats that benefit from proximity to side channels.

The acreage benefits were estimated for a generic island project. However, a detail analysis of the specific individual projects will be undertaken as each site is investigated. The average Illinois River island is approximately 12.1 acres (1 mile long by 100 feet wide) as are the side channels. Based on loss rates over the past 100 years, islands are eroding at a rate of approximately .25 percent per year system-wide. For this analysis it was assumed that since a number of islands are stable, and projects would focused on the most actively eroding, a 1 percent loss rate per year was used. The following table summarizes the benefit areas including the area of island and side channel that would be lost. Based on the 1 percent loss rate approximately 7.7 acres of island and 7.7 acres of side channel would be lost at each proposed site if no action were taken. This would also result in a proportional loss of associated main channel benefits. Other study efforts in the Midwest have estimated the main stem benefit area of a side channel at approximately 100 acres of surrounding main channel and main channel boarder habitats. Based on a loss of 7.7 acres of a 12.1 acre side channel (63.4 percent loss) the loss of surrounding main stem habitat would be 63.4 acres. In total, an island restoration project would benefit approximately 788 acres. Table 3-28 summarizes the total benefit areas for the two alternatives as well as the average annual cost per acre restored.

Side Channel Restoration. In terms of improving the habitat diversity and maintaining depths in side channels, various options to add structure to side channel areas were evaluated. Based on conversations with St. Louis District staff, it was estimated that approximately 7 stub dike structures, each about 25 feet long, would be adequate per mile of side channel. These structures would create aquatic structure and localized areas of increased flow velocity, scour, and eddies, thereby providing a wide range of habitats. Costs were calculated assuming using rock to construct the structures, but timber piles or a combination of both could be used.

In addition to increased structure and diversity, a number of side channels are being affected by sedimentation. Based on available system information, it was assumed that roughly one-third of the side channel area would need some dredging to increase and maintain depths. The stub dike structures would be added following dredging (if needed) to increase sustainability and maintain depths. Hydraulic modeling will occur as part of a site specific project to maximize sustainability and habitat values of features. Table 3-29 summarizes information on the number of side channels restored and the costs involved.

The actual direct and indirect benefit area was also calculated to provide an estimate of the area of side channel and associated main stem habitat restored by the proposed projects. The acreage benefits were estimated for a generic side channel restoration project. However, a detail habitat benefit analysis will be undertaken as any individual projects move forward. The average Illinois River side channel is approximately 12.1 acres (1 mile long by 100 feet wide). Other study efforts in the Midwest have estimated the main stem benefit area of a side channel at approximately 100 acres of surrounding main channel and main channel boarder habitats, due to the beneficial effects of side channels as refuge, nursery, overwintering, and feeding areas. As a result the total benefit area of a side channel project was estimated at 112.1 acres. Table 3-30 summarizes the total benefit areas for the two alternatives as well as the average annual cost per acre restored.

Table 3-28. Summary of Total Benefit Area of Island Protection Projects

Alternative	Number of Islands Protected	Island Acres Protected	Side Channel Acres Protected	Benefit Acres Main stem	Total Benefit Area (Acres)	Total First Cost	Cost Per Acre
2M	10	77	77	634	788	$11,544,000	$14,700
2N	15	115	115	951	1,182	$17,316,000	$14,700

Table 3-29. Potential Side Channel Restoration Alternatives

Alternative	Number of Side Channels Restored	Construction	Real Estate [1]	Total First Cost	Annual O&M
2T	10	$ 3,527,591	$ 450,368	$3,977,959	$1,640
2U	20	$ 7,055,182	$ 900,737	$7,955,919	$3,280
2V	30	$10,582,773	$1,351,105	$11,933,878	$4,920
2W	35	$12,346,569	$1,576,289	$13,922,858	$5,740
2X	40	$14,110,364	$1,801,473	$15,911,838	$6,560

[1] Real Estate costs do not include acquisition or appraisal costs.

Table 3-30. Summary of Total Benefit Area of Side Channel Restoration Projects

Alternative	Number of Side Channels Restored	Acres Dredged	Side Channel Acres	Benefit Acres Main Stem	Total Benefit Acres	Total First Cost	Cost Per Acre
2T	10	30	121	1,000	1,121	$ 3,861,000	$3,400
2U	20	60	242	2,000	2,242	$ 7,722,000	$3,400
2V	30	90	364	3,000	3,364	$ 11,584,000	$3,400
2W	35	105	424	3,500	3,924	$ 13,514,000	$3,400
2X	40	120	485	4,000	4,485	$ 15,445,000	$3,400

3. Evaluation and Comparison of Plans

a. Backwaters. As discussed under the alternatives section, various levels of restoration were assessed on a per-backwater basis. The analysis framework was developed to account for acreage and quality associated with the various alternatives. The analysis revealed that Alternative 2G and 2H were best buy plans. Alternative 2G, the restoration of 60 backwaters to level 5 (40 percent dredging), was the most cost effective on a per unit basis. However, the entire range was cost effective, but the more cost effective plans were 2D to 2H. Only the most effective plans were carried forward for further system evaluation.

b. Side Channels and Islands. The various side channel and island protection options simply represented varying scales of the same cost-effective measures. As a result, all alternatives were carried forward for further system analysis.

4. Plans Recommended for System Analysis

a. Restoration Alternatives. While varying somewhat in cost effectiveness, all of the alternative plans developed are recommended for consideration at the system level, except for backwater restoration Alternative 2A to 2C.

b. Risk and Uncertainty. While a number of backwater restoration projects have been implemented in the Midwest providing valuable information on the performance of various measures and demonstrating significant ecological benefits, restoration of backwater and side channel habitats involves some risk and uncertainty due to a number of factors. Particular areas of risk and uncertainty include determining the scale of projects necessary to achieve optimal benefits, estimating future sedimentation rates to accurately capture costs and estimate sustainability, and assessing ecological responses.

The study team directly addressed various scales of backwater restoration in order to determine the optimal level of restoration activities. Due to uncertainties, future restoration projects should be pursued under an adaptive management framework where various scales of backwater dredging are undertaken and monitored in the initial years of the program to further optimize the amount of dredging and configuration of dredging that produces the greatest ecological responses and sustainability of project features. This framework would also be applied to optimize side channel and island stabilization features.

Sediment delivery from tributaries is being addressed under Goal 1. However, how those reductions in delivery translate to reduced sedimentation rates in the backwaters and side channels will affect the cost of maintaining the habitats.

A final item of uncertainty is the ecological response from the proposed level of backwater, side channel, and island protection projects. The team is confident that the proposed objectives will provide significant and measurable benefits and that the physical changes will have significant ecological benefits. However, some desired biological responses, including increases in aquatic plant and macroinvertebrate communities, depend on improving not only depth diversity and structure, but also the combined effects of more natural water levels and reduced turbidity. In addition, there is the potential for currently unknown limiting factors to reduce the effectiveness of restoration projects.

c. Information and Further Study Needs. The following information and further study needs have been identified.

- Conduct pool plans addressing backwater and side channel needs/priority/etc. throughout the basin.
- Analysis of historic and existing conditions - collecting and using bathymetry data to better assess conditions and sedimentation rates.
- Better characterization of sediments (physical and chemical).
- Better characterization of nitrogen and phosphorus loading.
- Further detailed assessment of the extent to which backwaters represent a limiting factor for fish and other aquatic species.
- Assessment of the effectiveness and sustainability of various backwater restoration configurations
- Hydraulic information along main stem channels and backwater – discharge and velocity data.

H. GOAL 3: FLOODPLAIN, RIPARIAN, AND AQUATIC. Improve floodplain, riparian , and aquatic habitats and functions

Problem. Land-use and hydrologic changes have reduced the quantity, quality, and functions of aquatic, floodplain, and riparian habitats. Flood storage, flood conveyance, habitat availability, and nutrient exchange are some of the critical aspects of the floodplain environment that have been adversely impacted.

Objectives

Illinois River Main Stem. The system objective for the Illinois main stem floodplain and riparian areas is the restoration of approximately 30 percent of the cover types lost since settlement. This amounts to 150,000 acres of isolated and connected floodplain areas.

Illinois River Basin Tributaries. The system objective for the Illinois River Basin Tributary floodplain and riparian areas is the restoration of approximately 18 percent of the habitat areas of the Illinois River tributaries lost since settlement. This amounts to 150,000 acres of isolated and connected floodplain and riparian areas.

Aquatic Habitat. The system objective for the tributary streams of the Illinois River Basin is to restore approximately 33 percent of the streams impaired by channelization in the Illinois River Basin. This amounts to 1,000 miles of aquatic habitat within the tributary streams of the basin.

Anticipated Outputs. A healthy functioning floodplain, riparian and aquatic systems in the Illinois River Basin will result in ecological benefits due to connectivity of the river and floodplain habitats critical to the life stages of numerous native species. In addition, restored riparian and floodplain corridors provide one of the best opportunities for landscape scale restoration and connectivity of remaining resource rich areas in the highly modified Midwestern landscape, improving the viability of sensitive populations and species. In addition to benefiting hundreds of thousands of waterfowl which use the Illinois River as part of the Mississippi River Flyway, numerous other bird species would benefit from the restored floodplain and riparian habitat. These species include the Federally listed bald eagle and Illinois state listed species such as the northern harrier, sandhill crane, yellow-headed blackbird, forester's tern, black tern, and least bittern. Numerous fish species would benefit from restored floodplain, riparian, and aquatic systems including the paddlefish, and State listed darter, redhorse, and minnow species. Other species anticipated to benefit from the projects include river otter, bobcat, the Federally listed Indiana bat and decurrent false aster, and the State listed Blanding's turtle and Illinois chorus frog.

1. Inventory Resource Conditions

a. Historic Conditions. The streams, floodplains, and riparian areas of the Illinois River Basin were once a rich mosaic of habitats that were represented by a variety of aquatic and terrestrial cover types, including prairies, wetlands, and forests. Important factors contributing to this diversity and function were predictable annual hydrologic cycles, including annual high water and dependable summer low flows, wetlands, and prairies that buffered flood flows and slowly released the runoff; fire disturbance that maintained diverse plant communities; and limited human demands. The healthy functioning floodplain system once found in the Illinois River Basin resulted from an un-fractured landscape that integrated the ecological outputs of the hydrologic cycle (rainfall, droughts, and floods) through the complex structure of prairies, wetlands, and forests to produce an abundance of aquatic, insect, wildlife, and plant species. Historic land cover was evaluated to characterize pre-disturbance conditions in the basin.

Prior to settlement, the vegetation found on the floodplains of the major tributaries of the Illinois River Basin was similar to that along the Illinois River main stem, with the notable difference of a higher occurrence of prairies (between 10 and 20 percent) along the tributaries than along the main stem. This difference might be explained by the use of fire within the basin by indigenous peoples; the main stem floodplain served as a larger firebreak than the tributaries and therefore more forest-based cover was able to emerge in the main stem floodplain. For the purposes of this analysis, the land cover distributions along the tributaries were differentiated from those along the main stem.

Before 1900, the floodplain and riparian areas remained connected to the rivers and streams. Following diversion of Lake Michigan water into the Illinois, numerous levee and drainage districts were created. The alternations necessary for agriculture resulted in nearly 50 percent of the main stem floodplain being isolated or disconnected from the river. Levee and drainage projects can be found in all of the major basins, especially the Mackinaw, Spoon, and Sangamon, but none of a scale comparable to the Illinois River main stem.

ii. Illinois River Basin Tributaries. GLO records were analyzed to establish historical cover types within the floodplain for the 19 major sub-basins of the Illinois River Basin (Figure 3-13). They are the Chicago, Des Plaines, Spoon, Upper Sangamon, South Fork Sangamon, Lower Sangamon, Salt Creek, LaMoine, Lower Illinois, Lower Illinois - Lake Chautauqua, Lower Illinois - Lake Senachwine, Macoupin, Upper Fox, Lower Fox, Upper Illinois, Kankakee, Iroquois, Vermilion, and Mackinaw watersheds. While the Illinois River floodplain was dominated by forests, the tributary floodplains had a much more even distribution of cover types. Forest, prairie, and wetland cover types each covered roughly a third of the total acreage.

Figure 3-13. Illinois River Basin Sub-basins

i. Illinois River Main Stem. Forest, prairie (grassland), and wetlands, were the dominant cover types in the historical floodplain. The Illinois River floodplain, within the area of analysis, consists of approximately 500,000 acres. Historically, forests accounted for nearly two-thirds of the Illinois River floodplain (340,000 acres). Wet, mesic, and upland prairies accounted for the balance (160,000 acres) of the floodplain. Wetlands, both forested and non-forested, accounted for perhaps a third (194,000 acres) of the forest and prairie communities found in the floodplain.

Government Land Office (GLO) records from 1804-1859 were analyzed using Geographic Information Systems (GIS) software to establish historical cover types within the floodplain. Separate analyses were conducted for the Marseilles, Starved Rock, Peoria, La Grange, and Alton navigation pools. Navigation pools upstream of Marseilles were not evaluated because of intense urbanization and other limiting factors, but this should not exclude them from consideration for restoration implementation as appropriate opportunities become available.

Prairie stream headwaters are not typically forested, are surface water fed, have warmer water, and have a high level of in-stream primary production because of the lack of shading. Invertebrate grazers are the dominant primary consumer (photosynthesis) and fishes are more characteristic of warm water communities. Prairie streams typically become more forested downstream as flows become more reliable because of increasing groundwater influence and contributing surface area. Riparian corridors develop and the production base shifts from an in-stream basis to one that is nourished by nutrients from upstream and from litter falling from the riparian corridor.

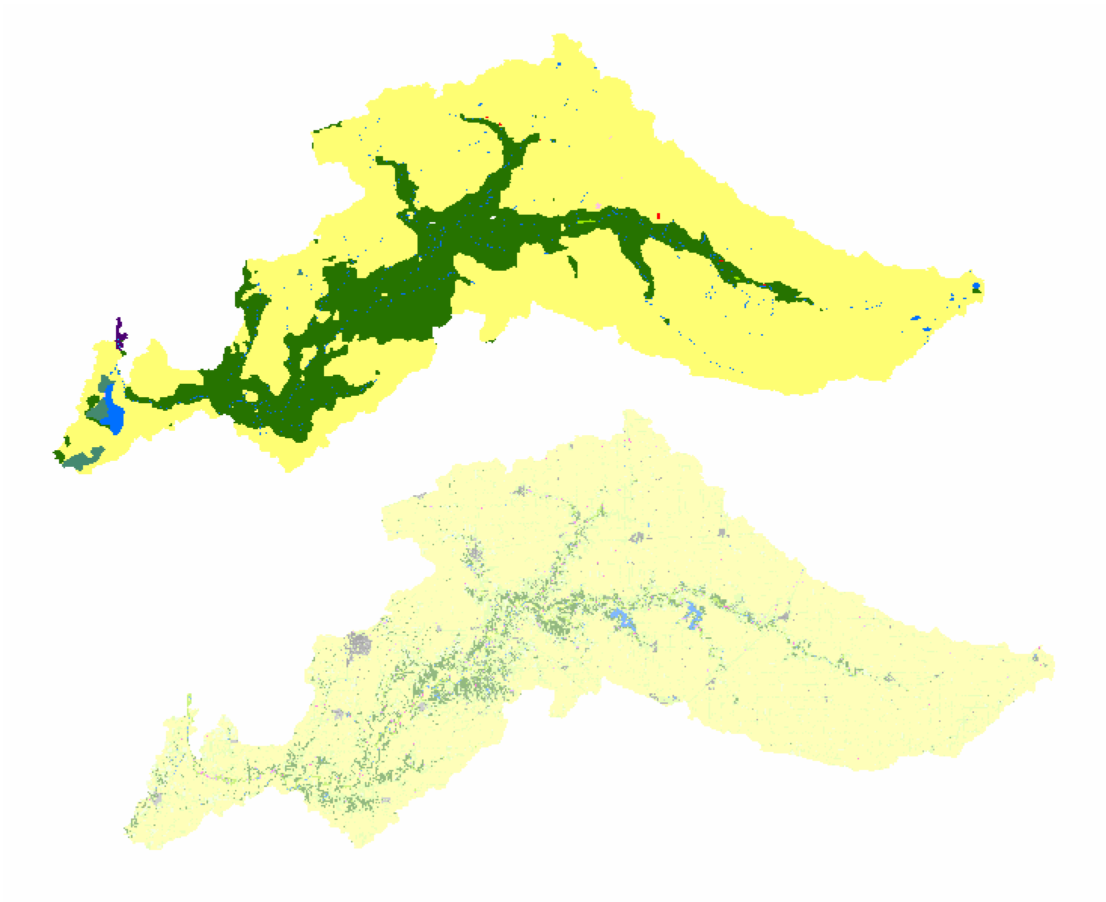


Figure 3-14. Presettlement and Contemporary Land Cover in the Mackinaw River Watershed

b. Existing Conditions. Land-use and hydrologic changes have reduced the quantity, quality, and functions of aquatic, floodplain, and riparian habitats. Flood storage, flood conveyance, habitat availability, and nutrient exchange are some of the critical aspects of the floodplain environment that have been adversely impacted because the Illinois River, and some of its major tributaries have been isolated from the floodplain through levee construction.

i. Illinois River Main Stem. Losses of the major cover types, as illustrated in table 3-31 and Figure 3-15, range from 70 to 80 percent; most dramatic has been the nearly complete elimination of prairie from the floodplain. The nature of the remaining vegetation is different from historic communities. Modern-day grasslands are limited to pasture, levees, and roadside patches with very little species diversity. Remaining bottomland forest species do not provide the ecosystem support functions of the mast-producing tree species of the historic floodplain. Finally, wetlands of all types have been severely impacted by diversion, dam construction to support navigation, and conversion to agriculture due to drainage. Nearly 50 percent of the floodplain has been isolated from the river. Wetlands were not particularly well mapped in the GLO surveys because their methods were coarse and many wetlands were small, isolated units that might have been too small to be captured at this mapping resolution. Therefore, the data in the table should be considered an underestimate. In comparison, hydric soils analyses indicate that throughout the basin about 90 percent of the wetlands have been lost due to conversion or drainage.

Table 3-31. Illinois River Main Stem Floodplain Historic and Existing Land Cover

Illinois River Main Stem Floodplain Land Cover	Forest	Grassland	Forested and Non-Forested Wetlands [1]	Total
Historic	338,680	120,620	42,473	501,773
Existing	85,530	23,245	12,775	121,550
Loss	253,150	97,375	29,698	380,223
Loss %	74.7%	80.7%	69.9%	75.8%
% of Historic Landscape	67.5%	24.0%	8.5%	

[1] This cover type includes three types of wetlands. It combines an equivalent Forest and Prairie cover type value with values indicated in the GLO data. This results from the assumption that approximately 25% of the historical forest and prairie cover type could be characterized as wetlands.

ii. Illinois River Basin Tributaries. Area l coverage of the major habitat types in tributary floodplains has been reduced by 15 to 70 percent from 1804 to 1995 (table 3-32). Tributary floodplains have been less severely impacted by agricultural conversion than the Illinois River main stem. However, the same problems exist of fragmentation and low diversity of habitat types. To counteract the underreporting of wetlands in the GLO records, interagency coordination with experts in the field estimated that approximately 25 percent of the forest and prairie acreage mapped in the GLO dataset was of wetland type. Forested cover types are relatively intact in terms of area, but habitat quality is severely degraded. Grasslands appear to have only lost one-third of their historic areas, but again quality is severely degraded. Wetlands have probably been the most impacted by conversion to other land uses.

Table 3-32. Illinois River Basin Tributary Floodplain Historic and Existing Land Cover

Illinois River Basin Tributary Floodplain Land Cover	Total Acres	Forest	Grassland	Forested and Non-Forested Wetlands [1]
Historic	851,946	422,140	409,957	19,849
Modified Historic Assumption		316,605	307,468	227,873
% of Historic Landscape		37.1	36.1	26.7
Existing	532,122	267,571	196,233	68,318
Loss	319,824	49,034	111,235	159,555
Loss %		-15.5	-36.2	-70.1

[1] This cover type includes three types of wetlands. It combines an equivalent Forest and Prairie cover type value with values indicated in the GLO data. This results from the assumption that approximately 25% of the historical forest and prairie cover type could be characterized as wetlands.

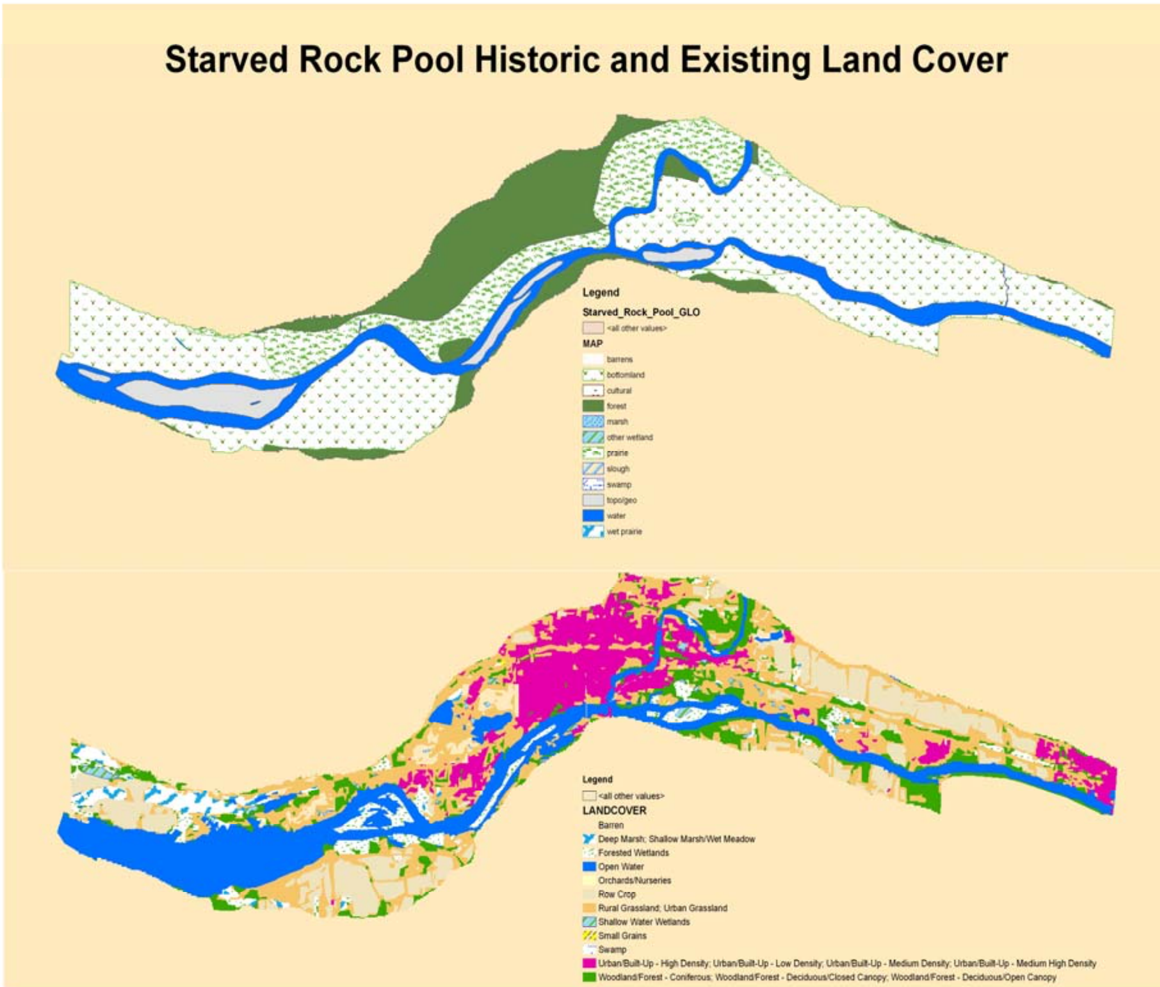


Figure 3-15. Comparison of Historic and Existing Cover Types in the Starved Rock Pool

iii. Aquatic Habitats. Alterations within the watershed have also had a pervasive negative effect on basin stream systems. The IEPA 305(b) report (2002), identified nearly 11,000 miles of perennial streams in the Illinois River Basin with an estimated 20,000 to 25,000 additional miles of ephemeral streams.

Based on the frequency observed in the IEPA analysis, channelization potentially impairs approximately 1,400 of perennial stream miles within the Illinois River Basin. However, unassessed streams tend to be smaller, and CTAP (1994) identified that the smaller streams tend to be channelized to a disproportionately high extent. Lopinot (1972) estimated that 27 percent of streams in the state were channelized at the time of publication; this would correspond to nearly 3,000 stream miles in the Illinois River Basin. To reach this level, approximately 50 percent of the unassessed streams would have to be channelized, a rate that is consistent with the observations in the CTAP report (1994).

Therefore, it is estimated that at least 3,000 miles of perennial stream habitat, mostly in small streams, is presently degraded by channelization in the Illinois River Basin.

Channelization of streams shortens overall stream lengths and results in increased velocities, bed and bank erosion, and sedimentation. Modified stream channels often have little habitat structure and variability (life requisites) necessary for diverse and abundant aquatic species. Channelization also disconnects streams from floodplain and riparian areas that are often developed into agricultural or built environments.

Illinois DNR and Illinois EPA managers developed the Biological Stream Characterization Index (BSC) to rank stream quality uniformly across the state. The BSC is a mix of quantitative variables including the Index of Biotic Integrity for fish (Karr et al. 1986), the Macroinvertebrate Biotic Index (Hilsenhoff, 1988), habitat analyses, and qualitative judgments of DNR biologists. Illinois DNR scientists completed a statewide coverage and documented the condition of 6,430 stream miles. Table 3-33 displays the results for the assessed streams in the Illinois River Basin. The Mackinaw watershed had the most unique and highly rated stream miles. Highly valued and moderate stream reaches were the most common, and they were widely distributed throughout the Illinois River Basin. Streams in the urban watersheds of the Des Plaines, Fox, and Chicago Rivers, the agricultural watersheds of the Sangamon River, and the Spoon River watershed were generally of limited quality. Restricted stream reaches largely occur in the Chicago region and were only a small fraction of the total streams assessed. Protection of remaining high-quality areas was identified under the overarching system goal as a prioritization criteria for future restoration.

Table 3-33. Illinois River Sub-Basin Stream Miles Ranked Using the Illinois Department of Natural Resources Biological Stream Characterization (Bertrand et al. 1996, ISIS 1999)

Watershed	Unique	High	Moderate	Limited	Restricted
Des Plaines	11.3	68.8	189.2	260.0	19.5
Upper Fox	0.0	94.6	99.0	46.1	0.0
Chicago	0.0	0.0	64.9	156.7	24.1
Lower Fox	16.5	164.1	310.8	9.4	0.0
Lower Illinois-Senachwine Lake	8.8	124.2	113.4	0.0	0.0
Upper Illinois	45.0	163.4	28.9	0.0	0.0
Kankakee	0.0	228.8	92.6	0.1	0.0
Spoon	0.0	159.2	487.9	130.4	0.0
Vermilion	55.9	223.8	122.0	0.0	0.0
Iroquois	0.0	167.6	33.1	0.0	0.0
Lower Illinois-Lake Chautauqua	0.0	50.1	60.5	0.0	0.0
Mackinaw	156.1	211.5	65.4	1.2	0.0
LaMoine	19.6	176.3	231.9	0.6	0.0
Upper Sangamon	46.2	117.5	250.5	34.1	0.0
Salt	18.7	184.2	234.4	53.6	0.0
Lower Sangamon	0.0	12.8	193.9	36.1	0.0
Lower Illinois	0.0	219.7	33.9	0.0	0.0
South Fork Sangamon	0.0	0.6	116.1	81.8	0.0
Macoupin	0.0	101.2	0.5	0.5	0.0
Total Stream Miles	**378.1**	**2,468.4**	**2,728.9**	**810.6**	**43.6**
Percent of Sampled	**5.9%**	**38.4%**	**42.4%**	**12.6%**	**0.7%**

Channelization, wetland drainage, and snagging were extremely common throughout the Illinois River Basin for the purposes of draining water from croplands and for flood control. The adverse effects of such activities are extensive, ranging from the direct destruction of stream habitat, to the reduction of structure and microhabitat for fishes, aquatic invertebrates, freshwater mussels, and aquatic plants, to the alteration of water conveyance, which increases erosion and sedimentation. The negative effects of channelization and drainage may persist for very long periods and adversely affect habitat many miles away.

c. Future Without-Project Conditions

i. Illinois River Main Stem. The main stem Illinois River study area will likely remain relatively unchanged in terms of land use over the 50-year period of analysis. Some areas of various cover types will be converted to urban uses. However, this is likely to be a small amount due to the high regulatory cost of new development within the main stem floodplain. Habitat quality and ecological functions will likely remain at current degraded levels. Habitat fragmentation and unstable hydrologic regimes will continue to degrade the remaining habitat areas.

The Nature Conservancy and The Wetlands Initiative have made major investments by purchasing levee and drainage districts for the purpose of restoration. In total, they have acquired more than 11,000 acres of Illinois River floodplain and adjacent habitats at Spunky Bottoms, Emiquon, and Hennepin. Some restoration efforts have begun, such as shutting off drainage pumps and planting native species.

The USFWS currently manages four refuges along the Illinois River, totaling approximately 12,000 acres. The recently completed *Illinois River National Wildlife and Fish Refuges Complex Draft Comprehensive Conservation Plan and Environmental Assessment* recommends protection management on an additional 380 acres of native grassland; 200 acres of savanna; 1,300 acres of native forest; and 4,000 acres of wetlands within the focus areas through voluntary partnerships.

Finally, the UMRS-IWW System Navigation Feasibility Study has selected a recommended plan that calls for the restoration of approximately 20,000 acres of Illinois River floodplain. The restoration measures identified under the Navigation Study are consistent with those of this study, and would be considered overlapping if implemented under either study.

ii. Illinois River Basin Tributaries. Overall, the tributary floodplains are also likely to remain in a degraded condition. Urban development is perhaps more likely than on the main stem, particularly near the larger urban areas of Chicago, Bloomington-Normal, Decatur, Peoria, and Springfield. One bright spot is the continued success of the CREP program in Illinois. While focused on sediment, the acreages that have been enrolled and are currently being enrolled are in the floodplain and riparian areas of Illinois River Basin streams. This provides opportunities for increased connectivity of various riparian habitats. However, these benefits may be offset by the continued degradation of aquatic stream and riparian habitats resulting from bed and bank erosion.

iii. Aquatic Habitats. In-stream habitats throughout the basin are likely to degrade over the 50-year period of analysis. Stressors on the stream network include:

(1) direct modification of stream channels for urban and rural development;
(2) increased impervious land surfaces resulting in increased runoff and higher flow;
(3) increased tile-drained agricultural areas;
(4) introduction of point and non-point source pollutants into the system; and
(5) introduction of invasive and exotic species.

While numerous programs are in place to address these various stressors, they do not take a systemic approach to restoration and are unable to keep pace with the rate of landscape change occurring in the basin.

d. Desired Future Conditions

i. Illinois River Main Stem. The desired future condition of the Illinois River main stem floodplain is a reversal of historic loss of habitat and floodplain functions and increase in habitat area and quality. This would be accomplished by restoring 150,000 acres of isolated and connected floodplain areas, representing approximately 30 percent of the Illinois River Valley. This level of restoration would provide the necessary building blocks for a sustainable floodplain ecosystem in conjunction with other restoration efforts undertaken as part of this effort, particularly water level, backwaters, and side channels.

ii. Illinois River Tributaries. The desired future condition for the Illinois River Basin tributaries is the restoration of a sustainable level of floodplain and aquatic habitat functions. A portion of this would be accomplished by restoring 150,000 acres of isolated and connected floodplain areas. This represents approximately 18 percent of the Illinois River Basin tributary floodplain and riparian habitat areas. This level of restoration would provide the necessary building blocks for a sustainable floodplain ecosystem within the tributaries in conjunction with other restoration efforts undertaken as part of this effort, particularly sediment delivery.

General conditions for floodplains and riparian areas include terrestrial patch size desires (amount shown or greater). Bottomland hardwood forest would range from 500 to 1,000 acres in size with 3,000 acres needed for some interior avian species. Grasslands would range from 100 to 500 acres in size. Nonforested wetlands require a minimum of 100 acres, spaced 30 to 40 miles apart, and riparian zones for streams require a minimum of 100 feet on each side.

iii. Aquatic Habitats. Approximately 1,000 miles of impaired streams would be restored. This represents approximately one-third of the streams impaired by channelization within the Illinois River Basin. This level of restoration would provide the necessary building blocks for sustainable aquatic environments in the perennial and intermittent streams of the Illinois River Basin.

2. Formulation of Alternative Plans

a. Approach to Formulation and Assumptions. Alternative plan formulation for restoration of aquatic, floodplain, and riparian habitats and functions within the Illinois River Basin was conducted over a period of 6 months in 2003. Monthly meetings of technical and scientific professionals from the U.S. Army Corps of Engineers, the Illinois DNR, and other interested parties led to the development of the criteria, constraints, measures, and alternatives detailed below. Alternative plans were developed for the Illinois River main stem floodplain and the major tributary floodplains separately. This was appropriate due to the differences inherent in large floodplain rivers such as the Illinois and its tributaries. Further, many of the physical characteristics and assumptions developed for the formulation of the Illinois main stem do not apply to tributaries.

b. Criteria and Constraints

- **Flood Protection Policies.** No increase in flood elevations as required by Illinois law – Illinois state law specifies that any action in the floodplain that increases flood heights is not allowable or must be accompanied by mitigation of adverse effects. Due to the potential high cost associated with these actions, efforts will be made to avoid this threshold.

- **Landowner Interests.** Opportunities to implement restoration projects on private lands may be limited. Real estate acquisition is the sponsor's responsibility, but several strategies can be employed to increase landowner interest. Approaches to address this constraint are high levels of stakeholder involvement in project development, education regarding the benefits of restoration projects, and sponsor acquisition of voluntary easements and/or fee title to property as opportunities present themselves. No Federal site investigations (such as surveys or geotech investigations) will be conducted without contacting property owners and obtaining permission to access potential project areas.

- **Existing Altered River Hydrology and Water Quality.** Unnatural water level fluctuations throughout the system make it difficult to restore habitats. Efforts undertaken under system Goal 5 will improve conditions for floodplain habitats, and restoration of large areas of floodplain habitats, in particular wetlands, will help improve hydrologic conditions throughout the system. Design of specific project features can be done so that the unnatural effects of water level fluctuations are minimized and the sustainability of the feature is maximized.

- **Impacts on Local Tax Base.** Implementation of large-scale restoration in the Illinois River Basin floodplain, either through acquisition of land or easements, could have an impact upon local taxing authorities if future owners pay less taxes or none at all. Most of the floodplain is rural in nature and in some cases is a significant portion of a county's tax base. Negative impacts to that tax base would potentially generate public opposition to restoration. However, tax base decline could be offset by revenue generated through consumptive and non-consumptive wildlife uses.

c. Measures. Potential measures for implementation cover a wide range of practices designed to improve aquatic, floodplain, and riparian habitats. The following list shows the potential restoration measures that could be implemented under this program, with those in bold being evaluated for direct restoration benefits and costs. Site-specific investigations will be critical for optimization of project measures to be used. These measures correspond with those found in Section 4.

Aquatic, Floodplain, and Riparian Restoration Measures

- **Riffle Structures**
- **Channelization Remeander**
- In-Stream Structures (rock piles, lunkers, etc.)
- Moist Soil Units

- **Gated Levee**
- **Wetland Restoration**
- Lateral Wetlands
- Levee Setback
- Filter Strips/Contour Buffer Strips
- Riparian Forest Buffer
- **Wetland Plantings**
- **Mast Tree Planting**
- **Prairie Planting**
- Timber Stand Improvement
- Invasive Species Management

d. Alternative Plans. Alternative plans for the Illinois River floodplain and riparian areas are shown in tables 3-34 and 3-35. These plans represent incremental restoration efforts. The assumed distribution of major habitat types is based on the historic land cover distribution. This distribution serves more as a general guide than an absolute definition of what is to be restored; factors influencing the actual distribution of cover types will include availability of restorable land, limiting factors within the navigation pools, site-specific conditions, and cost. Further, suggested restoration levels for each cover type are based on the rate of loss from historical percentages. Due to the varied survey methods employed during the early 1800s, wetlands are significantly underrepresented in the historic data. Therefore, a panel of interagency floodplain experts was tasked with developing a weighting factor that more accurately reflected wetlands on the historical landscape in the main stem and tributary floodplains. As noted in the Forested and Non-Forested Wetlands category in tables 3-34 and 3-35, a percentage of historic forest and grassland was assumed to be wetlands and accounted for here. Finally, it is assumed that, due to the current degraded condition of the ecosystem and the floodplain and riparian components, that any restoration of forested, grassland, and wetlands will provide benefits to the system. Site-specific assessments will have to be conducted in order to optimize benefits vs costs.

Table 3-34. Illinois River Main Stem Floodplain and Riparian Alternatives

Illinois River Main Stem Floodplain Alternatives	Acres Restored	Forest	Grassland	Forested and Non-Forested Wetlands [1]	Total
3MA	0	0	0	0	0
3MB	5,000	1,700	1,200	2,100	5,000
3MC	10,000	3,400	2,400	4,200	10,000
3MD	20,000	6,800	4,800	8,400	15,000
3ME	40,000	13,600	9,600	16,800	40,000
3MF	75,000	25,300	18,000	31,700	75,000
3MG	150,000	50,700	36,000	63,300	150,000

[1] This cover type includes two types of wetlands. It combines an equivalent Forest cover type value with values indicated in the GLO data. This results from the assumption that approximately half of the historical forests cover type could be characterized as wetlands.

Table 3-35. Illinois River Basin Tributary Floodplain and Riparian Alternatives

Illinois River Basin Tributary Floodplain Alternatives	Acres Restored	Forest	Grassland	Forested and Non-Forested Wetlands [1]	Total
3TA	0	0	0	0	0
3TB	5,000	900	900	3,200	5,000
3TC	10,000	1,900	1,800	6,300	10,000
3TD	15,000	2,900	2,700	9,400	15,000
3TE	20,000	3,800	3,600	12,600	20,000
3TF	40,000	7,600	7,200	25,200	40,000
3TG	75,000	13,900	13,500	47,600	75,000
3TH	150,000	27,800	27,000	95,200	150,000

[1] This cover type includes two categories of wetlands. It combines an equivalent Forest and Prairie cover type value with values indicated in the GLO data. This results from the assumption that approximately 25% of the historical forest and prairie cover type could be characterized as wetlands.

Alternative plans for in-stream aquatic habitat restoration were developed on roughly equal intervals of restoration. At this scale and with the level of information available, it is impossible to state with any degree of certainty the specific quantities and types of restoration practices to be implemented. Restoration alternatives were chosen for evaluation based on the desired future condition of 1,000 miles of restored streams. Intervals of miles restored are 25, 50, 100, 250, 500, and 1,000 miles.

3. Evaluation and Comparison of Plans

The plan components developed for the main stem, tributaries, and streams in the basin are listed in table 3-36 with corresponding costs. It is assumed that that benefits can be compared on a per-acre and stream-mile basis; further site-specific analysis will be necessary to optimize project characteristics.

Detailed cost estimates can be found in Appendix E. Further, the Programmatic and Real Estate Cost Estimates for measures used in generating programmatic costs can be found Appendix F. A number of assumptions have gone into the cost estimates found in tables 3-36 through 3-38. For main stem restoration alternatives, costs were generated using the average costs of measures relevant to the major cover type. These costs were $3,900 per acre for forest restoration, $2,000 per acre for grassland, and $8,650 per acre for wetland restoration. Further, it was assumed that while ecosystem improvements would occur on the entire acreage of an alternative, only half of the acreage would be subject to construction activities and associated costs. For example, berm construction and plantings in a portion of the site could benefit the entire site by impacting the hydrology and providing a seed source. The remaining acres would see ecological benefits accrue through natural succession and or restored hydrology. These per-acre costs were multiplied by half of the acreage distributions found in table 3-34. Additionally, its was assumed that at each level of restoration an incremental number of gated levees and rehabilitation of environmental levees would occur. These features range from one set in Alternative 3MB to 16 in Alternative 3MG. The addition of the four measures resulted in a first cost for construction to which a 35 percent contingency was added. Engineering and Design (E&D) during construction was estimated to be 30 percent of adjusted first cost of construction. Supervision and Administration (S&A) for construction contracts was estimated to be 9 percent of first cost for construction. Real Estate estimates assumed fee title acquisition costs of $3,000 per acre. This per acres cost was applied to all of the acres for each restoration alternative. The restoration cost for each alternative is the combination of the first cost of construction, E&D, S&A, and Real Estate costs.

For in-stream aquatic restoration alternatives, costs were generated using the average per-mile costs of riffles and channel remeandering. It was assumed that approximately 75 percent of aquatic restoration would involve riffles while the remaining 25 percent would be dedicated to channel remeander. Estimated costs per mile for riffles are $792,000. Approximately 16.5 percent will be of the larger tributary type shown in the programmatic cost sheet, with the remaining 83.5 percent being of the type constructed on minor tributaries. Depending on the size of the stream, the number of structures required ranges from four per mile for large tributaries to 22 for minor tributaries. Stream remeandering costs are estimated at $2,347,000 per mile. Costs for Real Estate were estimated at $93,200 per mile for riffles and $728,700 per mile for remeandering. Contingency, E&D, S&A and Real Estate contingencies were the same as above. The restoration cost for each alternative is the combination of the first cost of construction, E&D, S&A, and Real Estate costs.

A similar methodology was applied for the estimation of tributary restoration costs shown in table 3-37. Tributary alternative costs are based on average costs per practice distributed according to the acres suggested in table 3-35. No environmental levees or gates are included in this estimate.

Table 3-36. Main Stem Floodplain and Riparian Alternatives Cost Estimate

Illinois River Main Stem Floodplain Alternatives	Acres Restored	First Cost of Construction 35% Contingency	Planning, Engineering and Design 30%	Supervision and Administration 9%	Real Estate Including Contingency [1]	Total First Cost
3MA	0				$0	$0
3MB	5,000	$21,574,000	$6,472,000	$1,942,000	$15,093,000	$45,080,000
3MC	10,000	$43,147,000	$12,944,000	$3,883,000	$30,186,000	$90,161,000
3MD	20,000	$86,295,000	$25,888,000	$7,767,000	$60,372,000	$180,322,000
3ME	40,000	$166,155,000	$49,847,000	$14,954,000	$120,744,000	$351,700,000
3MF	75,000	$301,727,000	$90,518,000	$27,155,000	$226,398,000	$645,799,000
3MG	150,000	$603,133,000	$180,940,000	$54,282,000	$452,797,000	$1,291,152,00

Table 3-37. Tributary Floodplain and Riparian Alternatives Cost Estimate

Illinois River Basin Tributary Floodplain Alternatives	Acres Restored	First Cost of Construction 35% Contingency	Planning, Engineering and Design 30%	Supervision and Administration 9%	Real Estate Including Contingency [1]	Total First Cost
3TA	0	$0	$0	$0	$0	$0
3TB	5,000	$22,268,000	$6,680,000	$2,004,000	$21,910,000	$52,863,000
3TC	10,000	$44,216,000	$13,265,000	$3,979,000	$43,820,000	$105,280,000
3TD	15,000	$66,164,000	$19,849,000	$5,955,000	$65,730,000	$157,697,000
3TE	20,000	$88,432,000	$26,530,000	$7,959,000	$87,640,000	$210,560,000
3TF	40,000	$176,864,000	$53,059,000	$15,918,000	$175,280,000	$421,120,000
3TG	75,000	$332,741,000	$99,822,000	$29,947,000	$328,650,000	$791,160,000
3TH	150,000	$665,483,000	$199,645,000	$59,893,000	$657,300,000	$1,582,321,000

Table 3-38. Aquatic Habitat Restoration Alternatives Cost Estimate

Aquatic Habitat Restoration Alternatives	Stream Miles	First Cost of Construction 35% Contingency	Planning, Engineering and Design 30%	Supervision and Administration 9%	Real Estate Including Contingency [1]	Total First Cost
3SA	0	$0	$0	$0	$0	$0
3SB	25	$40,044,000	$12,013,000	$3,604,000	$6,302,000	$61,964,000
3SC	50	$80,089,000	$24,027,000	$7,208,000	$12,604,000	$123,927,000
3SD	100	$160,178,000	$48,053,000	$14,416,000	$25,207,000	$247,854,000
3SE	250	$400,444,000	$120,133,000	$36,040,000	$63,018,000	$619,635,000
3SF	500	$800,888,000	$240,266,000	$72,080,000	$126,037,000	$1,239,271,000
3SG	1000	$1,601,775,000	$477,495,000	$143,249,000	$252,074,000	$2,478,541,000

[1] Real Estate costs do not include acquisition or appraisal costs.

Annual O&M costs for the alternative plans were estimated and are summarized in table 3-39.

Table 3-39. Annual Operation and Maintenance Costs for Alternative Plans

Illinois River Main Stem Floodplain Alternatives	Acres Restored	Annual O&M
4A	0	
4B	5,000	$162,000
4C	10,000	$324,000
4D	20,000	$648,000
4E	40,000	$1,295,000
4F	75,000	$2,419,000
4G	150,000	$4,843,000

Illinois River Basin Tributary Floodplain Alternatives	Acres Restored	Annual O&M
4A	0	0
4B	5,000	$129,000
4C	10,000	$262,000
4D	15,000	$396,000
4E	20,000	$525,000
4F	40,000	$1,049,000
4G	75,000	$1,951,000
4H	150,000	$3,902,000

Aquatic Habitat Restoration Alternatives	Stream Miles	Annual O&M
4SA	0	
4SB	25	$79,000
4SC	50	$157,000
4SD	100	$314,000
4SE	250	$786,000
4SF	500	$1,572,000
4SG	1000	$3,143,000

4. Plans Recommended for System Evaluation. The alternative plans developed are all recommended for consideration at the system level.

a. Risk and Uncertainties. Reestablishment of large areas of habitat within the floodplains and aquatic systems of the basin will produce significant ecosystem benefit. However, continued water level fluctuations, excessive erosion, and sedimentation will degrade current and future aquatic, floodplain and riparian areas.

Another general consideration for the future is a landscape free of introduced species that can change the look and makeup of an entire system, thereby changing species composition, decreasing rare species, and even changing or degrading the normal functioning of the system. Once the invasive species have been controlled or eliminated and restoration is initiated, ecosystems may see lost components or functions restored.

b. Information and Further Study Needs. At this time, no further investigations other than those identified in the monitoring plan are envisioned.