I. GOAL 4: AQUATIC CONNECTIVITY (FISH PASSAGE). Restore aquatic connectivity on the Illinois River and its tributaries, where appropriate, to restore healthy populations of native species

Problem. There is diminished aquatic connectivity (upstream/downstream) on the Illinois River and its tributaries. Aquatic organisms do not have sufficient access to diverse habitat such as backwater and tributary habitats 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.

Anticipated Outputs

The dams found throughout the Illinois River Basin block fish movement, but most dams are partially passable under some conditions. For native fish species, fish passage must be available during the appropriate times of the year or life stages, which is often not the case. Expected outputs would include improved fish access to spawning, nursery, and overwintering areas at appropriate times. Connectivity also allows for recolonization and improved genetic diversity of populations of native fish and mussels. While virtually all fish species would benefit, species of particular interest including the State listed river redhorse, greater redhorse, Iowa darter, and numerous shiner species. Freshwater mussels would also benefit, due to the life cycle requirements of utilizing fish species as host to colonize and re-colonize areas. The end result would be greater numbers, health, and species diversity for native fish and mussel populations.

1. Inventory Resource Conditions

a. Historic Conditions. Dam construction is a common disturbance in streams nationwide. Throughout the Illinois River Basin, hundreds of dams, ranging in size from very small weirs to large dams, have been constructed since the early 1800s. During the early development period in the 1800's, dams were constructed to power mills and factories located adjacent to streams. On large rivers such as the Illinois, dams were constructed to aid navigation during the 1840s to 1860s and rebuilt by state and the U.S. Army Corps of Engineers for the current 9-foot navigation channel in the 1930s. Later, dams were constructed along major tributaries for water supply, flood control, and recreation. All along, farmers were building ponds to water livestock and raise fish for food, and other landowners were pooling small streams with weirs for aesthetics. Most recently, ponds, dry dams, and water and sediment control basins (WASCOBS) are being constructed through U.S. Department of Agriculture programs to help reduce water and sediment transport to streams. The U.S. Geological Survey has records of about 140 large dams in the Illinois River Basin. There are hundreds more small dams documented by other agencies and many more that are undocumented. Seven dams on the Illinois Waterway and approximately 467 dams within the basin are considered in this report for fish passage.

b. Existing Conditions. There are numerous dams throughout the Illinois River Basin. The navigation dams on the main stem Illinois River/Illinois Waterway are located at La Grange, Peoria, Starved Rock, Marseilles, Dresden, Brandon Road, and Lockport. Table 3-40 and figure 3-16 identify the locations of the main stem dams. The lower two dams at La Grange and Peoria are wicket dams and allow open river conditions 48 percent and 42 percent of the time, respectively. The remaining dams hinder fish movement, although there is some incidental fish passage through the lock chambers at all the dams. Table 3-40 shows the opportunity for fish passage based on the percent of time the dam gates are out of the water and free passage conditions exist. In addition to dams, in 2001, a temporary electrical barrier was installed at Illinois RM 296.3 in the Lockport Pool to discourage movement of non-indigenous species between Lake Michigan and the Upper Mississippi River System. A permanent electrical barrier is currently under construction immediately downstream.

Table 3-40. Illinois River Main Stem Dams

Dam	River Mile	Hydraulic Height	% Year Free Passage Conditions Exist [1]
La Grange Lock and Dam	80	10 [2]	48%
Peoria Lock and Dam	158	11 [2]	42%
Starved Rock Lock and Dam	231	19 [3]	0%
Marseilles Lock and Dam	247	24 [3]	0%
Dresden Lock and Dam	271	22 [2]	0%
Brandon Road Lock and Dam	286	34 [2]	0%
Lockport Lock and Dam	291	40 [3]	0%

[1] Upper Mississippi River and Illinois Waterway Cumulative Effects Study, West Consultants Inc., Bellevue, Washington, June 2000.
[2] GIS data layer, National Inventory of Dams, FEMA, Corps 1995-1996.
[3] www.towboat.org/lock.htm

The number and impact of dams on the major tributaries vary. Figure 3-16 shows the existing stream miles that are connected to the main stem of the Illinois River. There are no dams on the main stems of the La Moine River and Mackinaw River. A few dams are located on the main stems of the Sangamon River (figure 3-17), Spoon River (figure 3-18), Vermilion River (figure 3-19), Aux Sable Creek (figure 3-21), and Kankakee River (figure 3-22). Numerous dams are found on the main stem of the Fox River (figure 3-20), DuPage River (figure 3-23), Des Plaines River (figure 3-24), and North Branch of the Chicago River (figure 3-25). Table 3-41 reports the number of dams on the major tributaries and distance of the first dam from the Illinois River.

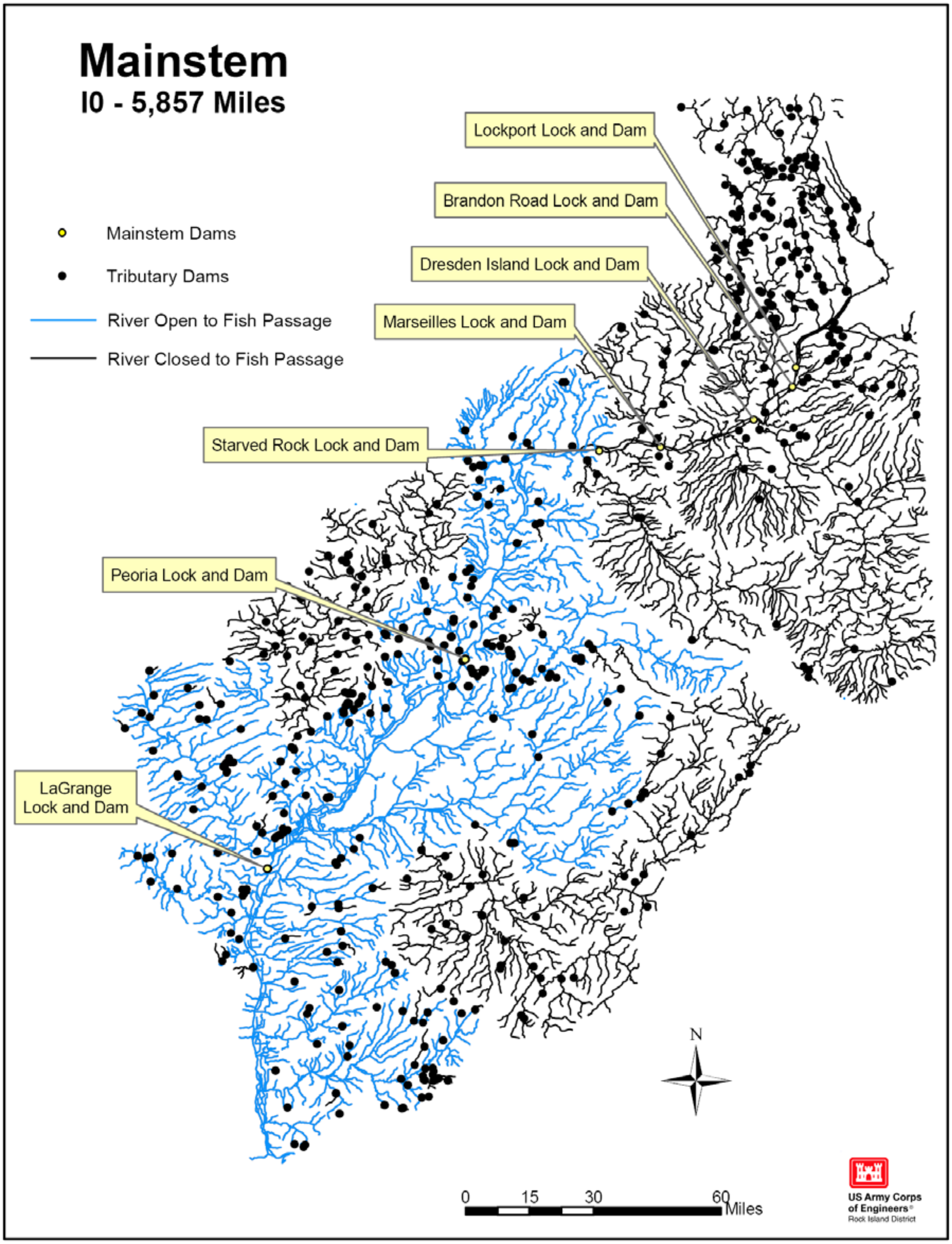


Figure 3-16. Illinois River Existing Connected Stream Segments

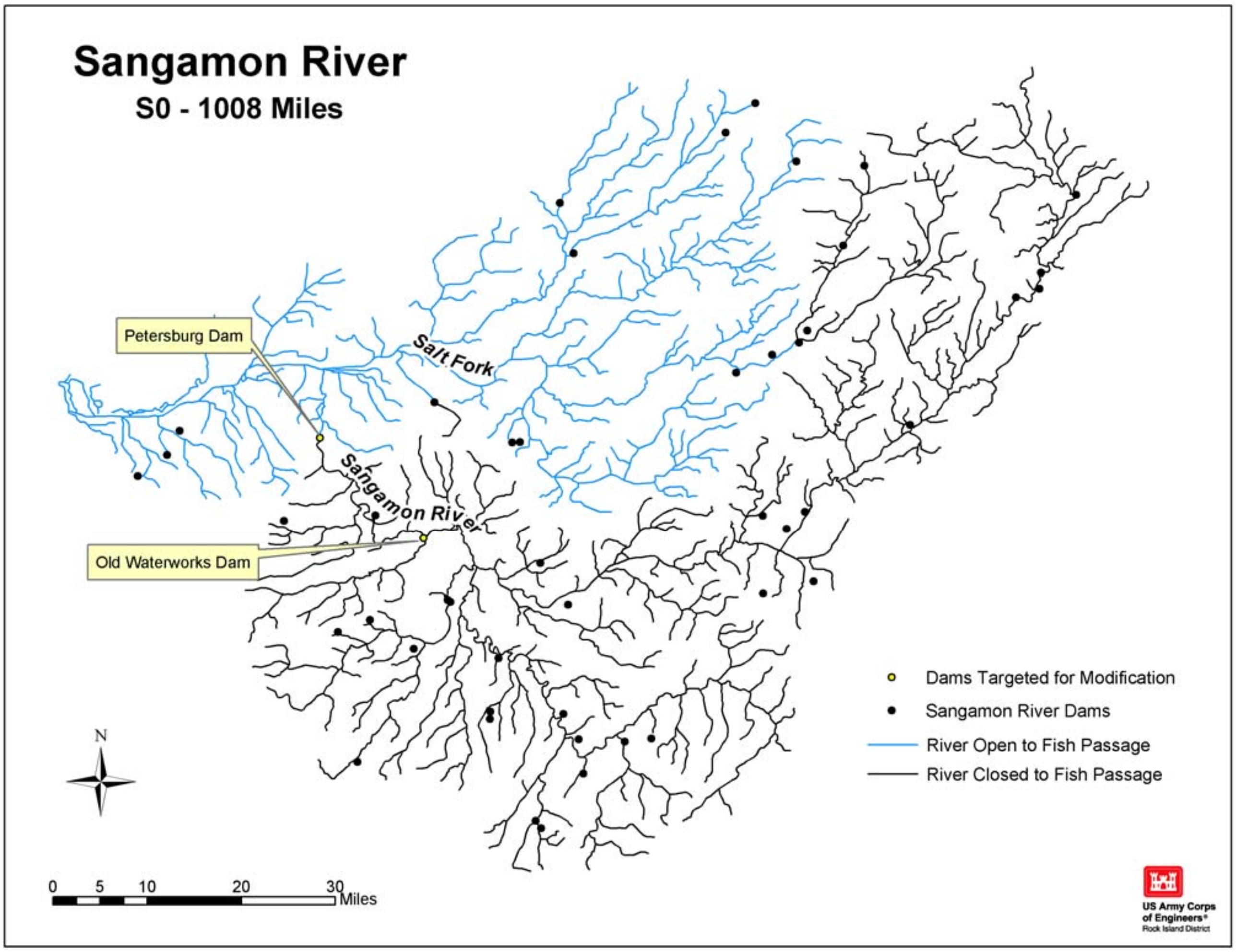


Figure 3-17. Sangamon River Connected Stream Miles

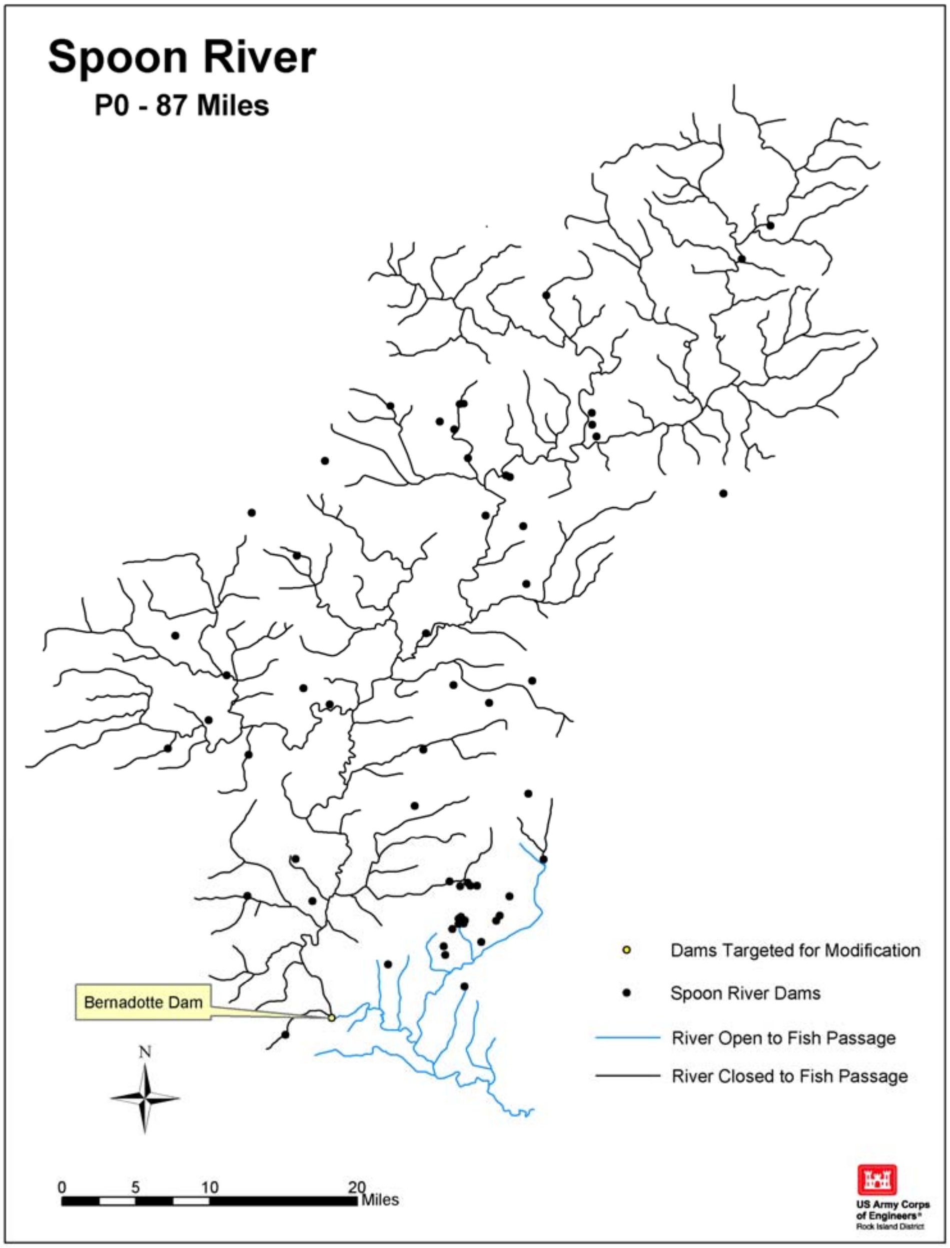


Figure 3-18. Spoon River Connected Stream Miles

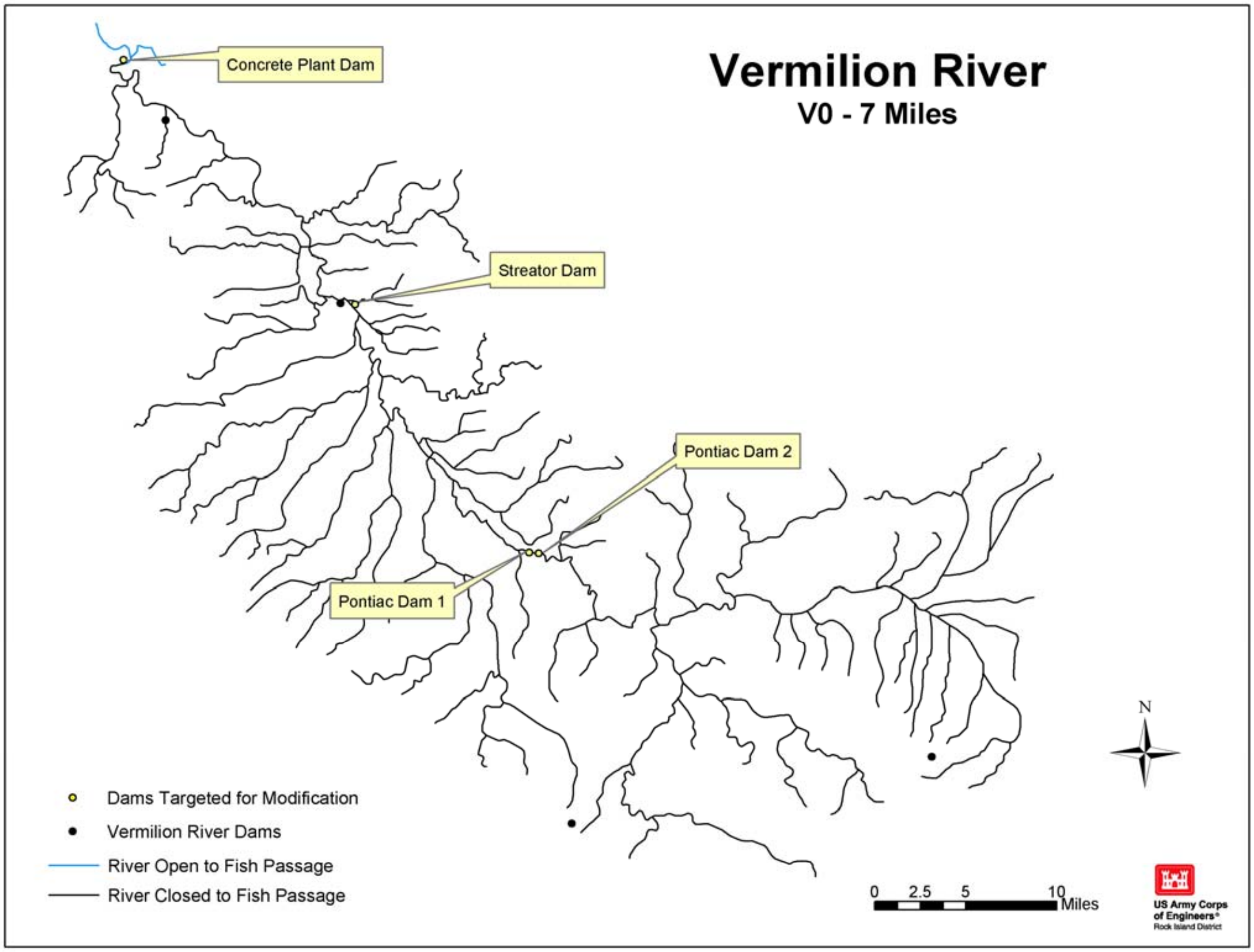


Figure 3-19. Vermilion River Connected Stream Miles

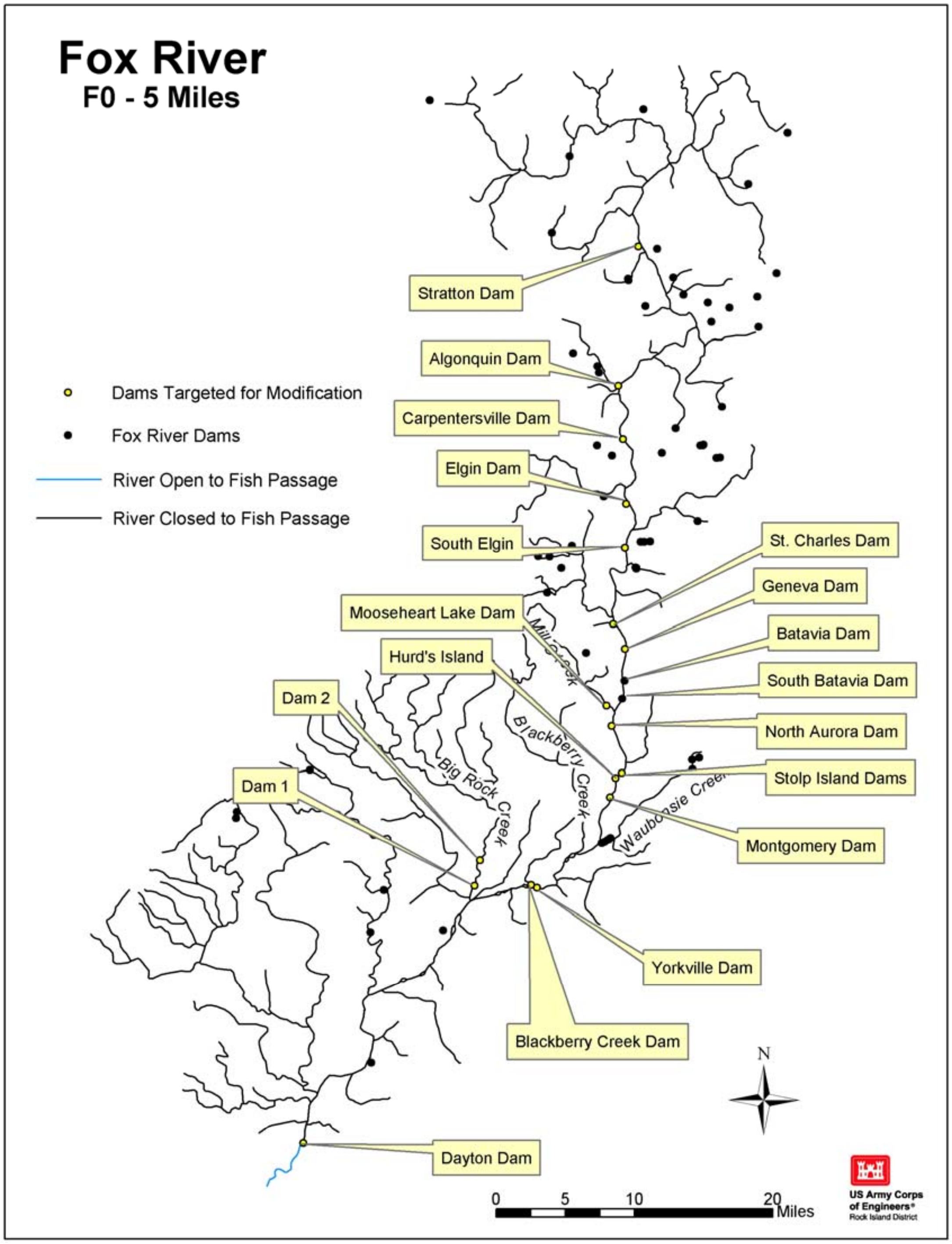


Figure 3-20. Fox River Connected Stream Miles

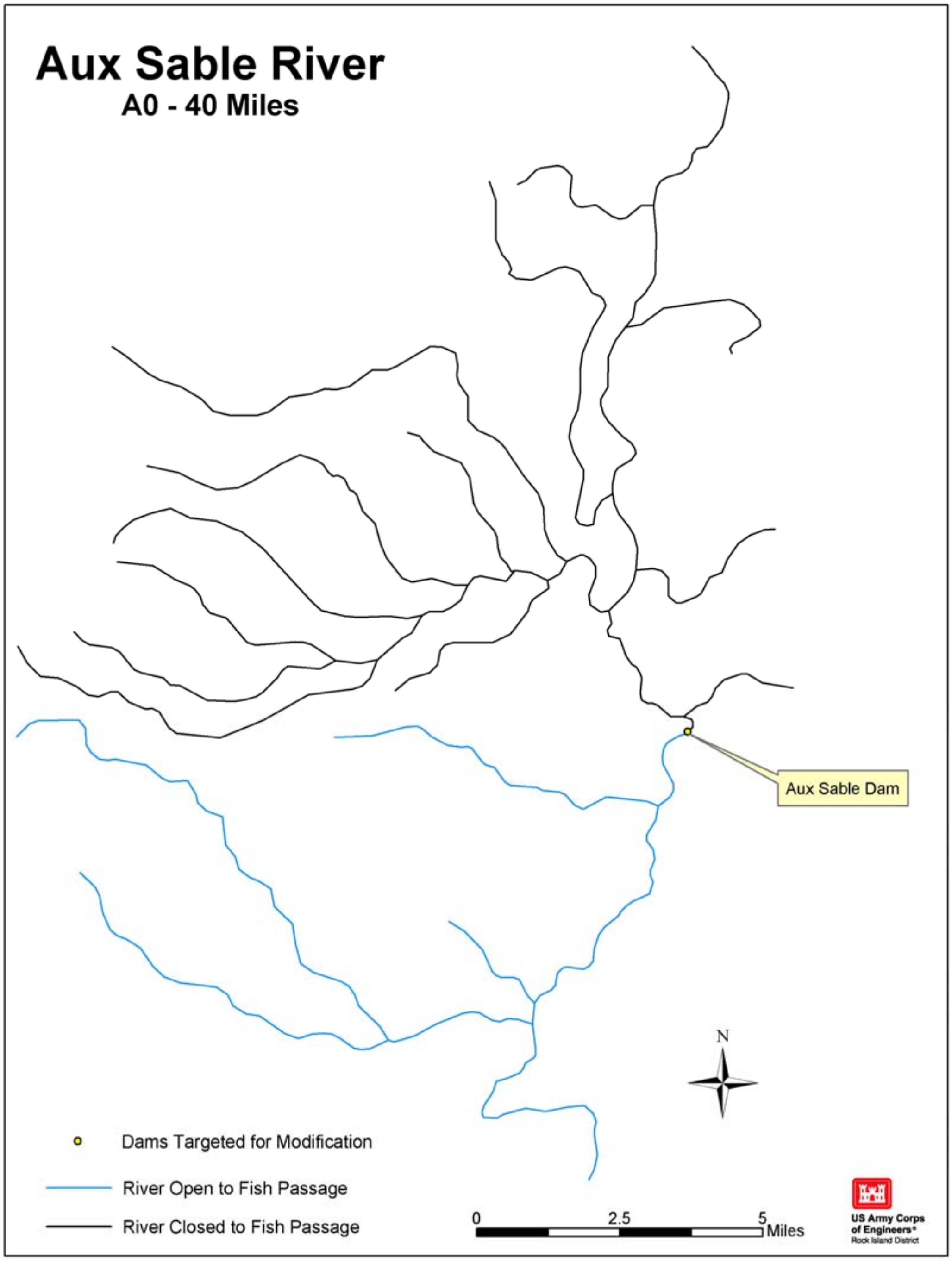


Figure 3-21. Aux Sable Creek Connected Stream Miles

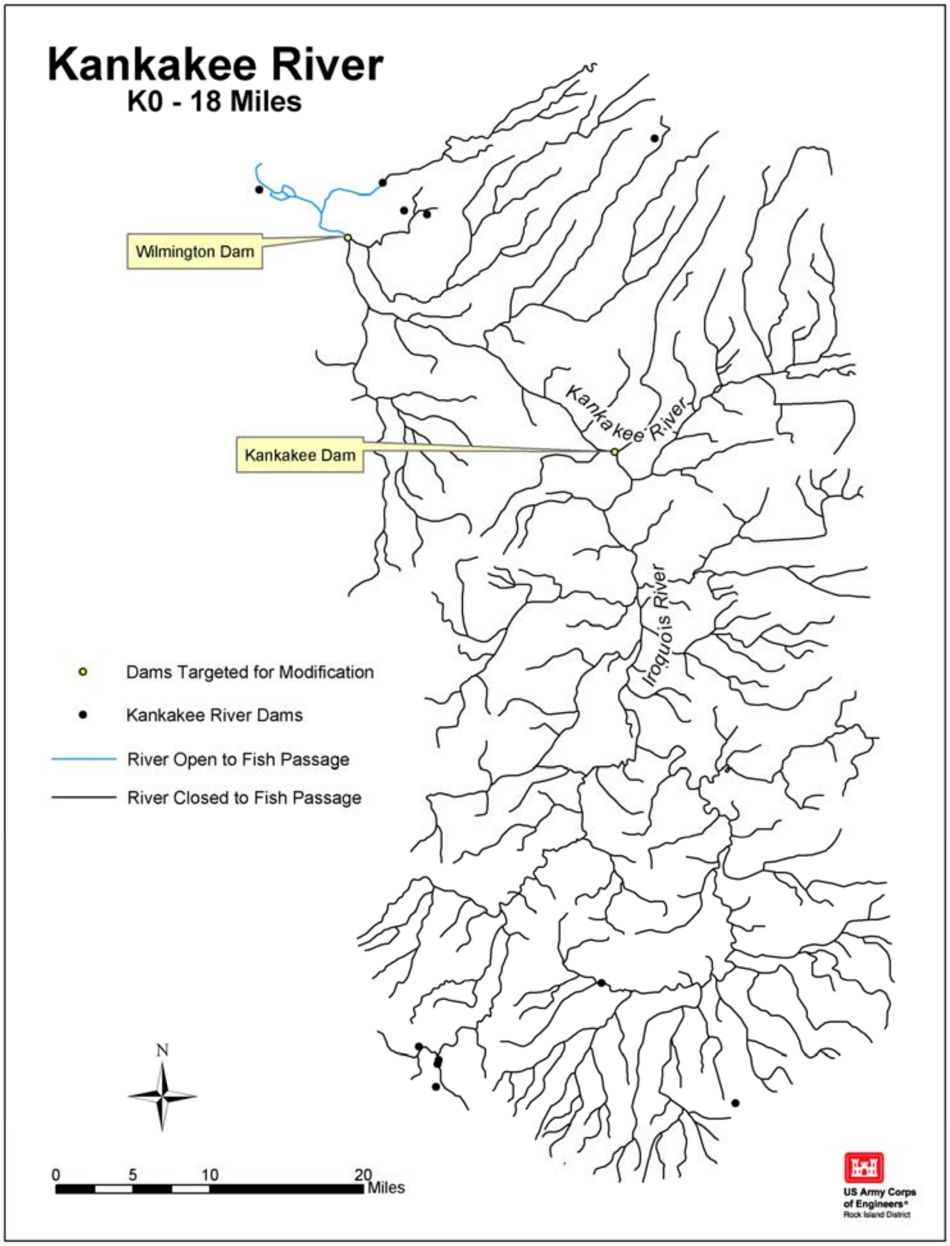


Figure 3-22. Kankakee River Connected Stream Miles

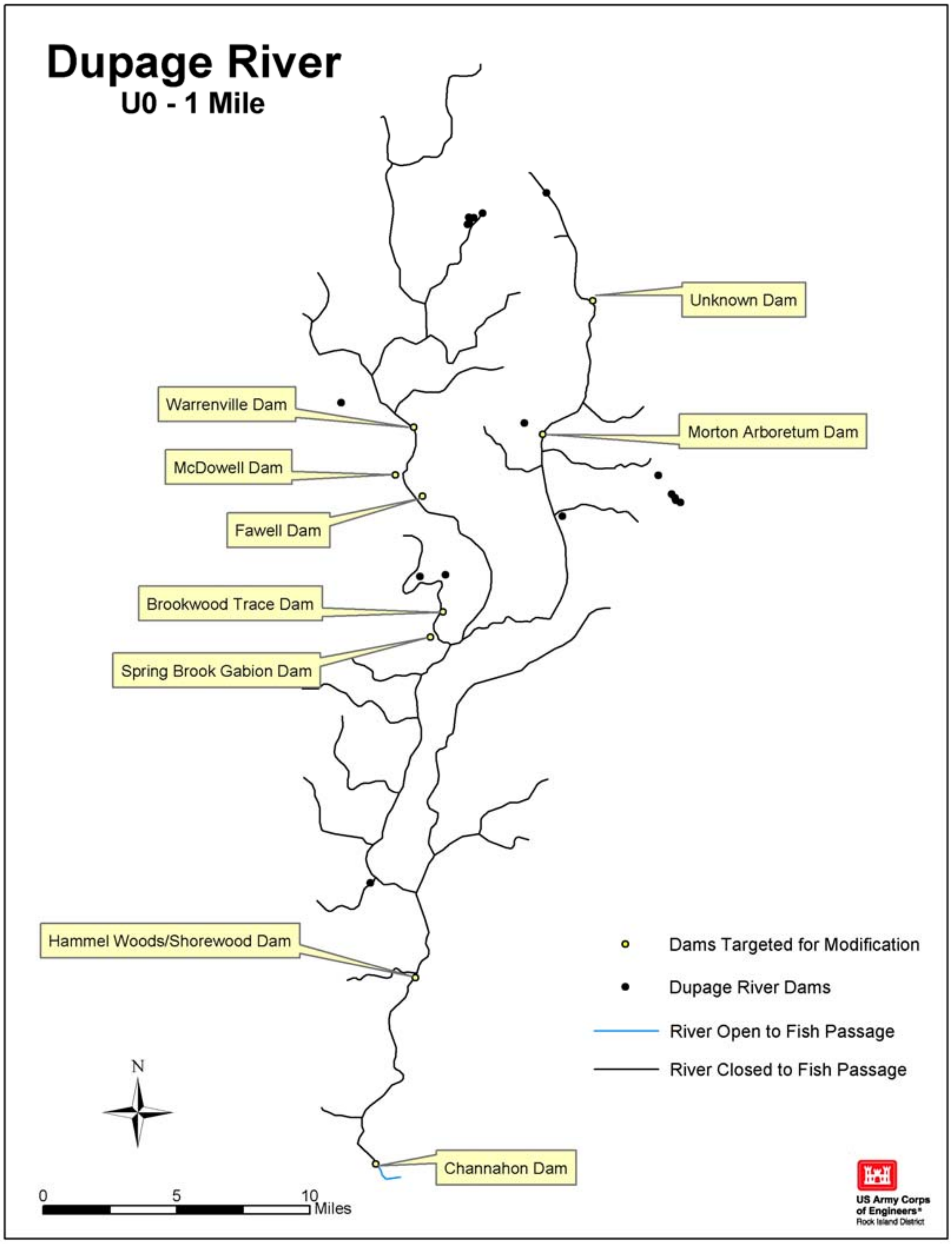


Figure 3-23. DuPage River Connected Stream Miles

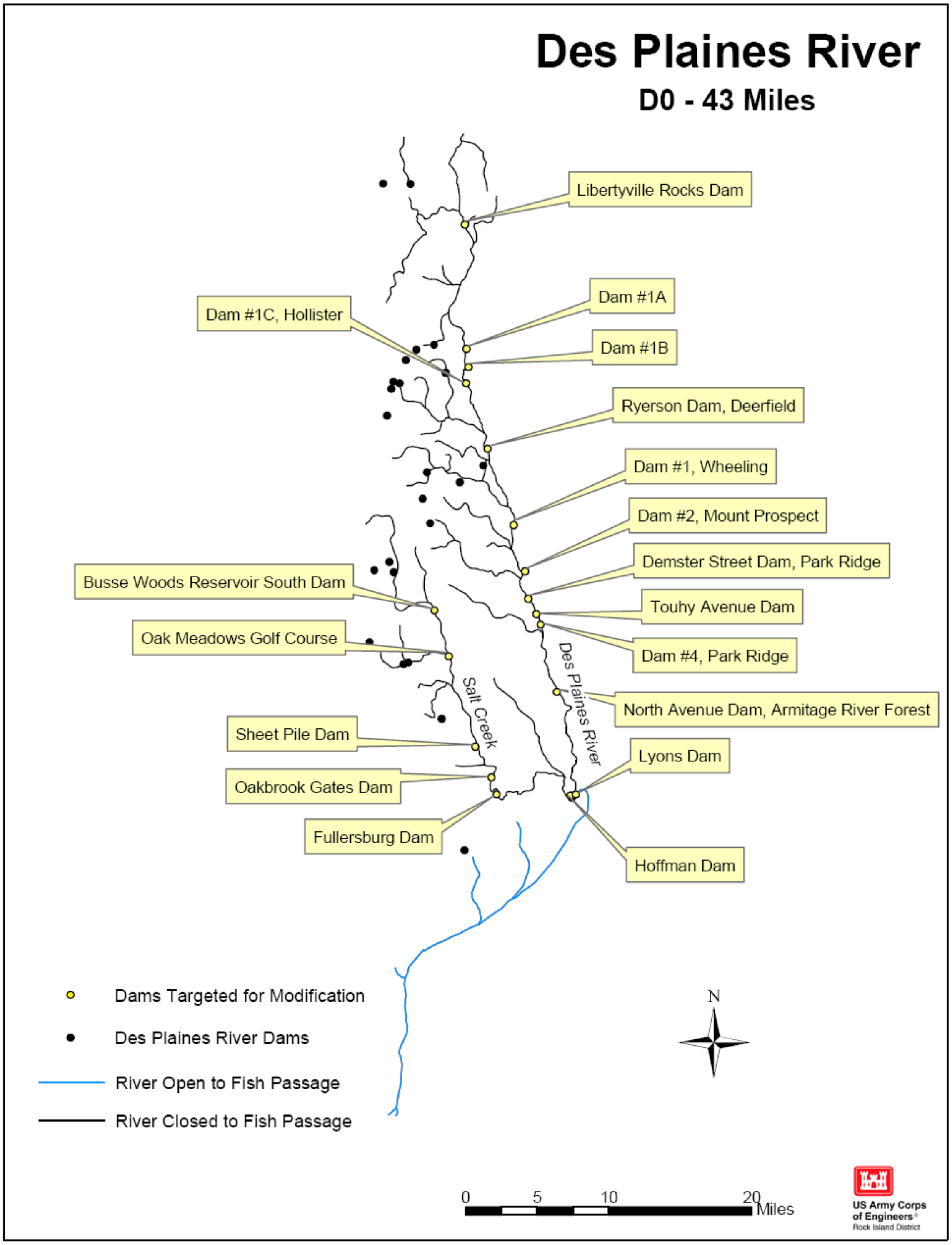


Figure 3-24. Des Plaines River Connected Stream Miles

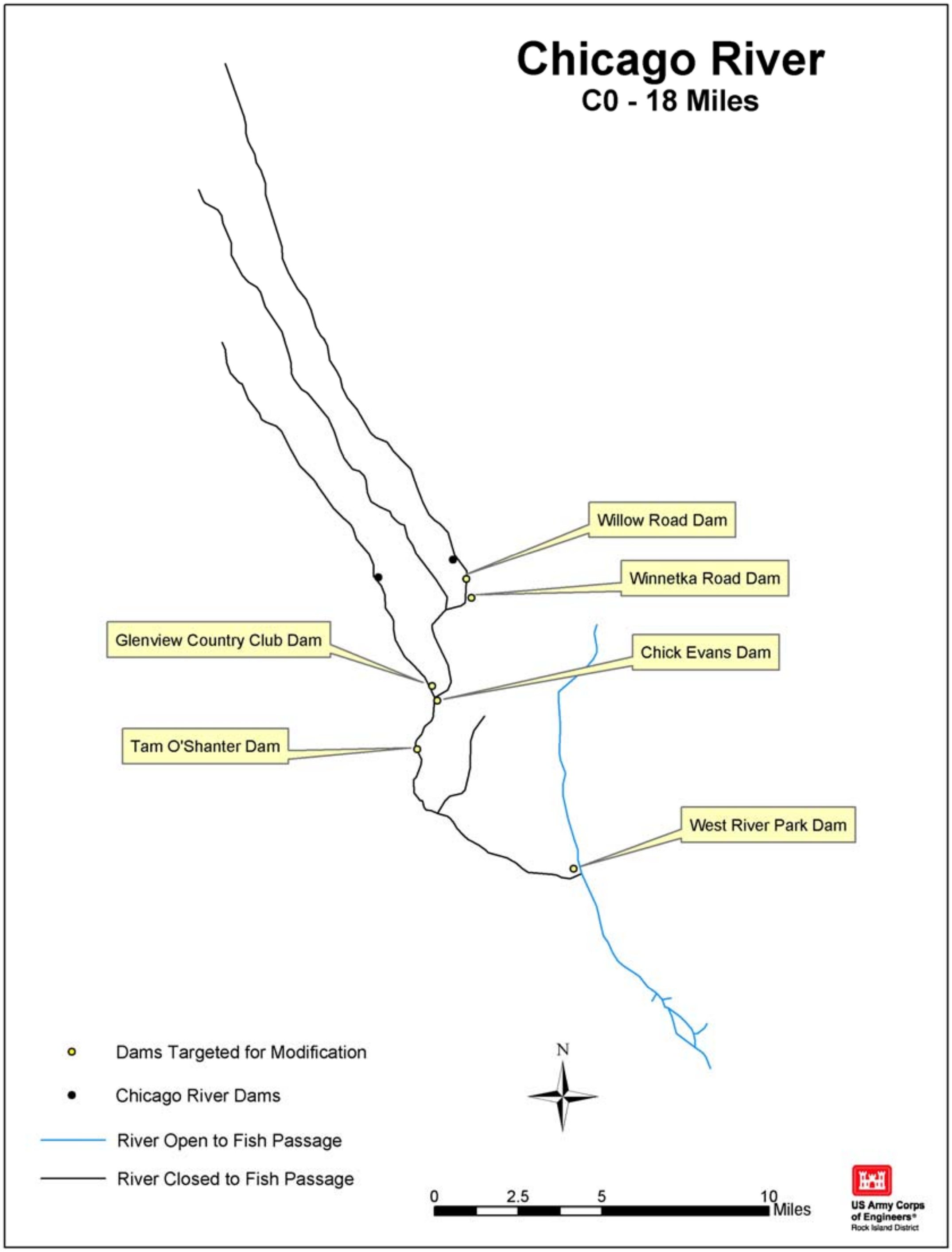


Figure 3-25. Chicago River Connected Stream Miles

Table 3-41. Illinois River Tributaries With First Dam Details

		First Tributary Dam		
Tributary Name	**Dams on Main stem**	**Name**	**Height (ft)**	**RM from Confluence with Illinois River**
Macoupin Creek	N			
Sandy Creek	N			
McKee Creek	N			
La Grange L/D				
LaMoine River	N			
Sangamon River	Y	Petersburg	2-3	42
Salt Fork	Y	Clinton Lake Dam	65	76 [1]
Spoon River	Y	Bernadotte Dam	2-3	27 [1]
Mackinaw River	N			
Peoria L/D				
Vermilion River	Y	Concrete Plan Dam	3-5	6
Starved Rock L/D				
Fox River	Y	Dayton Dam	29.6 [2]	5.7[2]
Marseilles L/D and Dresden L/D				
Kankakee River	Y	Wilmington Dam	5	9.5
DuPage River	Y	Channahon Dam	10	1.5
Brandon Road L/D				
Des Plaines River	Y	Lyons Dam	2	43

Data from National Inventory of Dams - (http://crunch.tec.army.mil/nid/webpages/nid.cfm) – except as noted:
[1] Illinois Streams Information System, Illinois DNR.
[2] Data from Vic Santucci, Max McGraw Wildlife Foundation.

c. Future Without-Project Conditions. Without the project, lack of aquatic connectivity (fish passage) will continue to negatively affect species and populations of aquatic organisms in the Illinois River Basin.

Additional dams may be constructed in the future. The need for potable water for increasing populations in northeastern Illinois may result in construction of dams or modification of existing dams for water supply purposes. It is anticipated that new dams may be constructed to accommodate fish passage; however, any new dams would likely have some impact on connectivity.

It is likely that some of the dams would be removed in the future. Dam removal would be municipality driven and would be related to the costs of continued O&M as well as safety concerns. Municipalities would weigh the benefits and services provided by the dam with the costs of reconstruction, repair, and continued O&M. The Illinois DNR Office of Water Resources is evaluating dam modification or dam removal on State-owned dams.

Fish passage at the Illinois River main stem dams was evaluated under the Upper Mississippi River - Illinois Waterway System Navigation Study, but was not determined to be a high priority on the Illinois River (Wilcox et al. 2004). The low to medium priority ranking was related to the relatively high cost to construct fishways at these sites and the relatively low access to tributary habitat when compared to the Upper Mississippi River dams. Restoration of fish passage at Starved Rock Lock and Dam, Marseilles Lock and Dam, and Dresden Lock and Dam was included in the alternative plan with the maximum amount of ecosystem restoration (USACE 2004b). Restoration of fish passage at Brandon Road Lock and Dam, Lockport Lock and Dam, and T. J. O'Brien Lock and Dam was not considered as this could facilitate dispersal of nonindigenous fish between the Upper Mississippi River System and the Great Lakes.

The success or failure of non-indigenous species barriers will affect connectivity in the future. Construction of a permanent electrical barrier 1,000 feet downstream of the temporary electrical barrier in the Lockport Pool began in 2004.

d. Desired Future Conditions. The desired future condition is a river system that provides connected habitats for native aquatic species, allowing them to utilize critical habitats at critical time periods and recolonize areas after extreme events or disturbance. This connectivity occurs at three scales; major tributary to main stem, within the major tributary basin, and within the main stem of the Illinois River.

The desired future condition is significant connectivity restoration between the main stem and the appropriate major tributaries. The main stem Illinois River would be connected to the majority of its tributaries including the Sangamon, Spoon, Fox, Kankakee, and DuPage Rivers.

The desired future condition is to restore within-tributary connectivity in the major tributary basins. Connectivity along the main stem of the Fox River would be reestablished, and connections would be restored to a few of the Fox River tributaries. Within-tributary connection also would be restored along the main stem of the DuPage, Des Plaines, Kankakee, Vermilion, Sangamon, and Spoon Rivers. Fish passage would be strongly advised for any new dam construction in order to maintain the current degree of connectivity.

The desired future condition is passage of 100 percent of large-river fish on the Illinois River main stem up to RM 286 at Brandon Road Lock and Dam. This would require improved passage at Starved Rock, Marseilles, and Dresden Lock and Dams. The Lockport and Brandon Locks and Dams would continue to block fish movement, thus limiting dispersal of non-indigenous aquatic species between the Upper Mississippi River System and the Great Lakes. Additional study is needed to assess the desirability of facilitating passage at the Brandon Road Lock and Dam. Restored connectivity between the main stem at Brandon Road Lock and Dam and the Des Plaines River is desirable, but this would need to be balanced with the desire to limit dispersal of non-indigenous species.

Restoring aquatic connectivity to aquatic systems restores a measure of ecological integrity to an area. By allowing access to habitats that supply different life requisites for fish species, the future of those species is more likely. In addition, transport of mussel glochidia (freshwater mussel larvae that attach to a vertebrate host for continued life cycle development) by different fish species ensures that mussel communities and species have access to appropriate habitats. Finally, by restoring this component to the ecosystem, some of the building blocks for a healthy and functioning system are restored.

2. Formulation of Alternative Plans

a. Approach/Assumptions. Expert panels and GIS maps were used to formulate and evaluate alternative plans. The GIS maps of dams and stream segments were analyzed to assess relative connectivity within the system. An expert panel of Illinois fisheries biologists from throughout the basin formulated restoration measures for the main stem and each major tributary. The GIS analysis was used to calculate the stream miles connected for each measure. The expert panel then evaluated the relative benefit of restoring connectivity in the various tributaries. The expert panel utilized total stream miles connected and relative benefit information to formulate alternative plans from the measures.

b. Criteria and Constraints. A number of criteria should be considered when formulating plans to restore aquatic connectivity. The magnitude of negative impacts that are caused by the dams was considered. It was assumed that tributaries with high dams, high numbers of dams, or dams close to the confluence with the Illinois River were more negatively impacted. The quality and amount of habitat upstream of the dams was also considered.

Design of site-specific projects to improve connectivity should consider criteria such as swimming speeds and seasonal movement patterns of targeted fish species.

Restoration of connectivity is constrained by the existing use of the dams and their impoundments. Some of the dams provide sufficient water depth for commercial and recreational navigation or hydropower production. This use may also constrain the methods to restore connectivity. Another constraint is the willingness of the dam owners and surrounding communities. Potential contamination of sediments accumulated upstream of the dam may be an issue at some dam locations, constraining potential dam removal.

Restoration of connectivity within tributaries should not increase dispersal of non-indigenous species. Dispersal from the Illinois River to Lake Michigan or from Lake Michigan to the Illinois River is a concern, as well as from the Illinois River to the major tributaries. Non-indigenous species can affect fish and aquatic community diversity by displacing native species and/or modifying their habitat. The Illinois River main stem dams and the electrical barrier currently provide a partial barrier between the Upper Mississippi River System and Lake Michigan. To limit dispersal of non-indigenous species, fish passage should not be restored at Lockport Lock and Dam or the T. J. O’Brien Lock and Dam, which is located on the Calumet-Sag Channel connecting the Illinois River to Calumet Harbor, Lake Michigan. Maintaining these dams does not prevent dispersal of non-indigenous species entirely as they can be transferred to other water bodies through human means such as in bait buckets, live wells, and other accidental means. Non-indigenous species issues should also be considered when reconnecting tributaries to the main stem of the Illinois River.

c. Measures. Fish passage can be accomplished through a variety of techniques. Only the most common methods are discussed here, however, all appropriate techniques should be considered during the site-specific evaluations.

i. Dam Removal. This alternative would consist of the removal of the existing dam (photograph 3-4). This removal would restore 100 percent fish passage at the site. However, many existing dams are highly valued by the surrounding communities, even when there is no longer a specific function for the dam. This measure will be used for ecosystem restoration purposes solely, and should accomplish objectives and produce benefits related to ecological restoration. This measure should not be used to meet regulatory or dam safety requirements. This measure also include significant water quality benefits by removing the often stagnant, shallow pools that form behind dams, thereby increasing dissolved oxygen levels, reducing water temperature, and restoring the flow of gravel, woody debris, and nutrients. This measure would also restore the fish species composition from primarily lacustrine (lake) species back to primarily riverine species.

Photograph 3-4. Before and After Photographs of Dam Removal of Woolen Mills Dam, Wisconsin
www.americanrivers.org

ii. Rock Ramp. Construction of a rock ramp fishway involves placement of stone on the downstream face of the dam to provide a relatively flat 3 to 5 percent gradient (photograph 3-5). Strategic placement of various sized fieldstone would convert the spillway to a more natural looking system of rapids. The roughened chute could be implemented completely across the spillway, converting the entire spillway to a rapids system, or limited to only a portion of the spillway. Pools and eddies would be implemented into the design to slow water velocities and allow resting spots for fish as they travel upstream. Water velocities of 1.5 feet per second or less should be provided throughout the fishway. Besides allowing upstream and downstream fish passage, the rocky bed would create habitat for fish and other aquatic organisms. The mixing action as water passes over and around rocks oxygenates the water, improving water quality. The fishway should be designed to operate under flows equating to the 10- to 90-percent duration range during the months of March, April, and May. During these months, native species such as: walleye, sauger, smallmouth and largemouth bass, northern pike, and channel catfish will be using the fishway to reach suitable upstream spawning grounds. A roughened chute reduces the drowning hazard by eliminating the problem of a downstream hydraulic roller; requires minimal maintenance, minimal real estate acquisition; and is aesthetically pleasing.

Photograph 3-5. Rock Ramp- Otter Tail River, Minnesota

iii. Bypass Channel. The construction of a channel consisting of a series of pool and riffle structures around of the dam is another alternative. A staircased rock and boulder riffle structure would gradually reduce the water level differential between the head and tailwaters of the dam. While this alternative solves the problem of fish passage, the safety risk associated with the hydraulic roller on the downstream face of the dam still exists.

iv. Denil Fishway. Denil Fishways are rectangular chutes or flumes with baffles extending from the sides and bottoms which point upstream (photograph 3-6). The internal roughness created by the baffling controls flow for fish passage. The preferred site would be on the side of the dam where fish tend to congregate. While this alternative solves the problem of fish passage, the safety risk associated with the hydraulic roller on the downstream face of the dam still exists.

Photograph 3-6. Denil Structure at Ipswich Mills Dam, Ipswich, Massachusetts
http://www.mass.gov/dfwele/dmf/publications/tr17_anad_p3_appendix.pdf

d. Alternatives. The study team identified dams throughout the basin that block or inhibit fish migration. Alternatives were developed for the main stem and each tributary basin to increase stream miles of connectivity.

Conditions on the main stem of the Illinois River were evaluated. Because the wicket gates at Peoria and LaGrange Lock and Dams are out of the water 48 percent and 42 percent of the time, respectively, fish passage was not considered necessary at these locations. The main stem dams remaining for consideration as alternatives are Starved Rock, Marseilles, and Dresden Lock and Dams. Adding fish passage at Starved Rock Lock and Dam provides access to the Fox River basin. No major tributaries enter the Marseilles pool; therefore, it was grouped with Dresden Lock and Dam, providing access to the Kankakee and DuPage basins. Finally, the addition of fish passage at Brandon Road Lock and Dam, which provides access to the Des Plaines River, was eliminated at this time in order to continue to block migration of nonindigenous fish between the Upper Mississippi River System and the Great Lakes. The risk associated with and potential benefits of fish passage at this location require further study and may be re-evaluated at a later time.

Tributary restoration alternatives were developed for the Sangamon River, Spoon River, Vermilion River, Fox River, Aux Sable Creek, Kankakee River, DuPage River, Des Plaines River, and North Branch of the Chicago River. Alternatives were developed by grouping specific dams targeted for fish passage. Table 3-42 presents the detailed connectivity alternatives considered. Connected stream miles and incremental gain in stream miles are reported for the various alternatives.

Table 3-42. Detailed Fish Passage Alternatives for the Illinois River Basin

	# of Dams	Stream Miles Connected	Net Increase in Stream Miles Connected
Main Stem		13130[1]	
I0 – No action		5990	
I1 – Fish Passage at Starved Rock	1	6090	100
I2 – Fish Passage at Starved Rock, Marseilles, and Dresden [2]	3	6730	640
Sangamon River		2604[1]	
S0 – No action		1008	
S1 – Fish Passage at Petersburg	1	1808	800
Spoon River		963[1]	
P0 – No action		87	
P1 – Fish passage at the Bernadotte Dam [2]	1	883	796
Vermilion River		715[1]	
V0 – No action		7	
V1 – Fish passage at Concrete Plant	1	144	137
V2 – Fish passage at Concrete Plant and Streator Dams	2	430	286
V3 – Fish passage at Concrete Plant, Streator and Pontiac Dams	4	711	281
Fox River		806[1]	
F0 – No action		5	
F1 – Fish Passage at all main stem dams	12	568	563
F2 – Fish Passage at all main stem dams and 4 tributaries [2]	17	702	134
Aux Sable River		131[1]	
A0 – No action		40	
A1 – Fish passage at Aux Sable Dam [2]	1	131	91
Kankakee River		1308[1]	
K0 – No action		18	
K1 – Fish Passage at Wilmington Dam	1	298	316
K2 – Fish Passage at Wilmington and Kankakee Dams [2]	2	1267	969
DuPage River		170[1]	
U0 – No action			
U1 – Fish passage at all dams on West Branch	5	149	
U2 – Fish passage at all dams on West and East Branch and 1 tributary (Springbrook) [2]	8	168	
Des Plaines River		267[1]	
D0 – No action		43	
D1 – Fish passage at Lyons, Hoffman, and Armitage Dams and 1 tributary (Salt Creek)	7	108	65
D2 – Fish passage at all main stem dams and 1 tributary (Salt Creek) [2]	17	248	140
Chicago River		81[1]	
C0 – No action		18	
C1 – Fish passage at 6 main stem dams	6	55	37

[1] Alternatives do not reconnect all stream miles due to additional dams on tributary systems. Stream miles estimated from GIS coverage (Illinois River Restoration Needs Assessment GIS, Scott A. Tweddale, Construction Engineering Research Laboratory (CERL)).
[2] Denotes system alternative plan

3. Evaluation and Comparison of Plans

Alternatives were evaluated, both qualitatively and quantitatively, and this information was used to formulate the alternative plans.

a. Tributaries. The study team developed the matrix in table 3-43 to qualitatively evaluate and compare potential benefits of restoring fish passage on the major tributaries. The study team used professional judgment based on field experience to estimate the relative negative impacts caused by dams. Biological Stream Characterization (BSC) data for the tributaries was used to estimate stream quality. These two categories were used to assess the relative potential benefits of restoring connectivity on a given tributary and assign a priority for restoring connectivity. Tributaries with low negative fisheries impacts had low to medium priority depending on the stream quality. The Sangamon River was identified as having low impacts due to the single low-head dam that separates two large reaches of river. Tributaries with medium negative fisheries impacts were rated as having medium priority unless stream quality was low. Streams with high negative fisheries impacts were given a high priority. For example, the Fox River has a large number of dams along the main stem and has a high fish species diversity. Restoring connectivity on the Fox, DuPage and Des Plaines Rivers was estimated to have a high potential benefit and was given a high priority. Restoring connectivity on the Spoon, Aux Sable and Kankakee Rivers was estimated to have a medium potential benefit and was assigned a medium priority. Restoring connectivity on the Sangamon, Vermilion, and Chicago Rivers was estimated to have a lower potential benefit and was assigned a low priority.

Table 3-43. Evaluation of Benefits of Fish Passage for the Major Tributaries

River	Negative Fisheries Impacts Caused by Dams	Stream Quality [1]	Priority for Fish Passage
Sangamon	L	M	L
Spoon	M	M-H	M
Vermilion	L	M-H	L
Fox	H	M-H	H
Aux Sable	M-H	H	M
Kankakee	L	H	M
DuPage	H	M	H
Des Plaines	H	M	H
Chicago River	M	L	L

[1] Estimated from Biological Stream Characterization data (Bertrand et al. 1996, ISIS 1999)

The tributaries were grouped by the relative benefits of fish passage to form system connectivity alternatives (table 3-44 and figure 3-26). The cost estimates for tributary passage were based on rock ramp construction. Table 3-44 provides the estimated costs and benefits of the system connectivity alternatives. Benefits are shown in total connected stream miles. The first tributary alternative, 4A, addresses restoring connectivity on the tributaries with a high priority—those tributaries that have been most negatively impacted by dams and with medium to high stream quality. This alternative includes restoring connectivity at all main stem dams and a few tributaries of the Fox River; restoring connectivity at all main stem dams on the DuPage and West Branch of the DuPage River; and restoring connectivity at all main stem dams on the Des Plaines River (figure 3-26). Alternative 4A would reconnect 916 stream miles at an estimated total cost of $52 million.

The second tributary alternative, 4B, includes Alternative 4A with the addition of the dams with medium priority—the main stem dams on the Spoon, Kankakee, and Aux Sable Rivers (figure 3-26). Alternative 4B would reconnect a net 3,052 stream miles.

The third tributary alternative, 4C, includes Alternative 4A+4B, with the addition of restored connectivity on main stem dams of the remaining major tributaries—the Sangamon, Vermilion, and North Branch of the Chicago Rivers (figure 3-26). Alternative 4C would reconnect a net 4,593 stream miles. In spite of the relatively low costs, the study team did not recommend that Alternative 4C be carried forward to the final array of alternatives. Impacts of the Petersburg Dam, on the Sangamon River, are thought to be minimal as the dam is higher up in a large watershed and is passable under some flow conditions. The impacts of the Vermilion River dams are lower as the dams are passable under some flow conditions. Low habitat quality and low water quality on the Chicago River currently limit the potential restoration benefits of fish passage.

b. Main Stem. The main stem alternatives carried forward for evaluation were renamed as follows: I1 and I2 (table 3-42) become 4X and 4Y (table 3-44 and figure 3-26) and reconnect 100 and 740 river miles, respectively. Table 3-44 reports the estimated costs and benefits of the connectivity alternatives.

The study team felt that restoring connectivity *within* tributary basins provided more benefits to the natural resources of the Illinois River Basin than restoring main stem connectivity. The study team did not recommend Alternative 4X that would provide passage only at Starved Rock, which would restore connectivity only to the Fox River. Alternative 4Y, which includes passage at Starved Rock, Marseilles, and Dresden Lock and Dams, was recommended for inclusion in the maximum system alternative plan.

4. Plans Recommended for System Analysis

a. Recommended Alternatives. A cost effectiveness/incremental cost analysis was conducted on the plans outlined in table 3-44 and combinations thereof, resulting in eight possible plans, shown in figure 3-27. Costs for the main stem alternatives were high compared to the amount of connectivity provided, and passage at these dams only became cost effective when combined with tributary connectivity plans. This analysis resulted in four cost effective plans, two of which were also best buys.

Of the two cost effective plans, Alternative 4B+X only provides connectivity to the Starved Rock pool and the Fox River; only 100 tributary steam miles would be reconnected at a cost of approximately $80 million. This alternative was not included into the final array for system alternatives. Alternative 4A, also cost effective, includes streams that are both good quality and highly impacted by dams, therefore given highest priority for fish passage. This alternative plan was recommended as the base plan for system alternatives. Both best buy plans were also recommended for the final array of system alternatives. Table 3-45 shows the final array of alternatives to be carried forward in developing comprehensive system restoration plans.

All system plans would include Blackberry and Waubonsie Creek projects already underway as Critical Restoration Projects. These projects were not included in this analysis.

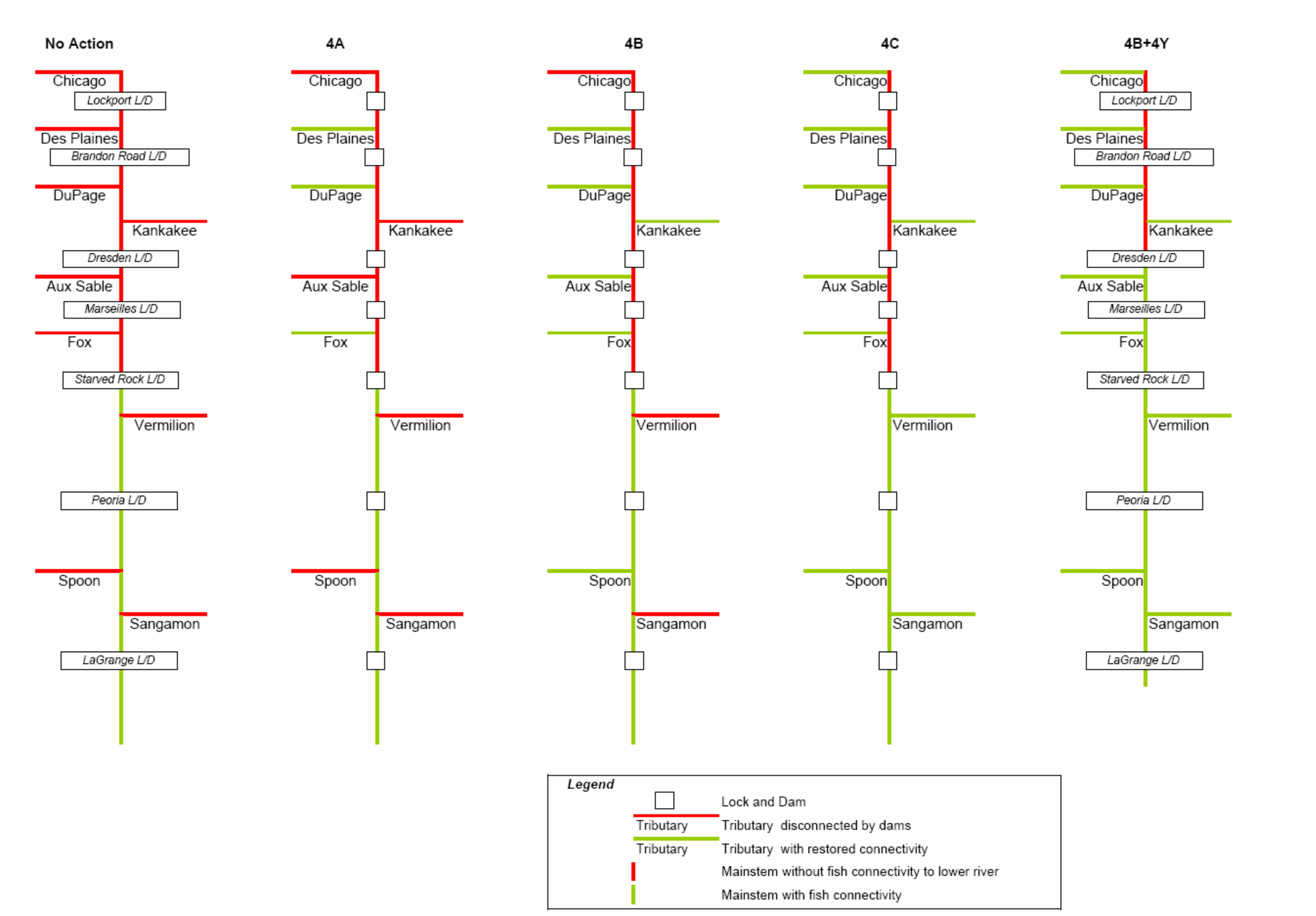


Figure 3-26. Schematic Diagram of Fish Passage Alternatives

Table 3-44. Connectivity Alternatives Evaluated for the Illinois River Basin

	Description	**Alternatives From Table 3-42**	**Number of Dams**	**Total Connected Stream Miles** [1]	**Net Connected Stream Miles** [2]	**Cost** [3]	**Cost per Connected Stream Mile**
Tributary Alternatives							
4A [4]	Fox, DuPage, Des Plaines	F1, U1, D2	34	2,143	916	$52 M	$57,000
4B [4]	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable	F1, U1, D2, K2, P1, A1	38	4,279	3,052	$55 M	$18,000
4C	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable, Sangamon, Vermilion, Chicago	F1, U1, D2, K2, P1, A1 S1, V3, C1	49	5,820	4,593	$61 M	$ 13,000
Main Stem Alternatives							
4X	Starved Rock	I1	1	6,090	100	$80 M	$800,000
4Y [4]	Starved Rock, Marseilles, Dresden	I2	3	6,730	740	$235 M	$317,600

[1] Includes total tributary stream miles for Sangamon, Spoon, Vermilion, Fox, Kankakee, DuPage, Des Plaines, and Chicago Rivers. Also used to express beneficial effects from increased connectivity.
[2] Used to express **direct** benefits from increased connectivity.
[3] Includes construction, 35% construction contingency, 30% Planning Engineering and Design, 9% Supervision and Administration, and Real Estate
[4] Denotes system alternative plan

b. Risk and Uncertainty. There are at least 15 introduced fish species in Illinois. Some of these are U.S. natives whose range has been expanded or are species from other parts of the world. There has been a great nationwide increase in the total number of species introduced since 1950, and the proportion on non-U.S. species has also increased significantly (Chick and Pegg 2001). The greatest proportion of non-U.S. species is coming from Asia and South America. The mode of introduction is shifting from intentional releases of food or sport fishes to accidental releases of aquarium fish, aquaculture species, and those carried in international shipping ballast water.

When any fish passage project is proposed, the risk of introducing non-native fish into an area must be considered. The dams found throughout the Illinois River Basin block fish movement, but most dams are partially passable at some time. For native fish species, fish passage must be available during the appropriate times of the year or life stages, which is often not the case. Non-native fish tend to be stronger swimmers than many native species and, because of this, may be able to negotiate sub-optimal passage conditions that would impede more weakly swimming species. Many river fisheries biologists believe that most dams in the basin currently allow non-native species to pass but block native fish species (Sallee, 2004) . Only a very few dams in the basin currently are 100 percent impassable under natural conditions. The risks of introducing non-native species to these areas must be carefully considered. However, even in these areas, people may accidentally release non-native species.

In addition to blocking movement of non-indigenous species, existing dams also retain sediment. While the capacity of many older impoundments to retain sediment has been filled, any dam removal actions may mobilize the stored sediments downstream. For any proposed dam removal, examination of sediment retention benefits, as well as the potential addition of sediment to the system, must be weighed against fish passage benefits. This will be dependent on the volume and nature of the sediment. This issue will be examined on a case by case basis as projects are considered in the future.

c. Information and Further Study Needs

- Tagging studies to better determine movements, timing, habitat use, and design consideration.
- Further discussion, study and consideration of conflicts between restoring connectivity for native fish and mussels and maintaining barriers to limit dispersal of non-indigenous species
- Risk and uncertainty of non-indigenous species
- Community concerns over dam removal

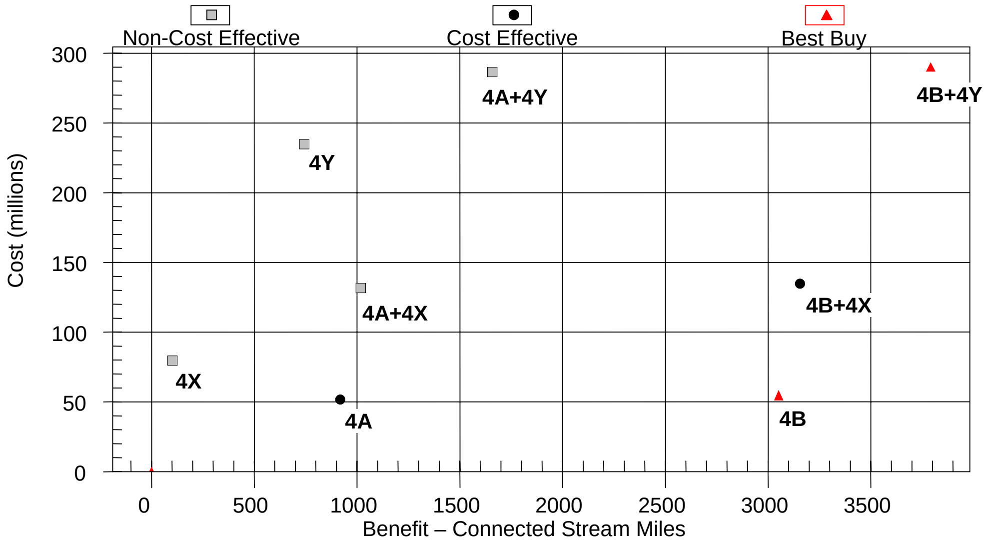


Figure 3-27. Cost Effectiveness of Alternative Plans

Table 3-45. Plans Recommended for System Alternative Plans

Alternative	Tributary	Total Construction Cost [1]	Total Real Estate Cost [2]	Total Estimated Costs	Annual O&M Costs
4A	Fox, DuPage, Des Plaines	$51,147,043	$337,1000	$51,484,143	$152,463
4B	Fox DuPage, Des Plaines, Kankakee, Spoon, Aux Sable	$54,968,125	$372,400	$55,340,525	$156,691
4B + 4Y	Fox DuPage, Des Plaines, Kankakee, Spoon, Aux Sable, Starved Rock, Marseilles, Dresden	$289,733,287	$854,500	$290,587,787	$494,483

[1] Includes 35% construction contingency; 30% Planning, Engineering and Design; and 9% Supervision and Administration.
[2] Includes a contingency, but does not include acquisition or appraisal costs.

J. GOAL 5: HYDROLOGY AND WATER LEVELS. 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. Two of the most critical results from the basin changes and river management, are the increased frequency and increased magnitude of water level fluctuations, especially during summer and fall low water periods. 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 would 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.
- Reduce the significant water level changes associated with 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 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.

Anticipated Outputs

Anticipated project outputs for this goal include: naturalizing tributary flow regimes by reducing peak flows and increasing base flows; reducing water level fluctuations on the main stem Illinois River; and exposing main stem areas by pool drawdown. These project outputs would provide a more desirable level of ecosystem function by providing critical habitat and more favorable habitat conditions for aquatic plant and animal (including fish and macroinvertebrates) species.

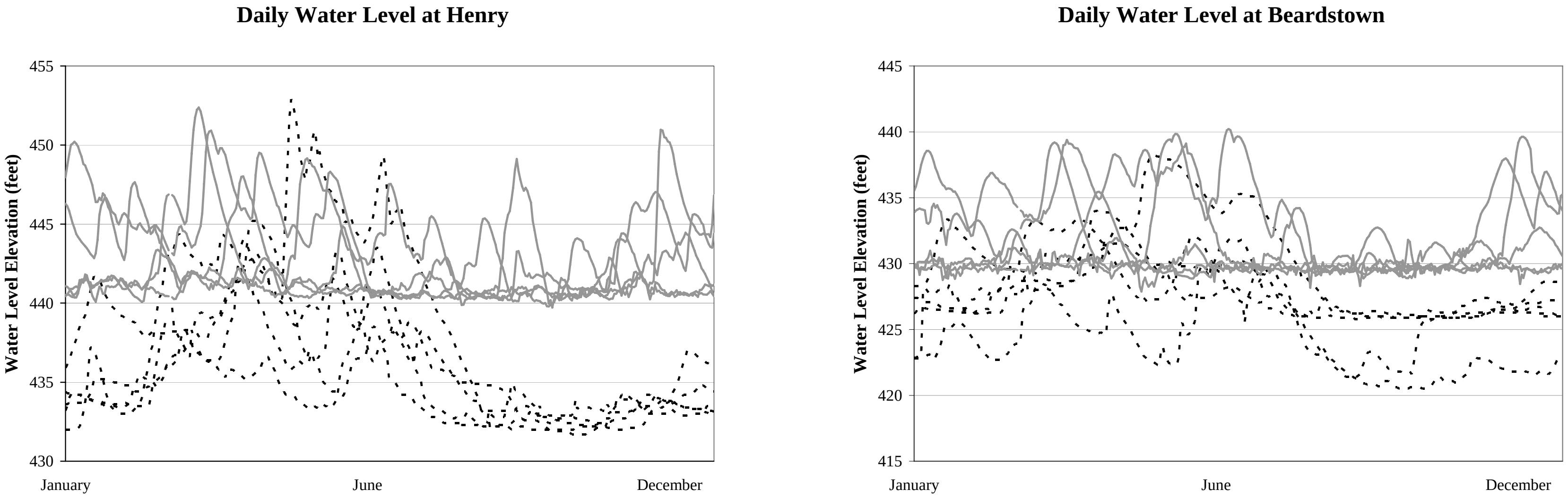
Pool drawdown would allow for the reestablishment of emergent vegetation (i.e. arrowhead, bulrush, and sedges) in some areas that are currently inundated and/or unable to support aquatic vegetation. Sediment compaction would also result, potentially reducing turbidity. As water levels are raised following the drawdown, these newly vegetated areas would provide food and cover for migratory waterfowl, fish, and macroinvertebrates.

Reducing water fluctuations would allow for the reestablishment of emergent plants (which serves as a food base for fish and waterfowl) in the shallow water areas of the lower three pools. Fewer and smaller fluctuations could reduce the probability that fish using the backwaters and side channels for spawning would become trapped. Fish species anticipated to benefit from reduced water level fluctuations include: largemouth bass, bluegill, gizzard shad, and emerald shiners.

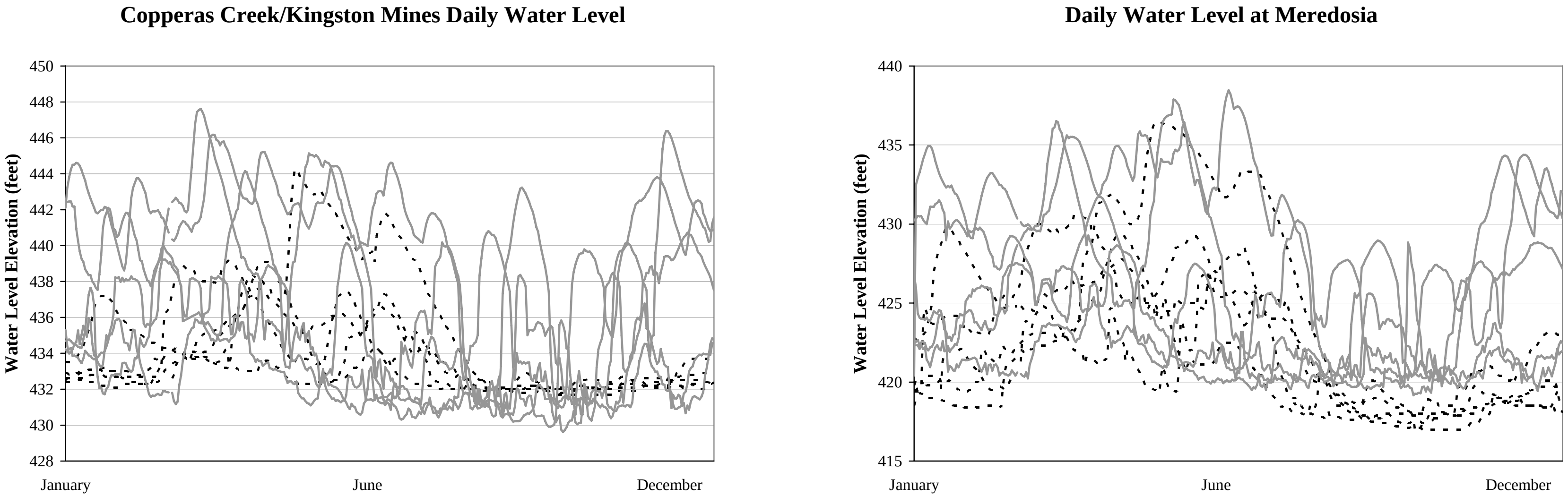
1. Inventory Resource Conditions

Hydrology is a primary driver of aquatic ecosystem processes (Poff and Ward 1989, Poff and Allan 1995). The magnitudes, timing, durations, and rates of change of flows and water levels often regulate the nature of chemical and biological functions in aquatic systems. Hydrologic regimes are largely determined by landscape conditions and subsequently so are the resulting ecosystem characteristics (Sparks 1992). Headwater streams in the Illinois River Basin experience short duration floods nearly every year in response to rainfall; animals in such streams are adapted to either avoid or endure these events by either migrating or finding shelter. These streams also experience extended low flows during the summer and fall. In larger streams and rivers, the average annual hydrologic regime is smoothed somewhat due to larger drainage areas and a greater influence of groundwater on summer low flow, or baseflows, and the relative difference between the flood and low-flow discharge is not so great. This reduced variability in flow conditions allows more organisms to take advantage of the aquatic habitat; the number of fish species, for example, generally increases in downstream areas in large part due to the addition of new species, as opposed to the replacement of species (Horwitz 1978). In the main stem river, a pronounced spring flood generally extends through the early summer and many organisms are able to take advantage of these high water events because they last longer and are more predictable (Sparks et al. 1990). Urban and agricultural development in the Illinois River Basin has altered the basin’s landscape, which has led to changes in the hydrologic regime of the tributaries and main stem. Altered hydrologic regimes can limit ecosystem function in any portion of the landscape when the frequency or magnitude of high or low water conditions vary significantly from those previously experienced and under which native systems have developed (Resh et al. 1988, Poff 1992).

a. Historic Conditions. Prior to 1900, when significant development and hydrologic modification began, much of the Illinois River experienced a cyclical regime in which water levels gradually rose from the late fall through the spring and then fell to stable low levels in the summer (Sparks 1995). This cyclical regime is illustrated in figure 3-28 which shows water levels at four gage locations on the Illinois River for multiple water years. Figure 3-29 shows the locations of the gages referred to in figure 3-28. Both historical (illustrated using black squares) and existing (illustrated using gray lines) water levels are shown in this figure. Existing water levels will be discussed in the next section. Historical observations and measurements of flows from undisturbed areas indicate that stormflows rates from Illinois River watersheds prior to European settlement were probably much lower than current rates. Much of the Illinois River Basin was prairie, savannah, and marshland that effectively retained rainfall. Prairie plants are very effective at transpiring water from the soil into the atmosphere, likely removing large quantities of water from the basin. Many current streams or ditches were historically ephemeral channels, wetland swales, or simply did not exist (Larimore and Smith 1963, Rhoads and Herricks 1996). As urban and agricultural areas developed throughout the watershed, the basin transformed from an infiltration based system, where water enters the soil at the ground surface and flows away from the ground surface, to a runoff based system, where water remains on or flows across the ground surface.


Daily Water Level at Henry

Daily Water Level at Beardstown


Copperas Creek/Kingston Mines Daily Water Level

Daily Water Level at Meredosia

Figure 3-28. Daily Water Levels at Long-term Illinois River Gages, Water Years 1888-1892 (black dashed lines) and 1988-1992 (gray solid lines). Water years run from October 1 through September 30.

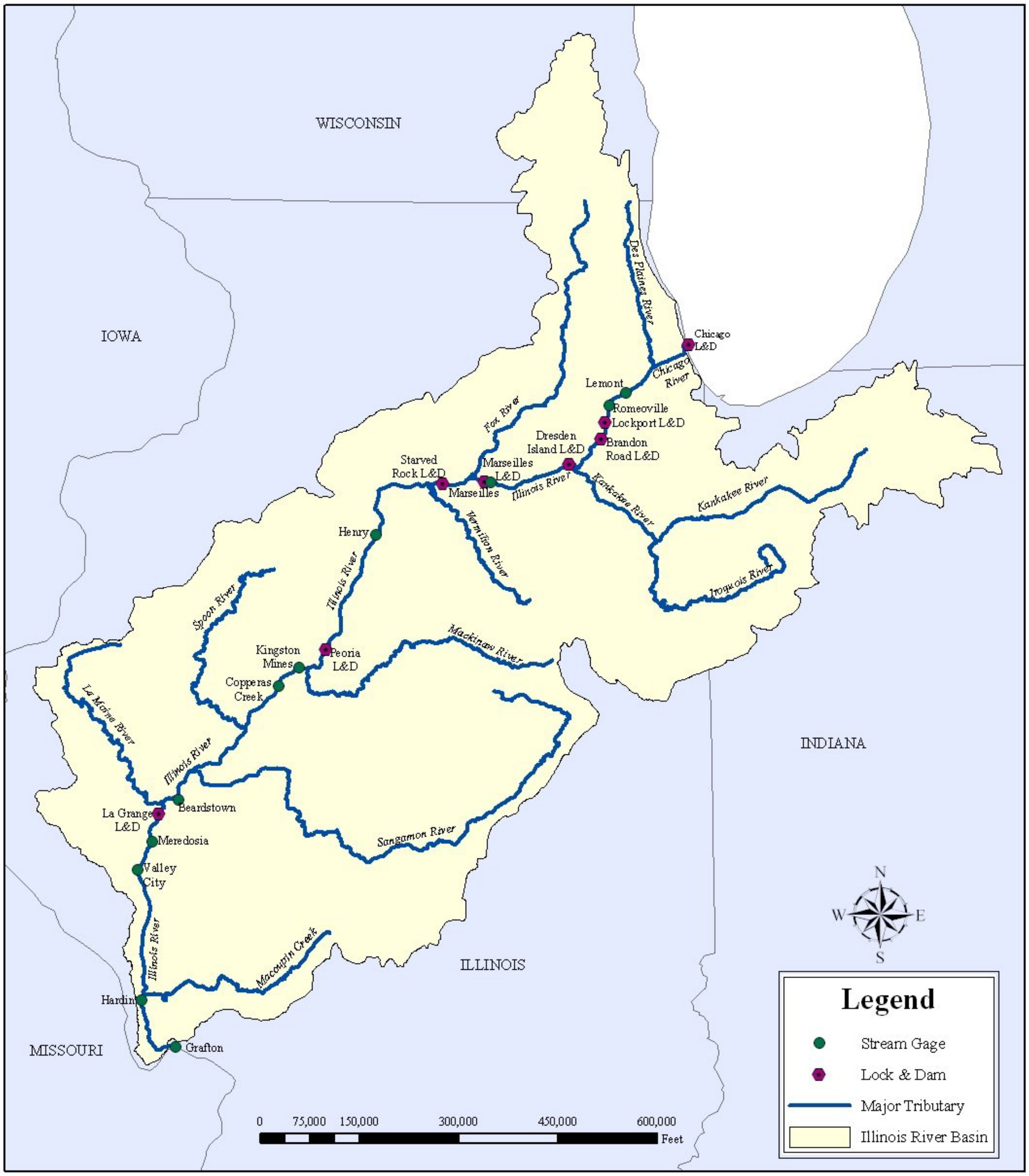


Figure 3-29. Gage Locations

To increase agricultural efficiency, land throughout the Illinois River Basin was cleared and drained. Tilled soil generally tends to create more runoff than vegetated soils (Sartz 1970), so land clearance and drainage in the Midwest increased the movement of water from the land surface and created conditions that resulted in larger storm flows (Knox 2002) and contributed to reduced low flows (Larimore and Smith 1963, Meek 1892, Quick in Menzel et al. 1984, Shriner and Copeland 1904).

Although flows from tile drains have led to sustained low flows at some locations (Rhoads and Herricks 1996), drainage generally reduces low flows by lowering groundwater levels and intercepting through flow, thereby increasing stream flow variability. For example, Larimore and Smith (1963) observed that the Sangamon River at Monticello displays less constant flow than it did before 1928. They noted that land drainage in the watershed led to quicker responses to precipitation and droughts with higher floods and reduced low flows. These changed conditions led to changes in fish distributions, specifically the loss of intolerant species. Smith (1971) noted that reduced summer low flows became more noticeable statewide after 1930 and that these had definite negative effects on headwater and creek fish species.

Hydrologic regime changes also came about due to urbanization and stream channelization. The construction associated with cities and towns leads to increases in impervious area and efficient systems to remove runoff. These led to large increases in the volume of stormwater carried to downstream streams and rivers, especially for small storms that would not cause runoff under more natural conditions, and higher peak flows. Likewise, channelization increases peak flows as it allows flood waves to pass more quickly through the basin (Campbell et al. 1972). The relative effects of hydrologic changes tend to be greatest in small streams, steep basins, and during fairly frequent events (Knox 1977).

The changes in the tributary hydrologic regimes translated downstream into a more uneven delivery of water to the Illinois River, especially for flows associated with storm events. Additionally, the construction of navigation dams and diversion of flows from Lake Michigan increased the river water surface elevation and have altered the nature of the flooding regime along certain reaches of the river. The diversion flows, as well as the possible increase in tributary flow volumes from a reduction in basin-wide annual evapotranspiration rates, lead to the probability that river flow volume increased. Between 1902 and 1928, levees were constructed to increase human use of the floodplain; these levees changed the hydrologic nature of the river system by preventing out-of-bank flows from expanding across significant portions of the floodplain, subsequently changing flood profiles and recession rates along the river (Mulvihill and Cornish 1929 in Havera and Bellrose 1985, Sparks 1995).

It should be noted that changes in rainfall patterns have also contributed to changes in Illinois River Basin hydrologic regimes (Ramamurthy et al. 1989). The CTAP (1994) noted that higher precipitation in the period 1966 to 1991 led to 13 to 20 percent higher average flows and 50 percent higher peak flows at many northern Illinois stream gaging stations. Agricultural landscapes tend to be particularly sensitive to climatic variability (Knox 2001) and so potential climatic shifts must be considered when evaluating hydrologic regime changes.

b. Existing Conditions. Changes in the Illinois River Basin have led to increased variability in most aspects of the hydrologic regimes experienced by the river and its tributaries. In general, stormflows in the basin are currently higher than occurred under pre-development conditions due to land use changes and increased efficiency brought about by channelization, drainage, and urbanization. High flows lead to increased physical stress on organisms, decreased habitat quality, and increased transport of sediment to the river. Low-flow conditions have also become more ecologically stressful, especially in smaller streams. These small streams are often unstable aquatic environments because of extreme water level fluctuations and desiccation during dry periods; for example, stagnant pools in small streams commonly experience temperatures exceeding 90 degrees Fahrenheit (Larimore and Smith 1963, Rhoads and Herricks 1996). Some exceptions occur in streams fed by relatively steady effluent discharges (CTAP 1994) or certain tile drain outlets (Rhoads and Herricks 1996).

The loss of connectivity between the main stem river and its floodplain has also affected the hydrologic regime of the river. Levees were constructed along the river to protect valuable urban and agricultural land from flood, but in doing so, the main stem river has been isolated from its floodplain in certain areas. This isolation, or lack of connectivity, is addressed further under Goal 4. Hydrologic variability on the main stem river is most evident in its water level records. For the purpose of this report, water level fluctuations (or "bumps") are defined as having the following characteristics:

- Elevation differences of 0.5-foot or greater,
- Occur within either 6-hour, 24-hour, or 5-day time periods, and
- Can be characterized as either increases or decreases.

Please note that during our analysis, water level fluctuations were characterized using both 2-hour and daily water level data. The frequency of the source data will be noted in the following discussion.

The ecological impact of these fluctuations is based on the time of year in which the fluctuation occurs; therefore, the fluctuations for any given year are categorized by season. For this analysis, the "summer" occurs from July 1 through November 15 (also referred to as the "growing season"), the "spring" is evaluated from March 1 through May 15, and the remaining portion of the year is referred to as the "winter." Both the "summer" and "winter" time periods encompass a limited amount of time outside of "summer" or "winter." These definitions will be used throughout this section.

The magnitude and frequency of water level fluctuations have notably increased in portions of the river since daily water level monitoring began in the 1880s . This difference is especially pronounced during the growing season (July 1 to November 15) as indicated in figure 3-37. During the pre-1900 growing seasons at all four gages in figure 3-37, there were very few fluctuations larger than 5 feet and the water levels were relatively low compared to the rest of the year. By examining the 1988 to 1992 flow data, it can be seen that large fluctuations occur throughout the year, which indicates that the flow regime has changed throughout the basin. It is possible that some of the changes in water level fluctuations are due to alterations in land cover throughout the basin.

The quantities of historical, observed, and modeled water level fluctuations of 0.5-foot or greater between daily readings, or over periods of up to five consecutive daily readings, during the growing season are compared in table 3-46. Data used in the table are from the Illinois River Ecosystem Restoration Water Level Management Analysis (USACE 2004a). The number of tributary induced fluctuations at each gage was determined using a hydraulic model of the Illinois River main stem with the observed flows but simulating the removal of the influence of the navigation dams. The hydraulic model is discussed in the section *Formulation of Alternative Plans.*

Table 3-46. Comparison of Historical Water Level Fluctuations (Pre-1900) With Observed and "Tributary Induced" Water Level Fluctuations (WY 1990 to 1997) During the Growing Season Using Daily Data

	24-Hour Fluctuations			5-Day Fluctuations		
		Current Conditions			Current Conditions	
Gage Location	**Pre-1900**	**Observed**	**Tributary Induced**	**Pre-1900**	**Observed**	**Tributary Induced**
Marseilles	no data	33	20	no data	34	26
Henry [1]	3	4	4	6	10	12 [2]
Peoria L&D (pool)	no data	8	3	no data	13	11
Copperas Creek/ Kingston Mines	2	19	7	5	21	15
Havana	2	12	5	7	19	13
Beardstown	1	8	3	5	13	9
La Grange L&D (pool)	no data	9	5	no data	13	10
Meredosia	4	15	7	7	22	15

[1] Observed Data for this gage are from water years 1990 to1996.
[2] The number of tributary induced water level fluctuations at the Henry gage is greater than the number of observed water level fluctuations possibly because tributary induced water level fluctuations were obtained using a computer model of the system or our operations are attenuating the natural fluctuations experienced on the main stem.

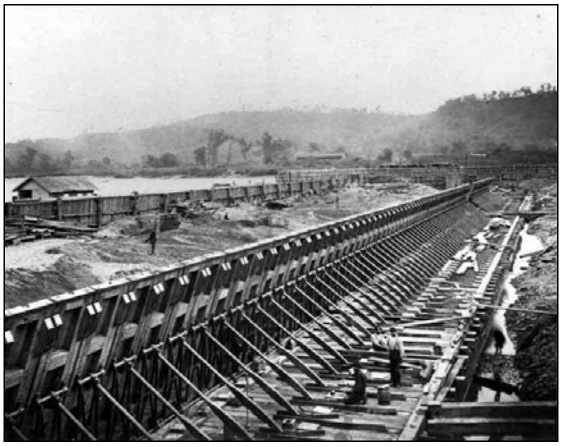
One source of water level fluctuation on the main stem is the episodic input of stormflows from the drained and developed watersheds of tributary streams feeding the river (Sparks et al. 2000). The altered tributary flow regimes contribute to rapidly rising and falling water levels and more uneven delivery of flows to the Illinois River. Table 3-46 displays a model estimate of the increase in river fluctuations that can be attributed to the altered tributary flow regimes. Flow changes arising out of growing season storm events cause water levels to quickly rise along the main stem river. Once the storm event is over, flow rates decrease and the water levels also fall. Storm water from Chicago has the potential to significantly impact water level fluctuations in the upper areas of the Illinois River.

Another potential fluctuation source is water level management activity (Appendix C). Management-related water level fluctuations are generally most evident in the upper regions of the pool including the tailwater of the upstream dam. These fluctuations are often attributable to gate adjustments at navigation dams (Pegg 2001, Koel and Sparks 2001). While the fluctuations resulting from management activities at all the dams along the main stem are important, the water level fluctuations associated with the wicket dams at the Peoria and La Grange Lock and Dams are distinct.

Photograph 3-7 shows the wicket dam at Peoria and photograph 3-8 shows the construction of a similar wicket dam on the Ohio River. Wicket dams are operated so that during periods of high water levels, the “wickets” lie on the bottom of the river and water flows unimpeded over them (this is referred to as “open pass”). Open pass conditions are purely a function of flow. As water levels decrease, the “wickets” are manually raised and the navigation pool is created. This is done to ensure that the nine-foot depth required for river navigation exists. When wicket dams are raised and lowered, it is possible that significant water level fluctuations may result. The response to wicket dam operations is less noticeable in the pool than it is in the tail water (below the dam). As the wicket dam is raised, the tail water drops significantly. The computed induced fluctuations in the tail water at Peoria and La Grange are 2.3 and 3.0 feet, respectively.

Figure 3-30 shows the pool and tailwater water levels at Peoria for water year 1995. Please note the abrupt changes in water levels during the wicket operations. During Water Years 1979 to 2000, there were approximately 194 wicket operations (either raising or lowering) at Peoria and 168 at LaGrange. This results in an average of 8.4 and 7.3 wicket operations per year at Peoria and LaGrange, respectively. A single tainter gate was installed at each dam in the early 1990s (photograph 3-9). The tainter gates were not designed to affect the frequency of wicket operations; they were installed to make it easier to operate the wicket dam and adjust the flow through the structure, thereby providing better control over the dam releases (USACE, 2005).

Photograph 3-7. Existing Wicket Dam at Peoria Lock and Dam



Photograph 3-8. Construction of Wicket Dam on the Ohio River

Photograph 3-9. Existing Tainter Gate at Peoria Lock and Dam

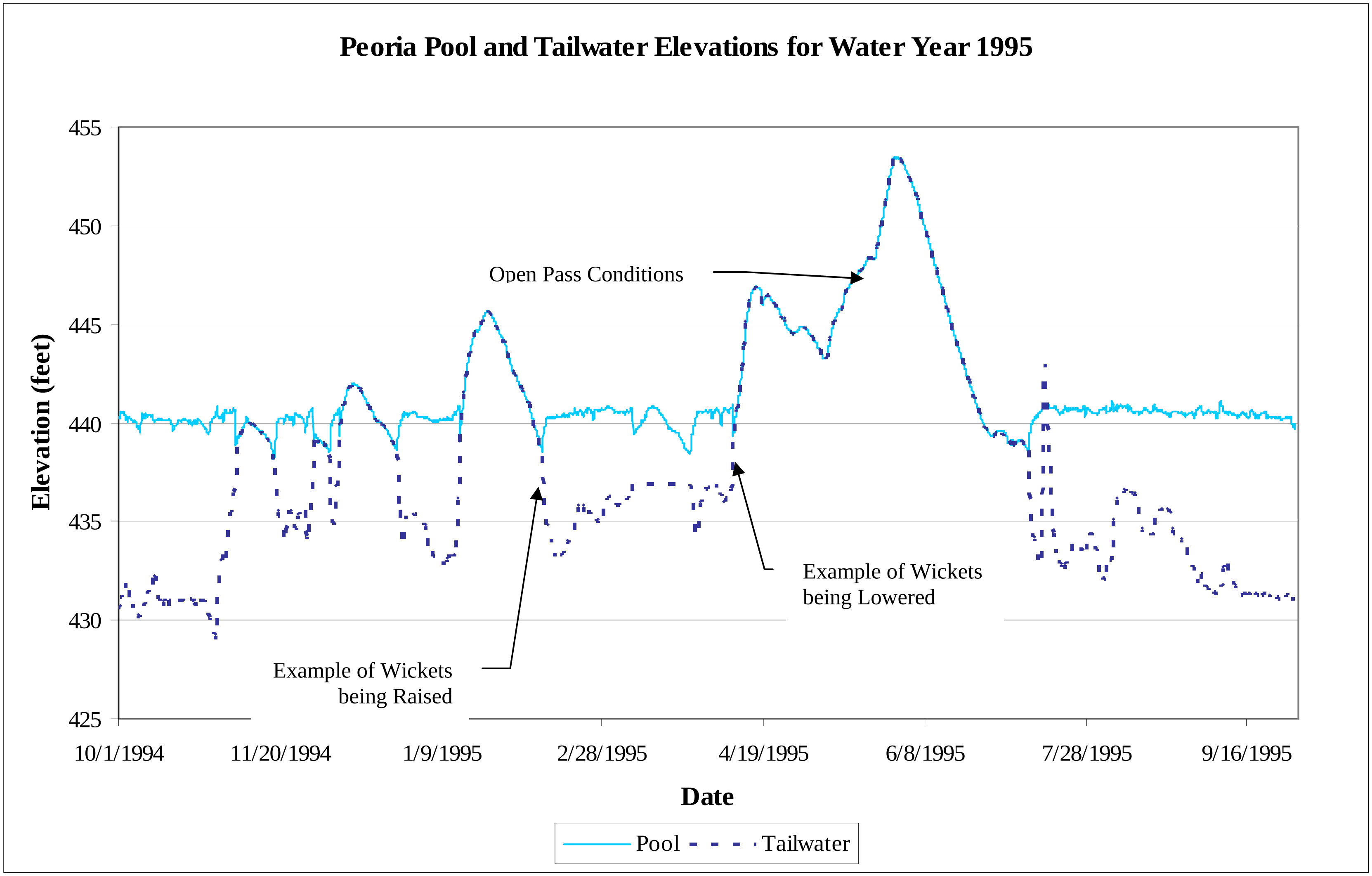


Figure 3-30. Water Level at Peoria Lock and Dam

Water level fluctuations during any part of the year have the potential to strand Illinois River fish or force them to move to avoid stranding (Koel and Sparks 2001, Raibley et al. 1997). Summer water level fluctuations can be especially stressful on aquatic plants (Sparks et al. 1998). Koel and Sparks (2001) found that the increased fluctuation rate seems to favor non-native fish species. Water level fluctuations also have the potential to drown moist soil plants which become established in mid to late June. To serve as a food base and cover for numerous species, these plants must not be inundated for a period long enough to produce seeds (approximately 70 days).

Researchers have noted that more gradual water level rises and falls would benefit a number of organisms. For example, Koel and Sparks (2002) indicate that water level changes should not exceed 0.13 to 0.17 feet per day to minimize fisheries impacts. Also, Atwood et al. (1996) recommend that water level rises not exceed 0.2 feet per day to avoid drowning out emergent vegetation.

Although the increased hydraulic variability has negatively affected the ecological function of some portions of the river, the reduction of hydrologic variability upstream of the dams has had negatively impacts on the ecological function of certain floodplain areas. Each dam keeps the water level in the pool upstream high enough to ensure a 9-foot navigation channel, and, as a result, the floodplains immediately upstream of each dam are far more continuously inundated than they would be under undammed conditions (Sparks 1992). The lack of a flood cycle in these areas acts as a disturbance for the river-floodplain system (Sparks et al. 1990).

These stable water levels limit the consolidation of sediment, leading to higher potential for resuspension, and prevent many native plant species from revegetating. This eliminates the seasonal drying of the sediments that favored the establishment of vegetation in these areas (Sparks et al. 2000). A decrease in the number and regeneration of mast trees has been observed in the areas upstream of the dams. However, the annual flooding regime at the upper end of the pools, where inundation effects are diminished, is often similar to that experienced under undammed conditions (Sparks 1995).

c. Future Without-Project Conditions. Several factors, most notably potential changes in land cover, land use, and climate, play major roles in the future hydrologic regimes throughout the Illinois River Basin. The flows from agricultural lands will be influenced by the extent to which conservation practices are implemented. With the exception of conservation practices, the usage of land in agricultural areas has been fairly constant recently because all suitable areas are being utilized. Tiling projects are expected to continue being implemented in the foreseeable future, while the development of new channelization projects is expected to decrease.

Tributary hydrologic regimes will continue to exhibit high peak flows and low baseflows that stress aquatic biota. These conditions will likely become more stressful in areas that experience increased urbanization. Without site-specific water level manipulation (drawdown), certain backwater and floodplain areas are likely to either continue to degrade or maintain relatively low levels of ecological function.

The current lack of aquatic connectivity between the main stem and its floodplain is likely to remain the same. Some studies are currently underway investigating limited connectivity in several locations. The amount of urbanized land in the basin will continue to increase, and the ecological benefits from stormwater controls are likely to be limited, especially on the main stem, unless efforts are made to control volume by implementing a large number of infiltration practices. While it is impossible to predict changes in climatic conditions, it is possible that some changes may lead to more extreme hydrologic regimes that could drive ecological processes to and over thresholds.

The successful implementation of planned stormwater control projects like the Tunnel and Reservoir Project (TARP) and the Chicago Underflow Project (CUP), may reduce some of the peak flows entering the river from northeastern Illinois, but increased development, even with peak flow control requirements, may increase the volume of storm water entering and the high water fluctuations of the Illinois River Diversions from Lake Michigan are expected to continue.

d. Desired Future Conditions. The desired future conditions would naturalize the water level conditions that would restore ecological function in the Illinois River Basin. This does not necessarily require a return to any particular prior state, but rather creating conditions that allow ecosystem functions to sustain themselves at an acceptable level given the constraints of multiple uses throughout the basin. Rhoads and Herricks (1996) describe this concept as “naturalization.”

Regarding tributary flows, the current state of knowledge suggests that flow regimes with reduced peak flows and increased baseflows would provide more desirable levels of ecosystem function than currently occur. The Lieutenant Governor’s Task Force (Kustra 1997) identified an initial goal of reducing tributary peak flows by 2 to 3 percent. The reductions necessary to meet this goal are shown in table 3-47.

Table 3-47. Tributary Peak Flows Estimated From USGS Flow Records

			Approximate Flow Recurrence (cfs)					
			Historical Averages		**2.5% Reduction**		**20% Reduction**	
Tributary	**Record**	**Years**	**2-yr**	**5-yr**	**2-yr**	**5-yr**	**2-yr**	**5-yr**
Des Plaines River at Riverside	1914-2001	88	4070	5500	102	138	814	1100
Fox River at Dayton	1915-2001	86	13900	18100	348	453	2780	3620
Kankakee River near Wilmington	1915-2001	87	24600	37500	615	938	4920	7500
Mackinaw River near Green Valley	1922-2001	79	8030	16000	200.8	400	1606	3200
Macoupin River near Kane	1921-2001	74	10200	17500	255	438	2040	3500
Sangamon River near Oakford	1910-2001	84	24100	36300	603	908	4820	7260
Spoon River at Seville	1916-2001	85	12700	20700	318	518	2540	4140
Vermilion River at Lenore	1931-2001	71	13000	20800	325	520	2600	4160

Although the precise relationships between regime components and ecosystem functions have not been fully developed, it was decided that a peak flow reduction exceeding 20 percent would be necessary to sufficiently modify the flow conditions that are currently degrading tributary ecosystems based on expert opinion. Likewise, a significant baseflows increase, 50 percent above the current levels, is desired to reduce low-flow stress to stream organisms. As a basis for project implementation, it is necessary to document and analyze the factors that lead to undesirable hydrologic conditions, and assess these factors basin-wide.

Although there is a significant desire to moderate the rate of rise and fall along the main stem Illinois River, the storage available within the system is very small relative to the flows in the river (USACE 2004a). Although the lack of storage makes it difficult to affect the hydrologic regime of the main stem, the desired future conditions include a reduction in the incidence and speed of water level changes.

Reducing the number of water level fluctuations would likely provide multiple benefits to native biological communities. These benefits would be especially significant during the time of year beginning after the recession of the spring flood in May and extending through the late growing season in October. The objective identified is to reduce the number of daily water level fluctuations exceeding 0.5 feet to levels observed in the 1890s during both growing season and winter time periods. One specific measure that would reduce fluctuations is a reconstruction of the wicket dams so that the dramatic water level changes associated with their operation can be removed. Another specific measure that would reduce the magnitude of water level fluctuations near the lock and dam structures at Peoria and LaGrange is to install an additional tainter gate at each of these locations. Although the addition of a single tainter gate at these structures would probably not decrease the number of fluctuations, it would minimize the effects of raising and lowering the wickets downstream of the dam. Reconnecting the river mainstem to its floodplain may also reduce the number and magnitude of water level fluctuations along the main stem. Future study is required in this area.

Temporarily lowering water levels in the Illinois River navigation pools would provide ecological benefits to areas of the pools that are continually inundated under current conditions, allowing sediments to consolidate and encouraging reestablishment of vegetation. Significant consolidation and benefits to plant growth have been observed in drawdowns in Illinois River and Mississippi River backwaters (Dalrymple 2000, Edwards 1988) and elsewhere (Fox et al. 1977). The desired future condition would be a successful drawdown lasting at least 30 days once every 5 years in the Peoria Pool, and once every five years in the La Grange Pool.

2. Formulation of Alternative Plans

a. Approach/Assumptions. Restoring basin-wide hydrologic regimes requires a systematic approach because of the downstream propagation of flow conditions and impact on sediment transport and channel stability. Illinois River tributaries influence ecosystem characteristics throughout the basin, and tributary flows significantly affect main stem conditions. As such, any attempt to restore the Illinois River hydrology would require a considerable amount of work to improve tributary conditions. At the same time, analysis has indicated that it would be prohibitively expensive, if not impossible, to restore conditions along the Illinois River main stem solely by improving tributary conditions, so improvement along the main stem would require management along the river itself. The final restoration plan; therefore, must include a mix of tributary and main stem measures.

As has been noted elsewhere, this program is being proposed to augment existing efforts and not to replace them. For example, urbanization will continue to increase the instability of tributary and main stem hydrologic regimes if stormwater management strategies that control volumes as well as peak flow levels are not implemented for future development activities. Projects within the Illinois River Basin Restoration program will be developed from ongoing and future watershed planning efforts that identify the suite of practices necessary to benefit hydrologic conditions in each particular watershed. To the extent possible, these projects will be coordinated with work being accomplished under other programs to support the overall basin restoration goal. The alternatives detailed in this report identify the potential measures to be constructed under this program as a part of the overall restoration effort.

Implementing projects to promote more favorable hydrologic regimes would require a number of planning tools developed at the program level (above and beyond the work detailed in these alternatives). Project evaluation will rely on a well-calibrated watershed hydrology model for the entire basin linked to an unsteady-state hydraulic model of the main stem river; this will be used to assess expected benefits and compare the cost effectiveness of various alternative configurations. The basis for the watershed model has already been developed using the USEPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model, and it is expected that sediment modeling capability would also be incorporated into the model. One of the major components of BASINS that was used in the analysis of various storage and infiltration scenarios is the Hydrological Simulation Program – Fortran (HSPF). A program called One-Dimensional Unsteady Flow Through a Full Network of Open Channels (UNET) was used to develop a basic hydraulic model for the main stem Illinois River. A FORTRAN program was written to calculate the number of water level fluctuations for the observed data and the various alternative scenarios studied.

In some cases, hydrologic changes may have the potential to lead to downstream sedimentation issues, so sediment transport issues must be addressed in the design of all of the measures implemented for this goal. Ongoing flow and water level monitoring at appropriate locations is also necessary to evaluate projects and adapt project objectives based on changing conditions. The need for flow monitoring on small tributaries is crucial to evaluating basin-wide conditions due to the large percentage of the basin that drains directly to low-order streams. Also, implementation would use the computerized inventory and analysis system developed for this project to evaluate potential projects and determine the benefits of constructed projects.

b. Criteria and Constraints There are several constraints that must be considered when formulating plans to influence water levels on the Illinois River, the first of which is that there is very little floodplain storage available on the Illinois River main stem, as was discussed earlier in this goal. Another constraint is that the 9-foot navigation pool must be maintained throughout the entire year. This influences the level to which pool drawdowns may be attempted. Most of the land adjacent to the Illinois River and its tributaries is in private ownership, which can limit where restoration measures are constructed. The levees which exist along the main stem isolate the river from its floodplain and can limit the effect of restoration efforts. The diversion of water from Lake Michigan into the Chicago Sanitary and Ship Canal, which then flows into the Illinois River, is an additional constraint that must be considered. The storm flow from the Metropolitan Water Reclamation District is another constraint.

c. Measures

i. Tributaries. Two systematic approaches were evaluated to meet the tributary objectives of reducing peak flows and increasing base flows. The first approach is to increase the volume of stormwater storage available within each tributary watershed so that runoff from relatively small events, including those expected to occur every 2 five years or more frequently, is temporarily retained before being released downstream. This storage might take various forms, including tile management, detention structures, or expanded riparian areas that provide ecological benefits in addition to flood storage. The second approach is to direct runoff to areas where it can infiltrate into the soil and recharge groundwater. Infiltration requires the proper soil and subsoil conditions; but if conditions are appropriate, it could be incorporated within tile management, conservation practices such as filter strips, or structures consisting of grassed fields enclosed within a berm. Infiltration can also be distributed throughout watersheds using practices that reduce runoff generation or allow runoff to infiltrate close to the point it is generated; the potential for such practices in an urbanizing area is discussed in the Blackberry Creek Watershed Alternative Futures Analysis (2003).

ii. Main Stem. Several measures were evaluated to determine the potential benefits they might provide to main stem water level regimes. Some of the tributary storage and infiltration measures evaluated in the previous section may reduce fluctuations, and other measures implementable on the river itself may also provide benefits. Different river management scenarios were studied, including “optimal” management. Reconfiguring the wicket gates and pool drawdowns at the Peoria and LaGrange lock and dams were also analyzed. This is discussed further in the following section.

d. Alternatives. Alternatives were developed using measures to address five types of hydrologic change: dam management, stormwater storage, infiltration, wicket dam modification, and pool drawdown. Measures that affect stormwater storage and infiltration would take place on the tributaries while measures that affect dam management, wicket dam modification, and pool drawdown would focus on the main stem. The measures were grouped to form plans that met the objectives for this goal to varying degrees. Implementation of these plans would rely on planning tools developed for this program but not budgeted here, specifically the computerized data inventory and analysis system and a fully calibrated hydrology and sediment model for the Illinois River Basin. Successful implementation also requires the continuation of conservation activities being undertaken under existing Federal and State authorities, as well as stormwater controls under the mandate of local authorities; expansion of these other efforts would increase the potential benefits to Illinois River Basin hydrologic regimes.

i. Tributaries. Alternatives that address tributary storage and infiltration are designed to reduce peak flows and increase baseflows. Since relatively common flood events are ecologically significant, it is appropriate to evaluate the change in intensity of 2- and 5-year events, as identified by the Lieutenant Governor’s Task Force. Tributary peak flow benefits for this study were quantified as the percent reduction in the 2- and 5-year events attributable to the measures. The benefits for improving tributary baseflows were quantified using the effect of the measures on the 90 percent exceedence flow (the level that average daily flows will meet or exceed over the long-term) expressed as a percent increase.

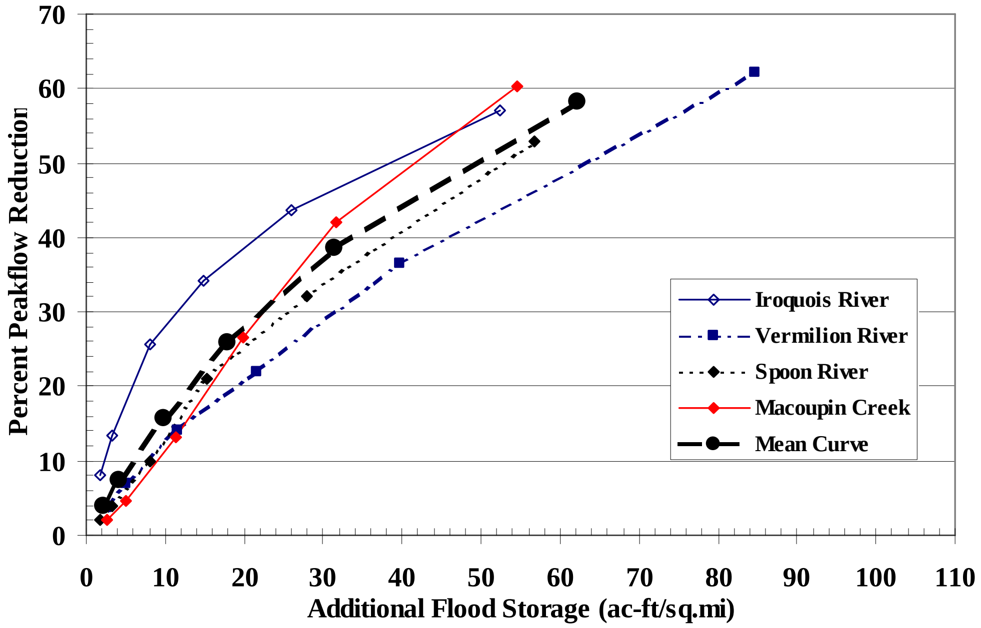
The various levels of storage and infiltration were evaluated by modifying the BASINS model of the Illinois River prepared by the Illinois State Water Survey (ISWS) (Appendix C-3). Model representations of several tributaries were modified to represent the hydrologic effects of either storage or infiltration, and predicted change in hydrologic conditions was evaluated by comparing simulated flows for these tributaries using the meteorological input data from the years 1970 to 1995 with the simulated flows for the same period without added storage or infiltration. The mean response from the selected tributaries was used to estimate the general basin response, and alternatives were generated assuming a similar response if the practices were applied to the approximately 30,000 square miles of the Illinois River Basin. Further model refinement will allow for more meaningful results.

The additional basin storage was simulated within the BASINS model as volume adjacent to basin streams but at an elevation slightly higher than the non-storm water level. Water depths during the range of flow events were used to determine the actual storage volume utilized during those events. This floodplain-like storage is expected to be a relatively efficient way to reduce peak flows, and so the storage-flow reduction relationships obtained represent a condition of fairly optimal storage distribution throughout the watershed; more volume may be required to meet the flow reduction goals if storage is distributed in a different manner. The infiltration scenarios were modeled, using the

BASINS model, by routing the runoff from a portion of the land area to special land segments that soaked in most of their inflow and discharged primarily through groundwater. This type of approach would not discriminate between infiltration methods (constructed facilities, filter strips, etc.) For modeling purposes, each acre of infiltration area received runoff from 19 acres of basin area, in addition to the precipitation falling on the infiltration area itself. There was no attempt to verify that appropriate areas were available either for the floodplain-like storage or for infiltration. Because of the setup of the ISWS BASINS model, changes in the Des Plaines watershed were modeled for neither storage nor infiltration. Also, because of difficulties with the model, the infiltration alternatives were not modeled in the Kankakee-Iroquois watershed.

The effectiveness of storage on reducing 2- and 5-year peak flows is shown in figure 3-31, and the effectiveness of infiltration is shown in figure 3-32. The mean curves in figure 3-32 represent the average peak flow reductions, in percent, for storage within the Iroquois River, Vermilion River, Spoon River, and Macoupin Creek watersheds. Although there is some variation, with the largest benefits in the Iroquois watershed, the mean curve indicates that an additional 3.0 acre-feet of storage per square mile of basin area would reduce 5-year peak flows by approximately 5 percent. This relatively small amount of storage is effective largely because it does not take a large volume of storage to shave the peaks off relatively frequent events. Figure 3-32 demonstrates that the percent reduction of peak flows would be nearly proportional to, but slightly less than, the percent of area treated by infiltration. The model results for the Vermilion, Spoon, and LaMoine River watersheds show very similar peak flow reductions.

(a) Reduction of 2-year flows



(b) Reduction of 5-year flows

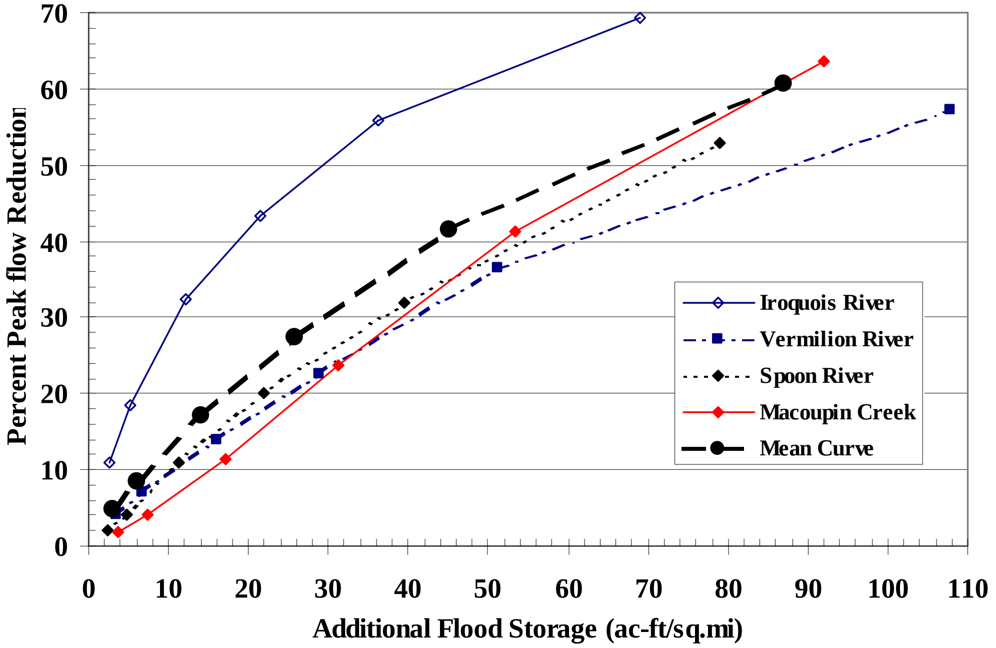
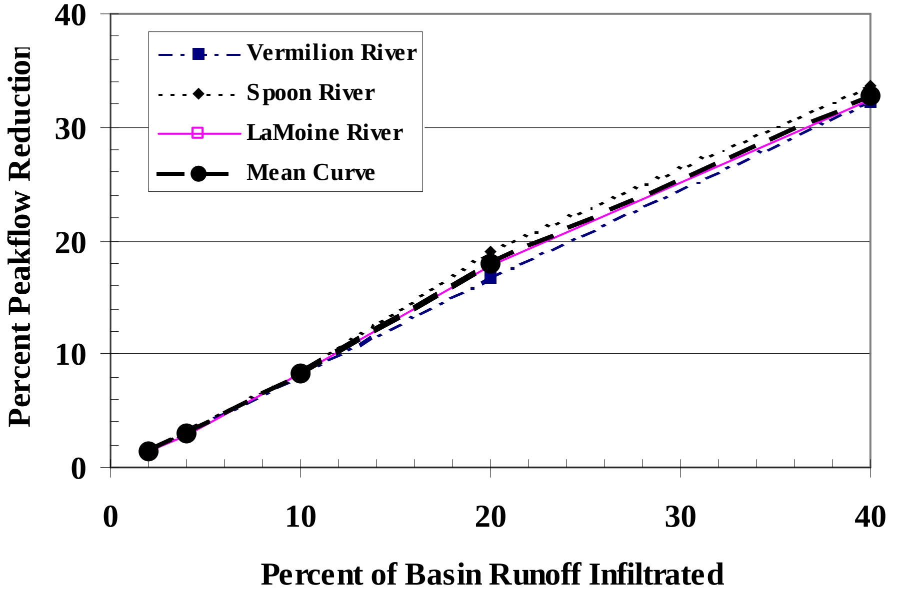


Figure 3-31. Potential Tributary Peak Flow Reduction for the (a) 2-Year and (b) 5-Year Flow Events With Additional Flood Storage Within Their Watersheds

(a) Reduction of 2-year flows



(b) Reduction of 5-year flows

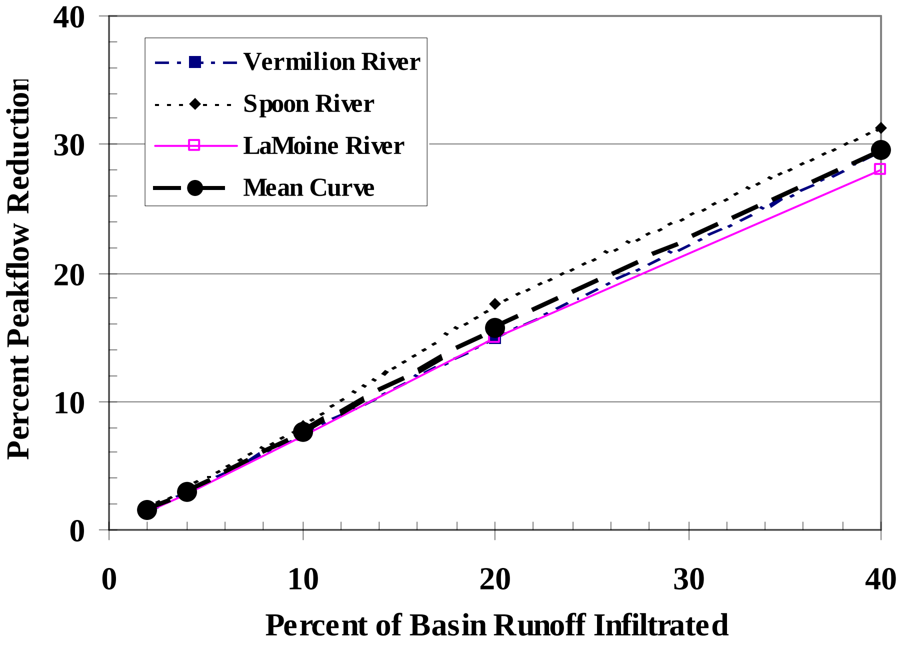


Figure 3-32. Potential Tributary Peak Flow Reduction for the (a) 2-Year and (b) 5-Year Flow Events With Additional Infiltration Within Their Watersheds

The values for the mean curves in figures 3-31 and 3-32 were used to calculate the benefits for various levels of program, implementation; figure 3-41 compares the relative effectiveness of infiltration and storage at reducing peak runoff flows. Using the assumptions that the infiltration facilities would be approximately 5 percent of their contributing areas and the floodplain wetlands are inundated to a depth of 1.5 feet during the 5-year event, the mean curves from figures 3-31 and 3-32 were adjusted to reflect the area required for each practice. Figure 3-33 shows that both practices are effective but that on a project footprint basis infiltration would provide a somewhat greater benefit per unit area than would flood storage. It should be noted that the relative effectiveness of each practice may change if designed under different assumptions, say infiltration facilities at 10 percent of their contributing basin or inundation depths of 2 feet. However, figure 3-33 is adequate to provide a basis for planning-level analysis. The two treatments should not be considered interchangeable because they may not be equally applicable in a given area; infiltration would not be available in basins with inappropriate soil conditions, and available land may limit the application of floodplain storage projects.

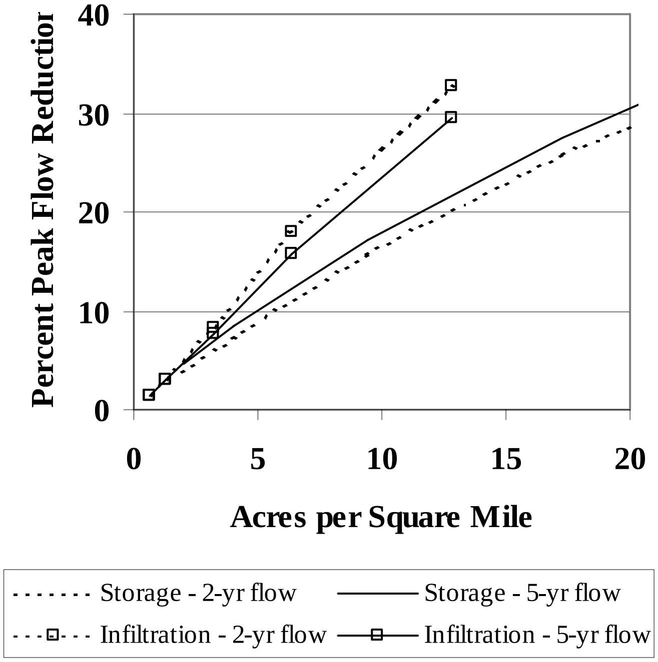


Figure 3-33. Comparison of Relative Peak Flow Reduction Effectiveness of Infiltration and Floodplain Storage Assumes storage depth of 1.5 feet during 5-year event and contributing area ratio of 20:1 for infiltration measures.

Figures 3-34, 3-35, and 3-36 illustrate the degree to which storage volume and infiltration lead to increased baseflows. Infiltration tends to be much more effective than storage at baseflows support. The per unit benefits of infiltration tend to decrease for scenarios exceeding 10 percent of basin runoff infiltrated. It should be noted that the Iroquois River, which showed the greatest baseflows benefits from storage, was not modeled for the infiltration scenarios due to problems representing infiltration areas in the model. It is likely that if benefits from that system were included, the mean curve in figure 3-43 and the infiltration curve in figure 3-44 would be somewhat higher.

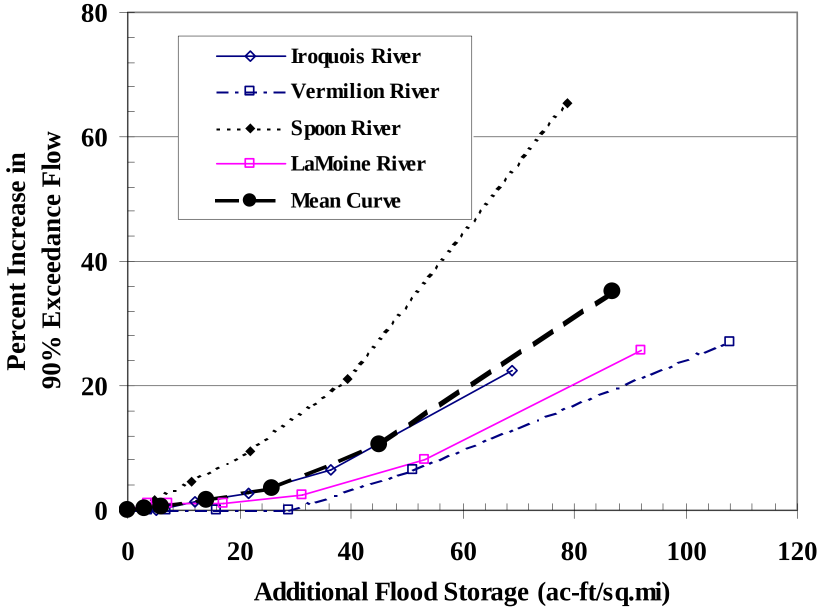


Figure 3-34. Potential Tributary Baseflow Increases With Additional Flood Storage Within Their Watersheds

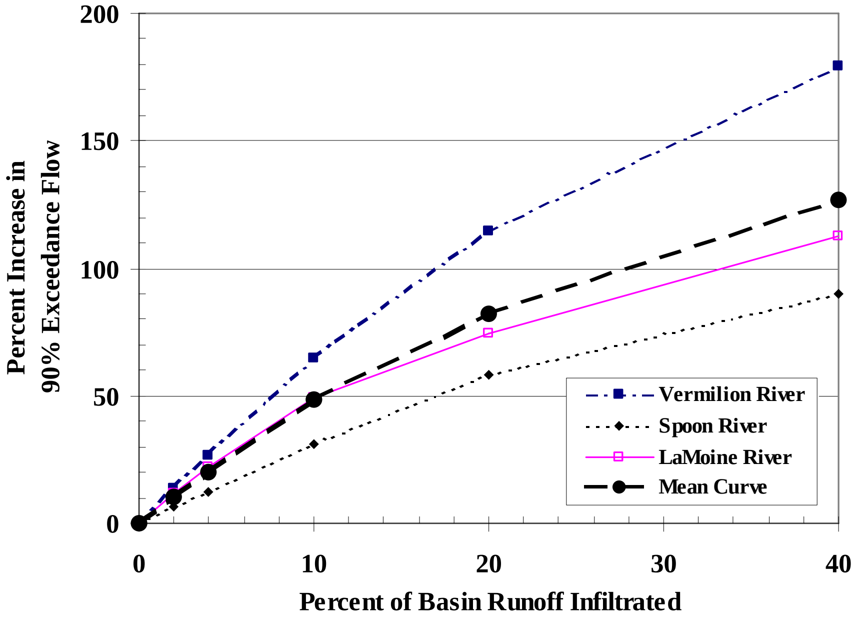


Figure 3-35. Potential Tributary Baseflow Increases With Additional Infiltration Within Their Watersheds

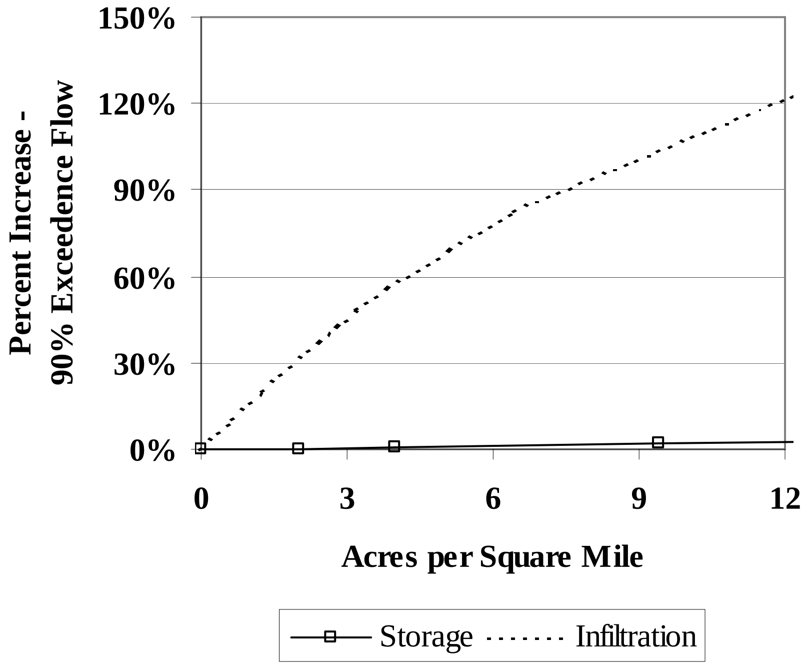


Figure 3-36. Comparison of Relative Tributary Baseflow Support Effectiveness of Infiltration and Floodplain Storage Assumes storage depth of 1.5 feet during 5-year event and contributing area ratio of 20:1 for infiltration measures.

Alternatives employing various levels of stormwater storage and infiltration area were developed using the above analysis.

ii. Stormwater Storage. Increasing the area available to retain peak flows along the tributaries would reduce the flashiness of tributary water regimes and may also provide benefits to the main stem. Five levels of basin-wide stormwater storage creation were considered for this program and are identified in table 3-48 (Plan R0 is the No-Action Alternative). The watershed model developed by the ISWS for the Illinois River Restoration Study was modified to represent storage areas adjacent to channels that capture low-level overflows. Figures 3-39 and 3-42 were used to determine the tributary peak flow reduction and the base flow increase, respectively, for each alternative.

iii. Infiltration. Infiltration represents another means to affect tributary hydrologic regimes, and in addition to proving effective at peak flow reduction, infiltration provides the additional benefit of augmenting low flows in the tributaries. Five levels of basin-wide implementation were considered for this program and are identified in table 3-49 (Plan I0 is the No-Action Alternative). Figures 3-40 and 3-43 were used to determine the extent to which the various alternatives would reduce the tributary 5-year peak flows and increase the tributary base flows, respectively.

Table 3-48. Stormwater Storage Alternatives

Plan ID	Additional Storage Created [1] (acre-feet)	Storage Area[2] (acres)	Storage Area[2] (miles)	Tributary Peak Flow Rate Reduction (%)	Tributary Base Flow Increase (%)
R0	NA	NA	NA	NA	NA
R1	27000	18000	28	1.5	0.1
R2	45000	30000	47	2.5	0.1
R3	90000	60000	94	5	0.3
R4	160000	107000	167	8	0.6
R5	375000	250000	391	16	1.6

[1] During a storm event with a 5-year recurrence interval.
[2] Assuming an average depth of 1.5 feet

Table 3-49. Infiltration Area Alternatives [1]

Plan ID	Area From Which Runoff Is Infiltrated (miles^2)	% of Basin From Which Runoff Is Infiltrated	Infiltration Area Required [3] (acres)	Infiltration Area Required [3] (miles^2)	Tributary Peak Flow Rate Reduction (%)	Tributary Base Flow Increase (%)
I0	NA	NA	NA	NA	NA	NA
I1	300	1	9600	15	0.8	5.2
I2	600	2	19200	30	1.5	10.4
I3	1200	4	38400	60	3.0	20.4
I4	3000	10	96000	150	7.6	48.5
I5	6000	20	192000	300	15.8	82.4

[1] During a storm event with a 5-year recurrence interval.
[2] Assuming an average depth of 1.5 feet.
[3] Assuming that infiltration facilities are developed with a 1:20 ratio of facility area to drainage area.

3. Main Stem. On the main stem Illinois River, alternatives were formulated to address dam management, wicket dam modification, and pool drawdown. Alternatives will be analyzed in terms of the following benefits: reduced fluctuations and area exposed by drawdown.

a. Fluctuations. The water level fluctuation effects of the alternative measures proposed for this goal were summarized in terms of fluctuations that occur in the three different portions of the year under the Existing Conditions section (please refer to that section for the characteristics of "water level fluctuations" as used here). For each time period, fluctuations that occur within 6-hours, 1-day, and 5-days were evaluated. Although for some measures, the water level changes may occur over a longer period of time than 1-day, thereby reducing the number of changes within 6-hour or 1-day time windows, the consensus of the study team is that such a "reduction" may not be very meaningful if the change still occurs within a 5-day period.

i. River and Dam Management. The current dam management strategy in place on the Illinois River is to control the navigation pools within a set band. The Water Level Management Analysis identified that a large percentage of small fluctuations downstream of dams arise because the current management strategy does not prevent significant flow changes at the locks and dams. This translates into water level fluctuations in the Illinois River. Improvements to allow lockmasters to monitor flows entering and within their pools, coupled with an ability to make smaller gate setting changes at more frequent intervals, would allow an increased degree of water level management. This was found to significantly reduce small water level fluctuations within the river. Once such an increased management strategy is in place, additional benefits may accrue from coordinated storm response.

Hydraulic modeling for the Illinois River Ecosystem Restoration Water Level Management Analysis (Appendix C-2) suggests that a number of management changes could reduce the number of short-term fluctuations occurring along the Illinois Waterway. Model results for a "optimal" management scenario indicated that the total number of fluctuations observed along the river would significantly decline. In many locations, such a management strategy would remove nearly all of the fluctuations not induced by inflows from the watershed. "Optimal" management includes increasing the frequency of dam gate changes (every two hours) and ideal knowledge of flows within and inflows to the river. Although ideal knowledge of flows and inflows is not feasible at this point in time and gate changes every two hours is impractical, "optimal" management has been used in this analysis as a planning tool while they system is being studied.

The reduction of water level fluctuations under "optimal" management would accrue almost entirely during low-water periods. Fluctuations due to higher flows or storm events would generally not be affected by this measure. Using the UNET model results (Appendix C-1), it is possible to develop quantitative estimates of potential benefits for this measure. Costs to implement include extra gaging, equipment upgrades to allow more frequent changes of gate settings, and the development of new regulation manuals.

"Optimal" management is used in this analysis even though it is an idealized situation and it is unlikely that it could be completely realized using today's technology. There are several limitations of the computer models that were used to analyze water level fluctuations under "optimal" management. These limitations include the inability to replicate the effects of wind and tow boats and the use of lockage water (the water required to transport water craft through the lock chamber at a lock and dam site). Tow boats can produce a localized wave of up to 1.08 feet and drawdown of up to 0.69 feet (Bhowmik et al, 1982). A 50-year wind with a 6-hour duration can produce a wave of up to 1.6 feet on the Illinois River (Bhowmik et al, 1982).

The Water Level Management Analysis investigated the potential to use available storage within the system to reduce fluctuations. Such a management measure would require the measures described for "optimal" management, such as ideal knowledge of inflows and gate changes every two hours, as well as centralized control of the locks and dams along the river and a computerized system to optimize storage on a real-time basis. At this time, the software routines required for the complex system optimization at real-time have not been developed, and only Peoria Pool has a large enough volume-to-flow ratio to provide the required storage area to significantly affect fluctuations. Using the small amount of storage available in Peoria Pool to reduce fluctuations in the Illinois River system may increase local fluctuations within Peoria Pool, which may not be desirable. As the technology becomes available to conduct real-time optimization, this management strategy may be able to provide some downstream benefits.

Stormwater control may have the potential to reduce the larger fluctuations associated with storm events in the reaches immediately downstream of the stormwater facilities. The Tunnel and Reservoir Project (TARP) and the Chicago Underflow Project (CUP), currently under construction in the upper parts of the basin, will likely provide stormwater benefits downstream, with the magnitude and timing of these benefits depending on the specifics of project operations. Preliminary modeling indicates that the TARP/CUP operations will likely reduce fluctuations to some degree as far downstream as Starved Rock. To be fully successful, stormwater controls would have to be implemented throughout the basin, as rapidly fluctuating downstream inflows can mask upstream improvements. Also, the flat slope of the river from Henry downstream reduces the effectiveness of stormwater control practices because it increases the time that stormflows have to be held back to eliminate fluctuations.

Figures 3-37 and 3-38 show the average number of water level fluctuations for historical, existing, and modeled scenarios for both the growing season (figure 3-45) and the winter (figure 3-46). Winter effects are analyzed for the following two time periods: November 16 through February 28 and May 16 through June 30. Systemic averages were determined from daily (pre-1900 data) and two-hour gage records and synthetic (UNET) gage records for Peoria Pool (the pre-1900 data uses the gage at Henry instead of Peoria Pool), Kingston Mines, and Meredosia. Daily pre-1900 records were divided by 0.7 to account for resolution effects when comparing to two-hour gage records. Changes to tributary inflows for each of the modeled scenarios were developed using the BASINS hydrologic model for water years 1990 to 1995 which were then used as input to the UNET hydraulic model of the main stem Illinois River. The unmanaged scenario represents the effects of current tributary flows independent of main stem water level management activities. "Optimal" management implies gate setting changes every two hours and ideal knowledge of flows within and inflows to the river. As discussed earlier, it is improbable that "optimal" management could be realized using today's technology, nonetheless, it is useful as a planning tool. "Optimal" management is a part of every management scenario because the UNET model uses that management strategy to predict the hydraulic effects of changes in basin conditions. High storage represents an additional 423,000 acre-feet of basin storage, while moderate storage represents an additional 90,000 acre-feet of basin storage. High infiltration represents infiltration of 20 percent of basin runoff, and moderate infiltration represents infiltration of 4 percent of basin runoff.

"Optimal" management would eliminate most of the fluctuations generated by water level management activities and reduce fluctuation levels to those caused by basin inflows alone. Increased tributary storage at levels of 10 acre-feet or more per square mile of watershed area would result in some reduction in fluctuations along the river, but even the highest levels proposed for this project are not sufficient to reduce fluctuations to pre-1900 levels. Infiltration at the proposed levels does not significantly reduce 5-day fluctuations along the main stem beyond the potential reduction due to water level management changes. In some cases, the number of water level fluctuations increase when infiltration areas are added to the system. This may be due to the way infiltration areas tend to extend the time period in which stormwater flows are released from the basin, which could influence the number of water level fluctuations resulting from consecutive storm events. Although increasing tributary storage volume and infiltration areas shows little or no effect in reducing short-term, minor water level fluctuations on the main stem, it is believed that local tributary benefits would result from both measures. Further study is required in this area.

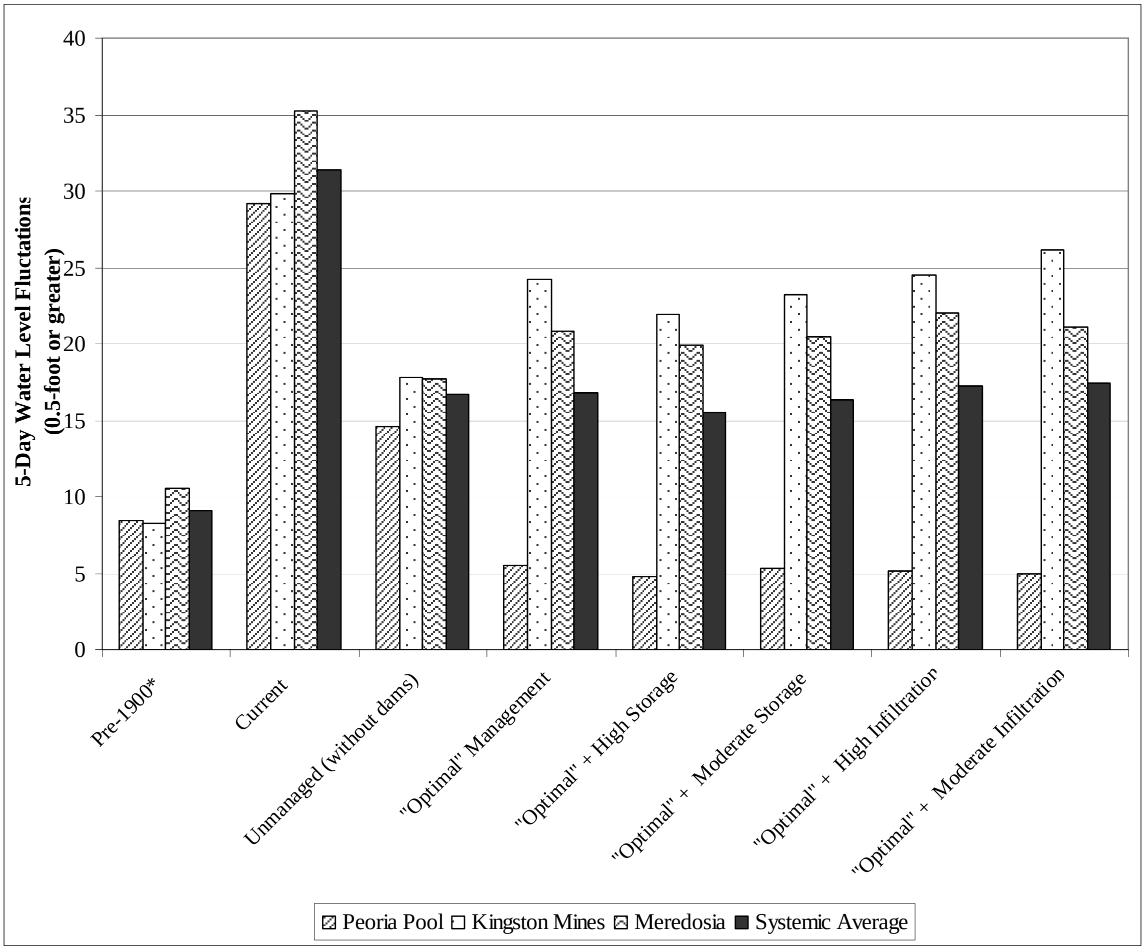


Figure 3-37. Growing Season Fluctuations Over 5-Day Windows Under Various Modeled Scenarios

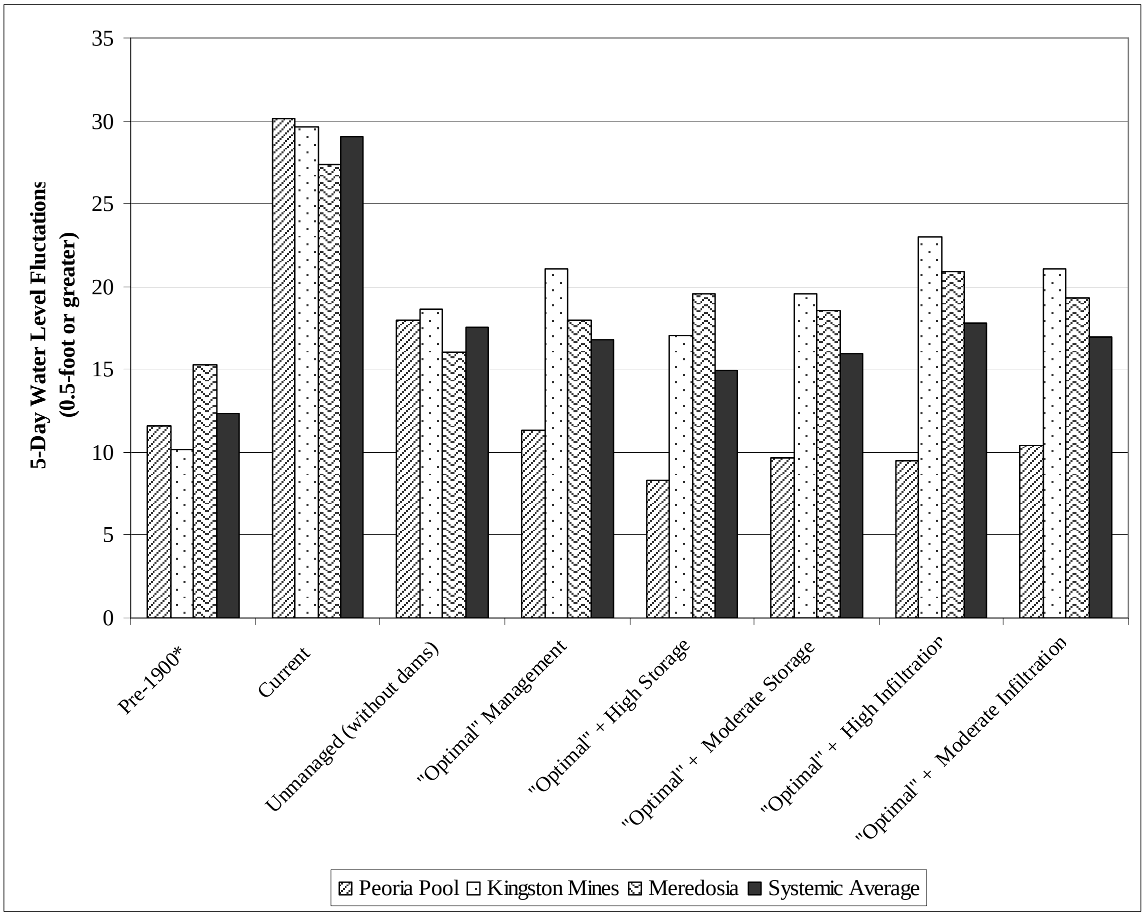


Figure 3-38. Winter Fluctuations Over 5-Day Windows Under Various Modeled Scenarios

The benefits shown in figures 3-37 and 3-38 are to some extent affected by the chosen benefit metric. The storage and infiltration measures are more effective at reducing the number of fluctuations within 24-hour time periods and at reducing the number of large fluctuations (one foot and greater), but the incidence of 5-day fluctuations of 0.5 foot or greater was felt to be a more stringent and accurate estimate of ecological benefit. These results strongly suggest that the landscape changes have changed the nature (and possibly the volumes) of the flows to the river to the extent that the hydraulic effects cannot be completely addressed by feasible watershed projects. The Illinois River is especially susceptible to such changes because its low slope accentuates water level changes under changing inflows. Therefore, under the levels considered here, the primary benefits from the infiltration and storage measures would accrue in the tributaries, not along the main stem. It is important to note that the “optimal” management scenarios represent a potential benefit, but it is likely that the actual benefit will be somewhat less because of the limitations imposed by real-world conditions. It is also likely that under somewhat less than “optimal” conditions there would be fluctuation benefits derived from infiltration or storage measures that would offset the non-optimal management conditions but cannot be recognized in this analysis due to the modeling limitations.

Three alternatives for dam management were considered for this program and are identified below:

- M0 – No action
- M1 – Increase frequency of dam gate changes with the aim of reducing low-water fluctuations; requires new regulation manuals, improved gage network (10) and increased capacity of operators to make gate changes (i.e. “Optimal” management)
- M2 – M1 + enact coordinated water control with the aim of minimizing fluctuations induced by storm events (i.e. centralize water control)

ii. Wicket Dam Modification. The operation of the wicket dams at Peoria and LaGrange induce significant water level fluctuations, both when the wickets are raised and when they are lowered. Totally eliminating these large fluctuations would likely require replacing the wickets with permanent structures, which would eliminate the ability to have open pass during periods of high water levels. Altering the method of wicket operation is not likely to significantly reduce the occurrence of these fluctuations. Although adding another tainter gate at either Peoria and LaGrange would probably not decrease the frequency of wicket operations at the dams, it would most likely reduce the magnitude of water level fluctuations that result from wicket operations. The computed induced water level fluctuations at Peoria and La Grange Lock and Dams with the addition of a single tainter gate at each dam are 0.5 and 1.1 feet, respectively (USACE, 2005). This represents a computed reduction in the magnitude of the water level fluctuations of 1.8 and 1.9 feet at Peoria and La Grange, respectively. Reconstruction of the dams, and replacement of all the wickets with tainter gates, could further smooth the fluctuations that currently occur during wicket operations and so would accrue benefits in the upper portions of the La Grange and Alton Pools.

The potential benefits from adding tainter gates would be a reduced intensity of the water level drops associated with gate raises because of the reduced need to hold back flows to build pool. Although adding a single tainter gate at Peoria and La Grange would not reduce the number of water level fluctuations (consequently the benefits in terms of water level fluctuations do not change), the reduction in magnitude of water level changes is significant and beneficial. Reconstructing the dams as permanent structures (i.e. replacing the wicket gates with tainter gates) may provide the opportunity to smooth water level changes enough to eliminate the fluctuations that would have occurred due to raising wicket gates. The benefits would occur at Kingston Mines and Meredosia, with maximum average reductions of 1.5 and 1.7 fluctuations per growing season, respectively, and 0.7 and 0.5 fluctuations per winter season, respectively. Effects due to the pulses from wicket lowering would be attenuated as well, but the benefits are not likely to be observable in the fluctuation metric because the rising water levels would generally induce fluctuations during a 5-day time window regardless.

The following six alternatives for wicket dam modification were considered for this program:

- WP0 – No action at Peoria dam
- WP1 – Add additional tainter gate at Peoria
- WP2 – Reconstruct wicket dam at Peoria to allow continuous dam operations
- WL0 – No action at La Grange dam
- WL1 – Add additional tainter gate at La Grange
- WL2 – Reconstruct wicket dam at La Grange to allow continuous dam operations

iii. Floodplain Storage. Potential fluctuation reduction benefits were investigated for floodplain management activities in the Peoria and La Grange Pools (please see Appendix C-4). Because of the historical loss of connected floodplain area, changes in flow are more restricted and these likely lead to a less stable water level regime than would occur if the additional area were available. Floodplain elevation is a key determinant of the nature of the benefits expected; to affect the water level changes occurring during low water, it is necessary for the available floodplain to be at or near flat pool elevations. Because of the interest in mitigating such low water fluctuations, the floodplain management analyses concentrated on scenarios that focused on making area available when the water level was relatively low.

The Hennepin Drainage & Levee District at RM 206 is the only significant contiguous area of disconnected floodplain within the Peoria Pool. That area is 2,900 acres protected from the river by an agricultural levee system. The UNET modeling indicated that making use of the leveed area to attenuate high flows could reduce maximum water levels at Henry, approximately 7 miles downstream, by as much as 0.5 foot, although all benefits depend on the design of the structure that would be used to divert flows into the district. Hydraulic modeling indicates that the area would be most effective at reducing fluctuations if its inlet weir is set just above level pool elevation (440 feet NGVD). With this design, the HDLD would reduce 5-day fluctuations downstream to the Peoria Lock and Dam (RM 158) by approximately 5 percent. Upstream reductions would be less (2 percent at Starved Rock Tail, RM 231), and downstream of the Peoria Lock and Dam the river would display 1 percent reductions or less. These benefits would be roughly additive when combined with work to restore tributary hydrologic regimes; if storage is added in the basin at levels of 10 acre-feet per square mile or greater, additional fluctuation benefits can be expected, but combinations with infiltration alternatives or low levels of storage are unlikely to display additional benefits beyond those attributable to the HDLD alone.

Modeling of floodplain storage in the La Grange Pool indicates somewhat smaller reductions in water level fluctuations from added storage area than the modeling of the HDLD. For this report, the Illinois State Water Survey used the UNET model to simulate a number of scenarios wherein different combinations of floodplain areas in the La Grange Pool were made available to attenuate low-level fluctuations, in the same way that the HDLD was modeled in Peoria Pool. Changes in the water level fluctuation regime were quantified at Kingston Mines, Copperas Creek, Havana, and Beardstown. The results of this effort suggest that although location-specific effects are significant, the fluctuation reductions due to the storage areas are roughly additive. The effects also diminish quickly with distance, and are much greater downstream from the added storage than upstream. Figure 3-39 summarizes the relationships developed from this analysis. Please note that the percent reduction in 5-day fluctuations is based on the average reduction under “optimal management” conditions based on UNET hydraulic modeling conducted by the Illinois State Water Survey.

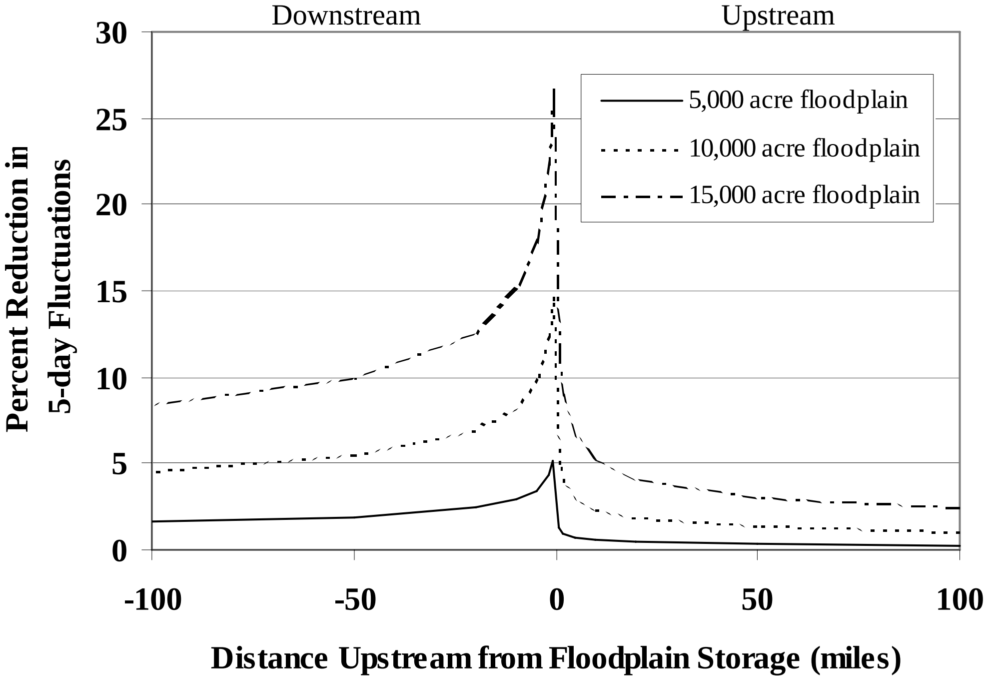


Figure 3-39. Expected Reduction in La Grange Pool Water Level Fluctuations Upstream and Downstream of Added Floodplain Storage

As figure 3-39 indicates, the incremental addition of floodplain storage areas in the La Grange Pool can have a large effect on local water level conditions, and there is sustained benefit downstream but benefits do not transmit a long distance upstream. For example, the addition of 15,000 acres at pool level would reduce fluctuations by 10 percent or more, under modeled conditions, for 50 miles downstream, but the fluctuation 10 miles upstream would be less than 5 percent. Locations with 5,000 acres or less would not be expected to reduce fluctuations anywhere by more than 5 percent. Large benefits can be expected only in the immediate vicinity of the floodplain projects, and to some degree downstream, and only if the total area exposed at low water is greater than about 10,000 acres.

No floodplain projects are recommended as part of this Goal for two reasons, (1) they are already addressed in Goal 3 and (2) the benefits realized from floodplain projects tend to influence only the local area. Some ancillary hydrologic benefits will be attained when floodplain projects are implemented to meet Goal 3. Some floodplain management activities may be considered as part of the effort to improve local conditions in the vicinity of other projects. For example, open areas of the floodplain could be created across the river from a habitat restoration project in an attempt to attenuate fluctuations. As part of a systematic effort, these results suggest that floodplain areas in the upper reaches of the pool may provide the most benefits; downstream areas would have little upstream benefits and it is likely that most of the fluctuation benefits do not pass downstream of the dams, when they are in operation. The Corps of Engineers has done some analysis of the effects of levee removal on the Mississippi and Illinois Rivers as part of the *Upper Mississippi River Comprehensive Plan for Systematic Flood Damage Reduction and Associated Environmental Sustainability* report which is still under review. Early results have shown that completely removing agricultural levees from the system could provide some reduction in water levels on the Illinois River in some locations. No analysis on water level fluctuations was performed as part of this study. Further study is required in this area.

b. Pool Drawdown. Several factors combine to determine the effects of a drawdown event, including:

- the duration of the event,
- the depth to which the water level is drawn down,
- the area of sediment exposed, and
- the month or season of drawdown.

Increased drawdown depth and implementation of added dewatering measures can increase sediment consolidation. It has been noted that 70 consecutive days with sustained low water conditions between July 10 and October 1 are required for optimal growth and establishment of moist soil plants (Bellrose et al. 1983), but benefits have been observed with drawdowns of lesser duration (Atwood et al. 1996). Seasonality is critical to the benefits achieved; drawdown during the winter may provide the benefit of sediment compaction, although it would not permit vegetation to establish.

Analyses for the UMR Navigation Study evaluated the potential for pool-wide drawdowns along the Illinois River. In that analysis, very little benefit was found in drawing down the river at points upstream of Starved Rock. Benefits were found at Peoria and La Grange, but a low probability of success was assigned to attempted drawdowns in those pools because flow conditions would prevent maintenance of a 2-foot drawdown for 60 continuous days between May and August in more than 50 percent of years. The Water Level Management Analysis conducted additional analyses of the potential for drawdown in the Peoria and La Grange Pools. Flow conditions during 30-day and 70-day time windows throughout the year were analyzed to determine the probability of maintaining drawdown during the entire window or for 30 consecutive days within each 70-day window. The values determined from this analysis are given in tables 3-48 and 3-49 as the “Full Success Rate” for the attempted drawdowns.

Main stem benefit analysis concentrated on the Illinois River from Henry to Meredosia. This reach contains most of the ecologically significant areas on the main stem, and downstream of Meredosia the river hydrologic regime becomes dominated by the backwater effects of the Mississippi River. Fluctuation benefits were generated for each pool, with the percent reduction at the Peoria Pool, Meredosia, and Kingston Mines gages representing Peoria Pool, Alton Pool, and La Grange Pool, respectively. The benefits at the three pools were averaged to develop a measure of systemic benefit.

Drawdown benefits were determined based on expected acres of exposure (the sum of the area exposed multiplied by the probability of success). Timing is crucial to ecological benefits of drawdowns, so a seasonal factor was used to adjust the benefits based on time of year. Drawdowns occurring between June 1 and September 1 were accorded a value of “1.0,” with the value of drawdown decreasing linearly to “0.2” on December 1 (figure 3-40). This factor is referred to as the “suitability” of the drawdown season.

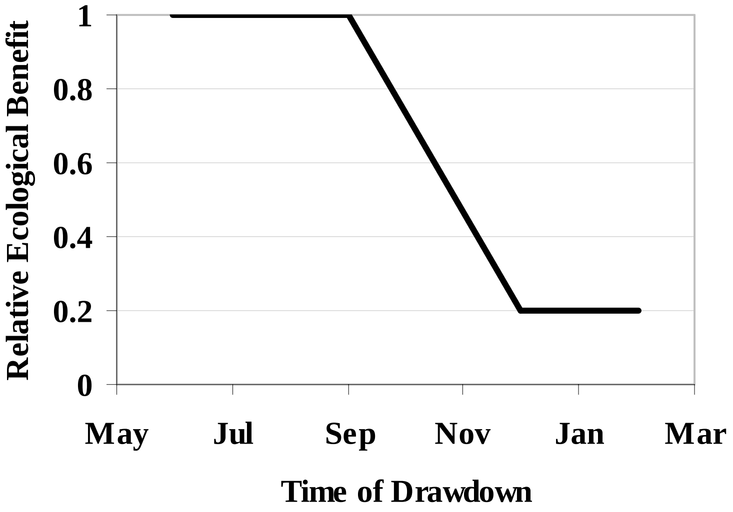


Figure 3-40. Assumed Seasonal Value of Drawdown Along Main Stem Illinois River

The probability of success combined with the suitability of the drawdown season and length of sustained drawdown provides a quality-weighted expected benefit factor of the drawdown. These values were calculated for the most favorable times of the year (tables 3-50 and 3-51). Combining these values with the average area of exposure, calculated using hydraulic modeling, provides the total expected benefits for the various drawdown scenarios (figures 3-41 and 3-42). Note that the uncontrolled scenario refers to the hypothetical situation in which main stem water level management activities have been removed from the system (i.e. no dams). The benefits quantified for the Peoria Pool used modeled exposed area: 3,000 acres for 1-foot drawdown, 8,000 for 2-foot drawdown, and 24,000 for uncontrolled drawdown. The values for La Grange use the modeled area exposed in the vicinity of the channel plus additional contiguous off-channel aquatic area identified for the Navigation Study totaling 4,300 acres for 1-foot drawdown, 8,600 for 2-foot drawdown, and 15,200 for uncontrolled drawdown.

The following formulas further explain this process:

Expected Benefit Per Acre = Suitability * Full Success Rate * Duration of Drawdown

Expected Drawdown Benefits = Expected Benefit Per Acre * Area Exposed by Drawdown

Table 3-50. Benefit Calculations for Peoria Pool Drawdowns

Starting Date		**Jun 1**	**Jul 1**	**Aug 1**	**Sep 1**	**Oct 1**	**Nov 1**	**Dec 1**
Suitability (30-day)		1.0	1.0	1.0	0.8	0.6	0.4	0.2
Suitability (70-day)		1.0	0.97	0.86	0.66	0.46	0.29	0.2
30-day attempt	Full success rate	0.15	0.3	0.6	0.65	0.65	0.55	0.4
	Expected benefit (per	**4.5**	**9**	**18**	**15.6**	**11.7**	**6.6**	**2.4**
70-day attempt	Full success rate	0.1	0.2	0.45	0.45	0.4	0.3	0.2
	Expected benefit (per	**7**	**13.6**	**27.1**	**20.8**	**12.9**	**6.1**	**2.8**
	30-day but not 70-day rate	0.4	0.6	0.4	0.4	0.4	0.4	0.55
	Expected benefit (per	**12**	**18**	**12**	**9.6**	**7.2**	**4.8**	**3.3**

Table 3-51. Benefit Calculations for La Grange Pool Drawdowns

Starting Date		**Jun 1**	**Jul 1**	**Aug 1**	**Sep 1**	**Oct 1**	**Nov 1**	**Dec 1**
Suitability (30-day)		1.0	1.0	1.0	0.8	0.6	0.4	0.2
Suitability (70-day)		1.0	0.97	0.86	0.66	0.46	0.29	0.2
30-day attempt	Full success rate	0.1	0.25	0.4	0.65	0.6	0.55	0.4
	Expected benefit (per	**3**	**7.5**	**12**	**15.6**	**10.8**	**6.6**	**2.4**
70-day attempt	Full success rate	0.0	0.15	0.3	0.45	0.4	0.25	0.2
	Expected benefit (per	**0**	**10.2**	**18.1**	**20.8**	**12.9**	**5.1**	**2.8**
	30-day but not 70-day rate	0.4	0.55	0.55	0.35	0.35	0.3	0.35
	Expected benefit (per	**12**	**16.5**	**16.5**	**8.4**	**6.3**	**3.6**	**2.1**

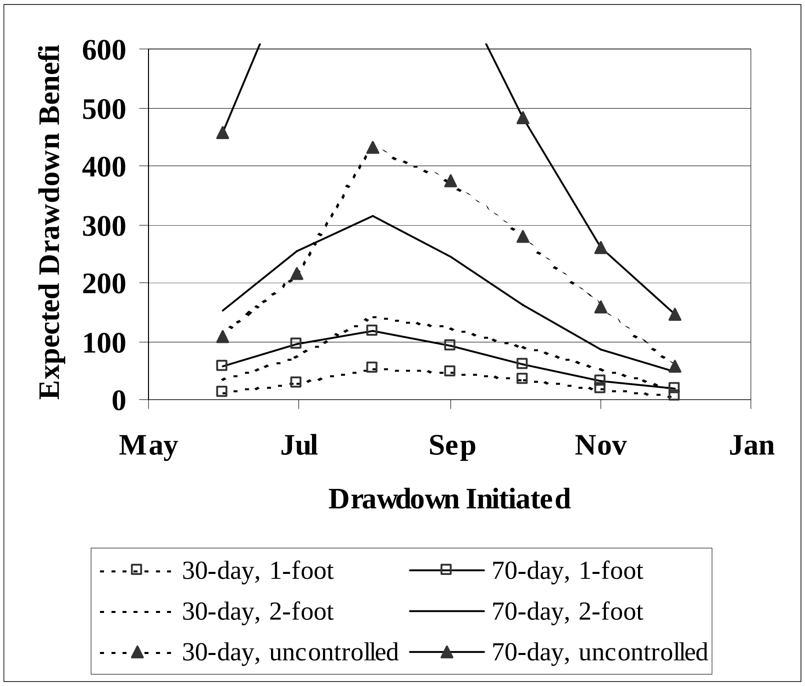


Figure 3-41. Expected Drawdown Benefits in Peoria Pool. Units are thousand quality acre-days.

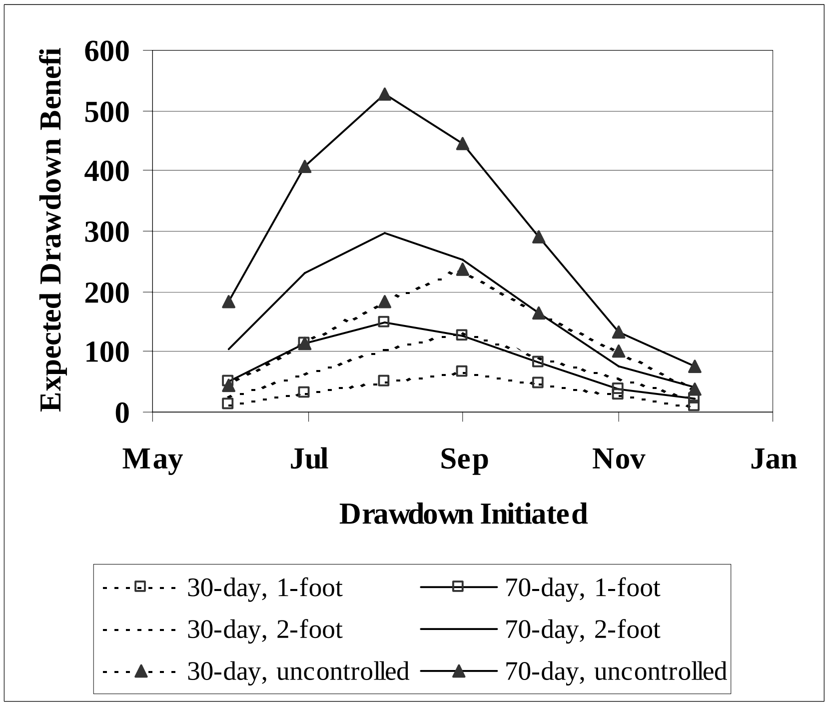


Figure 3-42. Expected Drawdown Benefits in La Grange Pool. Units are thousand quality acre-days.

Since the cost of drawdown is estimated using the long-term dredging requirements to maintain navigation with lower water levels, there is no incremental cost per drawdown attempt. For Peoria Pool, 2-foot drawdowns were chosen, but because of the likelihood of high dredging requirements, only a 1-foot drawdown was chosen for La Grange Pool. The individual measures were chosen based on the number of attempts to maintain at least 30 consecutive days of drawdown 10 times over 50 years.

Five alternatives for pool drawdown were considered for Peoria Pool (P) and seven alternatives for pool drawdown were considered for La Grange Pool (L). These alternatives are identified below:

- P0 – No Peoria Pool drawdown
- P1 – Attempt a 2-foot drawdown of Peoria Pool 2 years out of every 3 from Jul 1-30
- P2 – Attempt a 2-foot drawdown of Peoria Pool every 3 years from Aug 1-30
- P3 – Attempt a 2-foot drawdown of Peoria Pool 2 years out of every 5 from Jun 1- Aug 9
- P4 – Attempt a 2-foot drawdown of Peoria Pool every 4 years from Aug 1- October 9

- L0 – No La Grange Pool drawdown
- L1 – Attempt a 1-foot drawdown of La Grange Pool 4 years out of every 5 from Jul 1- 30
- L2 – Attempt a 1-foot drawdown of La Grange Pool every other year from Aug 1- 30
- L3 – Attempt a 1-foot drawdown of La Grange Pool 3 times every 10 years from Sep 1- 30
- L4 – Attempt a 1-foot drawdown of La Grange Pool every other year from Jun 1- Jul 9
- L5 – Attempt a 1-foot drawdown of La Grange Pool 2 years out of every 7 from Jul 1- Sep 9
- L6 – Attempt a 1-foot drawdown of La Grange Pool 6 times every 25 years from Aug 1- Oct 9

3. Evaluation and Comparison of Plans

A range of plans was developed by combining alternatives developed for dam management, stormwater storage, infiltration, wicket dam modification, and pool drawdown. The costs and benefits for these plans were estimated to allow evaluation of how well these plans meet the objectives of this goal and their relative cost-effectiveness. Based on this analysis, effective plans of different levels of effort were chosen for inclusion in the proposed system-level plans.

a. Costs. Costs for each of the alternatives were developed assuming a 50-year project life. Where possible, these costs were estimated using previously constructed projects or from other planning efforts, such as the Restructured Upper Mississippi-Illinois Waterway System Navigation Study. All construction costs include a 35 percent contingency, 30 percent for planning, engineering, and design, 9 percent for contract supervision and administration, and estimated real estate costs. Costs shown are in 2003 dollars.

Dam Management

M1 – Management improvements require three upgrades – initial cost $3.7M

- Place remote controls on rest of Illinois River dams (Marseilles already installed) – $5,629,500.
- Revise regulation manuals (7 total) - $108,000 each, for a total of $756,000.
- Install and maintain additional gages (10 total) - USGS initial cost $20,250 each, for a total of $202,500.

M2 – Navigation Study estimates $7,000,000 over 50 years. Assume initial cost of $1,000,000.

Storage (R1-R5)

Assume that each storage area would be on the order of 5 acres or more and a depth (during the design event) of 1.5 feet. Based on the cost estimate of a similar project, the construction cost for a floodplain pond was estimated to be approximately $6300 per acre-foot. Operation and Maintenance (O&M) Cost is estimated to be $5.00 per acre-foot per year.

Infiltration (I1-I5)

There are a variety of potential ways to develop infiltration facilities – assume half upland structures, half filter strip. Assume that each upland infiltration structure would be on the order of 5 acres or more. An upland structure/ filter strip project was estimated to cost $13,825 per acre, with annual O&M Cost of $6.75 per acre.

Wicket Dam Modification

Wicket dam modification would consist of replacing either 26 of the wickets with one tainter gate or all of the wickets (108 at Peoria and 109 at La Grange) with 4 tainter gates. One tainter gate was estimated to cost $26 million, with an annual estimated O&M cost of $30,000. Replacing the entire wicket structure with four tainter gates was estimated to cost a total of $300 million. The Navigation Study estimates that installing an additional tainter gate at either Peoria or La Grange (without removing any of the wickets) would cost approximately $13.9 million (USACE, 2005).

Drawdown

The Navigation Study estimated the cost to conduct drawdowns as the cost to dredge to maintain minimum channel conditions and access to facilities. This management would allow any number of drawdowns over the course of the project life. Preliminary estimates for Peoria Pool and La Grange Pool indicated that an additional 47,000 and 204,000 cubic yards of dredging would be required every 10 years to maintain navigation during 1.5-foot drawdowns of these two pools, respectively.

Because dredging needs were not determined for 2-foot drawdowns of Peoria Pool, it was assumed that such a drawdown would require twice as much dredging as the 1.5-foot drawdown. Likewise, it was assumed that the quantities required for a 1-foot drawdown of La Grange Pool would be the same as the dredging for a 1.5-foot drawdown. These assumptions lead to added channel maintenance dredging requirements of 470,000 cubic yards of material in Peoria Pool and 1,021,000 cubic yards in La Grange Pool over a 50-year time period.

Additional dredging would also be required to maintain facility access. USACE 2004a identified 12 marinas and 20 industrial facilities that would be affected by a drawdown in Peoria Pool and so would have to be dredged an additional 5 times over 50 years. The final cost estimate is $14.6 million to maintain 2-foot drawdown conditions in Peoria Pool and $22.9 million to maintain 1-foot drawdown conditions in La Grange Pool.

It should be noted that these costs do not reflect additional economic costs such as loss of recreation due to lower water levels. Also not quantified is the potential benefit from reduced future maintenance dredging. These issues will be addressed further in the project design phase.

b. Benefits. Quantifying hydrologic benefits under this goal requires consideration of multiple independent factors. Although the current understanding of Illinois River Basin ecosystem processes allows identification of several important aspects of the hydrologic regime, this understanding is not sufficient to determine many critical thresholds that are known to influence ecosystem integrity. In the absence of knowledge regarding thresholds, benefits are generally assumed to be directly associated with reduction of unfavorable conditions or increase of favorable conditions; that is, a 10 percent reduction in an unfavorable condition is interpreted as a 10 percent improvement in that aspect of the hydrologic regime. This is not altogether consistent with the importance of thresholds; for example, reducing unfavorable conditions may or may not achieve a proportional benefit because the reduced level may still be too unfavorable for ecosystem response. However, in the absence of a more detailed understanding, the assumption of a linear response is the best available. Where possible, it is better to compare the hydrologic regime to conditions that maintained a more desirable state.

One of the most important considerations in evaluating hydrologic benefits is that all of the significant aspects of the altered regime must be captured. Many of these aspects are independent and not directly comparable, so dissimilar benefits should not be lumped together before evaluation. In other words, providing additional benefits to one aspect of the hydrologic regime (e.g., peak flows) would not necessarily offset the effects of a different aspect (e.g., low flows). Because there is currently no accepted index that combines the aspects of the Illinois River Basin hydrologic regime into a single value for comparison, it is not possible to develop a single estimate of regime “quality.” Therefore, in this section the different alternatives were compared by individually accounting for the various relevant hydrologic regime benefits.

i. Tributary Benefits. Tributary benefits were quantified as reduced 2- to 5-year peak flows and increased baseflows. These two aspects of the hydrologic regime are generally acknowledged to provide independent benefits to stream and river communities. Reduced peak flows for these relatively common events are assumed to correlate with less extreme conditions during runoff events and so are related to other beneficial improvements during high water conditions. Baseflow levels are commonly directly related to ecosystem support during drought conditions.

The benefits for these two aspects were expressed directly as the modeled improvements shown in Figures 3-39 through 3-44, and are shown in table 3-50. This formulation assumes the proportional relationship between hydrologic improvements and ecosystem benefits described previously and does not identify any benefit thresholds. Where both storage and infiltration measures were used in an alternative, the benefits were assumed to be additive.

ii. Main Stem Benefits. Two types of benefits were identified that would independently improve main stem Illinois River hydrologic regimes: reduced fluctuations and bottom area exposed during sustained drawdown. Using the main stem fluctuation index defined as the average annual number of 5-day fluctuations exceeding 0.5 foot at the Peoria Pool, Kingston Mines, and Meredosia gages, main stem fluctuation benefits have been defined using:

Benefit = (Current-Alternative)/(Current – pre-1900)

The values for the fluctuation index for Water Years 1990 - 1997 (“Current”) are 31.4 for the growing season and 29.0 for the winter. Pre-1900, this index is estimated to be 9.0 for the growing season, 12.3 for the winter. Using these values, fluctuation benefits can be estimated using the following formulas:

Growing Season Benefit = (31.4 - Alternative)/22.4, and
Winter Benefit = (29.0 - Alternative)/16.7

The assumptions for this benefit calculation are that the fluctuations of 0.5 foot or more occurring over 5 days or less and measured using 2-hour data correlate with the conditions that are adversely affecting ecosystem function in the main stem Illinois River; that the average of these three locations accurately reflects overall river conditions; that the conditions observed in the 1890's are near-optimal for the current system; and that there is a proportional improvement in condition with each change that moves total fluctuation numbers closer to pre-1900 levels. The assumed fluctuation benefits for the various alternatives are shown in table 3-52.

Table 3-52. Tributary and Main Stem Alternative Hydrologic Regime Benefits

	Initial Cost ($M)			Tributaries		Reduced Main Stem Fluctuations	
Alternative	**Construction**	**Real Estate**	**Total**	**Reduced Peak Flow**	**Increased Baseflow**	**Growing Season**	**Winter**
R0, I0, M0, WP0, WL0	0	0	0	0	0	0%	0%
M1	6.6	0	6.6	0	0	65%	73%
M2	7.6	0	7.6	0	0	65%	73%
R1	**108**	**62**	**170**	**1.50%**	**0.1%**	**0%**	**0%**
R2	180	104	284	2.50%	0.1%	0%	0%
M1, R2	187	104	291	2.50%	0.1%	65%	73%
M1, R3	367	207	574	5%	0.3%	65%	73%
M1, R4	647	368	1015	8%	0.6%	66%	73%
M1, R5	1508	863	2371	16%	1.6%	67%	78%
I1	100	33	133	0.80%	5%	0%	0%
M1, I2	207	65	272	1.50%	10%	67%	73%
M1, I3	407	131	538	3%	20%	65%	73%
M1, I4	1008	326	1334	7.60%	50%	65%	73%
M1, I5	2009	653	2662	16%	80%	65%	73%
R1, I1	**208**	**95**	**303**	**2.30%**	**5%**	**0%**	**0%**
M1, R1, I1	**215**	**95**	**310**	**2.30%**	**5%**	**65%**	**73%**
M1, R3, I3	**767**	**338**	**1105**	**8%**	**20%**	**65%**	**73%**
M1, R4, I3, P4, L6	**1047**	**499**	**1546**	**11%**	**20%**	**66%**	**73%**
M1, R5, I4	2509	1189	3698	23%	50%	67%	78%
M1, R5, I4, WP2	2809	1189	3998	23%	50%	70%	79%
M1, R5, I4, WL2	2809	1189	3998	23%	50%	70%	79%
M1, R5, I4, WP2, WL2, P4, L6	**3109**	**1189**	**4298**	**23%**	**50%**	**72%**	**80%**

Key:
(R) - storage in tributary areas
(I) - infiltration in tributary areas
(M) - dam management
(WP) - modification of Peoria wicket dams
(WL) – modification of La Grange wicket dams
Bold type - alternative combinations that were used as system plans

Drawdown benefits were calculated using

$$\text{Expected benefit per attempt} = n * P * Q * A$$

as described above, where n is the desired length of drawdown, P is the probability of n consecutive days with appropriate flow conditions (Appendix C), Q is the quality factor that relates to the benefits accrued from the season the drawdown is taking place (figure 3-38) and A is the bottom area exposed by drawdown. This formulation assumes that there is no benefit unless the drawdown is maintained for at least n days. Expected benefits were formulated for n = 30 and 70 days, and expected benefits for the 70-day drawdown attempts included both the benefits from a 70-day drawdown and the benefits from drawdowns that last at least 30 days but not the full 70 days within that time period (tables 3-48 and 3-49). Total benefits are the expected benefits per attempt multiplied by the number of attempts over the course of the project (table 3-53). Alternatives were developed with the intent of one successful drawdown every 5 years, so drawdowns in less favorable seasons would be expected to require some attempts in additional years to attain the desired number of successes. For this reason, Table 3-53 lists the expected benefits based on the number of days that the pool is expected to be drawn down over the 50-year project life. Drawdown benefits are quantified as quality acre-days, representing the area exposed for at least 30 consecutive days, with quality reflecting seasonal benefits as shown in figure 3-38. Expected number of days drawn down are 30 and 70 for fully successful 30- and 70-day drawdowns, respectively, and 15 and 35 for drawdown attempts that are not fully successful.

4. Plans Recommended for System Analysis

a. Restoration Alternatives. The alternatives described above were combined to represent plans with different levels of effort, each adding increments onto the previous plans and with benefits corresponding to the various system-level alternatives. It is assumed that each is cost-effective because the most cost-effective measures will be used in the implementation of each plan. Characteristics of each plan are summarized in table 3-54.

5A – R1. Create an additional 27,000 acre-feet of storage during 5-year event. Reduces tributary peak flows by 1.5 percent and provides an initial level of benefit to tributary areas.

5B – R1, I1. Create an additional 27,000 acre-feet of storage during 5-year event and infiltrate runoff from 300 square miles. Provides tributary benefits by reducing peak flows by 2.3 percent, thereby meeting Lt. Governor’s goal and increasing low flows by 5 percent.

5C – M1, R1, I1. Create an additional 27,000 acre-feet of storage during 5-year event, infiltrate runoff from 300 square miles, and increase intensity of water level management at Illinois Waterway locks and dams. Provides tributary benefits by reducing peak flows by 2.3 percent, thereby meeting Lt. Governor’s goal and increasing low flows by 5 percent. Also provides significant reduction in low-flow water level fluctuations on main stem river.

5D – M1, R3, I3. Create an additional 90,000 acre-feet of storage during 5-year event, infiltrate runoff from 1,200 square miles, and increase intensity of water level management at Illinois Waterway locks and dams. Provides significant tributary benefits by reducing peak flows by 8 percent, thereby exceeding Lt. Governor’s goal and increasing low flows by 20 percent. Also provides significant reduction in low-flow water level fluctuations on main stem river..

Table 3-53. Drawdown Alternative Benefits

Alternative	Cost ($M)	Number of Attempts (50 yr)	Expected Benefit per Attempt (acre-days)	Expected Days Drawn Down	Total Benefit (acre-days)	Benefit per Day Drawn Down
P0, L0	0	0	0	0	0	
P1	14.6	33	72	495	2376	4.8
P2	14.6	17	144	405	2448	6
P3	14.6	20	152	1040	3040	2.9
P4	14.6	13	313	665	4069	6.1
L1	22.9	40	32.25	750	1290	1.7
L2	22.9	25	51.6	525	1290	2.5
L3	22.9	15	67.1	375	1007	2.7
L4	22.9	25	51.6	875	1290	1.5
L5	22.9	14	114.8	560	1607	2.9
L6	22.9	12	148.8	560	1786	3.2

Key:
P - Peoria Pool drawdowns
L - La Grange Pool drawdown

Table 3-54. Characteristics of Alternative Plans Selected As Part of System Plans

		Tributary Benefits		Main Stem Benefits			Initial Cost ($M)			
System Plan	Alt. Plan	Peak Flow Reduction	Base Flow Increase	Growing Season Reduced Fluctuation	Winter Reduced Fluctuation	Expected Drawdown (Peoria/La Grange)	Construction	Real Estate	Total	O&M ($K/yr)
1	5A	1.50%	0%	0%	0%	no/no	108	62	170	135
2	5B	2.30%	5%	0%	0%	no/no	208	95	303	200
3	5C	2.30%	5%	66%	75%	no/no	215	95	310	325
4,5	5D	8%	20%	66%	75%	no/no	767	338	1105	835
6	5E	11%	20%	66%	75%	yes/yes	1085	499	1584	1185
7	5F	23%	50%	73%	81%	yes/yes	3147	1189	4336	2650

5E – M1, R4, I3, P4, L6, WP1, WL1. Create an additional 160,000 acre-feet of storage during 5-year event, infiltrate runoff from 1,200 square miles and increase intensity of water level management at Illinois Waterway locks and dams, and reconstruct portions of the Peoria and La Grange dams to include an additional tainter gate at each dam. Provides significant tributary benefits by reducing peak flows by 11 percent, thereby exceeding Lt. Governor's goal and increasing low flows by 20 percent. Also provides significant reduction in low-flow water level fluctuations on main stem river. Provides additional infiltration and storage on the tributaries which would influence the tributary flow regime and provide associated benefits. Drawdowns of Peoria and La Grange Pools would expose bottom areas for at least 30 consecutive days during 1 year out of 5, with potential exposure for up to 70 consecutive days, consolidating sediment and encouraging plant growth during the late growing season. The additional tainter gates would decrease the magnitude of water level fluctuations associated with wicket operations

5F – M1, R5, I4, P4, L6, WP2, WL2. Create an additional 375,000 acre-feet of storage during 5-year event, infiltrate runoff from 3,000 square miles, increase intensity of water level management at Illinois Waterway locks and dams, and reconstruct Peoria and La Grange dams to remove effects of wicket operations. Considerably improves tributary hydrologic regimes, reducing peak flows by 23 percent, thereby exceeding Lt. Governor's goal and increasing low flows by 50 percent. Also provides significant reduction in water level fluctuations on main stem river, increased management, wicket removal and tributary basin improvements contributing to more stable water levels. Provides additional infiltration and storage on the tributaries which would influence the tributary flow regime and provide associated benefits. Drawdowns of Peoria and La Grange Pools would expose bottom areas for at least 30 consecutive days during 1 year out of 5, with potential exposure for up to 70 consecutive days, consolidating sediment and encouraging plant growth during the late growing season.

b. Risk and Uncertainty. Because of the likely sensitivity of the Illinois River Basin hydrologic regime to climate impacts (Knox 2001), it is necessary to develop alternatives that are robust to the range of potential climate variation likely to be expected over the life of the project. Extreme events and climatic cycles are also significant aspects of the hydrologic regime. In the last century, the Illinois River Basin has experienced both extreme drought and extreme floods. Temporal changes in climatic or hydrologic conditions will be reflected as changes in the hydrologic regimes of the streams and rivers within the Illinois River Basin. The design of individual projects should be robust enough to function under potential hydrologic regime and sediment delivery conditions.

The measures selected for this goal, when correctly designed and applied, would improve the hydrologic regime characteristics of rivers and streams in the Illinois River Basin. The extent and degree of improvements for each individual project would depend on project design and watershed conditions, but sophisticated hydrologic and hydraulic modeling provides confidence that the benefits for the proposed levels of project implementation are reasonable. The model results have uncertainty associated with them, and the achieved benefits may be somewhat more or less than the current modeling suggests. In addition, there is uncertainty in the realizable benefits from the proposed management improvements; hydraulic modeling indicates a potential level of benefit under a certain management scheme, but it is yet to be seen how closely "real-world" management can come to the optimal level.

One item of significant uncertainty is the net effect of outside influences on the hydrologic regime of the Illinois River in the future. Factors that will affect future hydrologic conditions are climate, land use and land cover conditions. Changes in any of these factors could mask some of the 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.

Finally, an additional item of uncertainty is the ecological response from the proposed level of hydrologic regime change. The team is confidant that the proposed objectives would provide significant and measurable benefits, and that these changes would have significant ecological benefits. However, in the absence of a complete model to relate ecosystem integrity and hydrologic regime, it cannot be confidently assumed that all of the hydrologic characteristics required to maintain a specific level of integrity have been addressed. 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 objectives may be revised if necessary.

c. Additional Benefit Quantification. Originally, the benefits for Goal 5 were quantified for each alternative in terms of: percent reduction in tributary peak flow (TPF) for the 5-year event, percent increase in tributary base flow (TBF), percent decrease in main stem fluctuations (MSF), and whether pool drawdowns and wicket dam reconstruction would be attempted. The benefits for Goal 5 have been further quantified in terms of stream miles and acres, as to the length of stream and the watershed area that would be affected by the measures included in a particular alternative. Table 3-55(a) show the main stem areas with direct benefits (the area adjacent to the sites with proposed management changes).

Table 3-55 (a). Additional Benefit Quantification for Goal 5

		Main Stem Area with Benefits Resulting from the Proposed Measures (acres)			
System Plan	**Alternative Plan**	**Main Stem Water Level Management Changes**	**Navigation Pool Drawdown**	**Wicket Dam Modification**	**Total Acres**
1	5A	0	0	0	0
2	5B	0	0	0	0
3	5C	8,600	0	0	8,600
4,5	5D	8,600	0	0	8,600
6	5E	8,600	12,300	0[1]	20,900[1]
7	5F	8,600	12,300	2,800	23,700

[1] System Plan 6 /5E - Further analysis is required to more completely quantify the benefits from the addition of a tainter gate at Peoria and La Grange dams.

Tables 3-55(b) and 3-55(c) show the watershed and stream length influenced (the reach or area that potentially experiences benefits from the proposed management changes or construction activities) for each alternative.

The direct benefits and the watershed area and length of stream influenced from the proposed measures for each of the alternatives were calculated based on engineering expertise. There are approximately 11,000 perennial stream miles (approximately 33,000 total stream miles in the basin)

and 300 sub-watersheds in the Illinois River Basin. It is assumed that a proportional percentage of stream miles lie in specified percentage of sub-watersheds (i.e. 50 percent of the stream miles (5,500 miles) lie in 50 percent of the sub-watersheds (150 sub-watersheds).
It is assumed that the Main Stem Water Level Management Changes proposed for Alternatives 3 through 7 will provide benefits to approximately one-fourth of the pool area downstream of the dams based on consideration of the geography of the downstream pools. For this analysis, the average water surface area in Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange pools was assumed to be approximately 270 acres, 1,510 acres, 2,170 acres, 2,660 acres, 20,050 acres, and 7,840 acres, respectively, based on information obtained from the HEC-RAS models of the Illinois River developed by the Rock Island District. The total potential area benefited from water level management changes (i.e. "optimization") is approximately 8,600 acres [table 3-55(a)].

The potential direct benefits resulting from the proposed Navigation Pool Drawdown were calculated by watershed modeling described in earlier in this report. The potential area benefited from a 2-foot drawdown at Peoria Pool is 8,000 acres and the potential area benefited from a 1-foot drawdown at La Grange is 4,300 acres.

It is assumed that the Wicket Dam Modification (total reconstruction of the dams at Peoria and La Grange – alternative 7) will benefit approximately one-tenth of the pools downstream of Peoria and La Grange dams based on consideration of the geography of the downstream pool. The total area that will potentially be benefited from the wicket dam reconstruction is approximately 2,800 acres. The addition of a tainter gate at Peoria and La Grange dams (Alt 6 / 5E) will benefit the area downstream by reducing the magnitude of water level changes. Further analysis is required to more completely quantify the benefits that will result from the addition of tainter gates at Peoria and La Grange.

The main stem area with beneficial effects from main stem water level management, navigation pool drawdown, and wicket dam modification proposed under Goal 5 have been added because the main stem area will be benefited in different ways for the three measures.

Stormwater storage volume (SV) and infiltration area (IA) measures will be implemented in half of the watersheds in the Illinois River Watershed for Alternative 6/5E; therefore, half of the perennial stream miles (5,500 stream miles) and sub-watersheds (150) will realize beneficial effects [table 3-55(b)].

Table 3-55 (b). Additional Benefit Quantification for Goal 5

			Number of Sub-Watersheds With:		Percentage of the Illinois River Watershed With:		Potential Number of Stream Miles Benefited from (miles)	
Alternative Plan	**Proposed Add'l Storage Volume (acre-feet)**	**Proposed Add'l Infiltration Area (acres)**	**Add'l Storage Volume**	**Add'l Infiltration Area**	**Add'l Storage Volume**	**Add'l Infiltration Area**	**Add'l Storage Volume**	**Add'l Infiltration Area**
5A	27,000	0	25	0	8%	0%	920	0
5B	27,000	9,600	25	38	8%	13%	920	1,390
5C	27,000	9,600	25	38	8%	13%	920	1,390
5D	90,000	38,400	84	150	28%	50%	3,080	5,500
5E	160,000	38,400	150	150	50%	50%	5,500	5,500
5F	375,000	96,000	300[1]	300[1]	100%	100%	11,000	11,000

[1] Alternative 5F would include restoration measures in all watersheds.

For Alternative 6, 160,000 acre-feet of additional SV and 38,400 acres of IA would be created. The amount of SV and IA created in each sub-watershed are given below:

SV_s = stormwater storage volume per sub-watershed
$SV_{\text{Alternative 6}}$ / 150 sub-watersheds = 160,000 acre-feet / 150 watersheds
= 1067 acre-feet per watershed

IA_s = infiltration area per sub-watershed
$IA_{\text{Alternative 6}}$ / 150 sub-watersheds = 38,400 acres / 150 watersheds
256 acres per watershed

The stream miles with beneficial effects from additional stormwater SV and IA for Alternatives 1 through 5 are based on the following assumptions: (1) there are approximately 300 sub-watersheds in the Illinois River Basin, (2) the additional SV developed for each sub-watershed (SV_s) is 1,067 acre-feet, (3) the additional IA developed for each sub-watershed (IA_s) is 256 acres.

The additional SV and IA proposed for Alternatives 1 through 5 was divided by SV_s and IA_s, respectively, to obtain the number of sub-watersheds affected. The number of subwatersheds with additional SV and IA were divided by 300 to determine the approximate percentage of the Illinois River Basin with additional SV and IA (and the potential length of stream with beneficial effects for each), respectively. The percentage of the Illinois River Basin with additional SV and IA was multiplied by the total number of perennial stream miles in the Illinois River Basin to obtain the number of stream miles benefited for each alternative. It is assumed that the stormwater storage and infiltration measures proposed for Alternative 7 will indirectly benefit the entire Illinois River Watershed and all the perennial streams within the Illinois River Watershed. The stream lengths with beneficial effects from the increased stormwater storage volume and infiltration area proposed under Goal 5 have been added because the streams will be benefited in different ways for the two measures [table 3-55(c)].

Table 3-55 (c). Additional Benefit Quantification for Goal 5

		Stream Length Influenced by the Proposed Measures (miles)		
System Plan	**Alternative Plan**	**Stormwater Storage**	**Increasing Infiltration**	**Total Miles**
1	5A	920	0	920
2	5B	920	1,390	2,310
3	5C	920	1,390	2,310
4,5	5D	3,080	5,500	8,580
6	5E	5,500	5,500	11,000
7	5F	11,000	11,000	22,000

d. Ancillary Benefits. Additional hydrologic regime benefits are likely to accrue from projects undertaken for other goals. These include:

- Reduced fluctuations and additional hydrologic benefits from floodplain and riparian restoration projects (Goal 3)
- Flow attenuation due to stream restoration, especially re-meandering projects (Campbell et al. 1972, Goal 3)
- Some flow attenuation as water passes through water quality facilities (Goal 5) and sediment control facilities (Goal 5)

In addition, the projects enacted under this goal are likely to have ancillary benefits for other goals.

- Some floodplain benefits to support Goal 3, including habitat, would be provided by the constructed storage areas
- Sediment delivery would be reduced due to trapping in storage areas and pretreatment for infiltration areas (Goal 1)
- Reduced stream power due to hydrologic benefits would reduce streambank and bed erosion in tributary areas (Goal 1), and reduce overall sediment transport (figure 3-43) subsequently reducing the transport of nutrients (Goal 6)
- Nutrients would be trapped and transformed in storage areas (Goal 6).

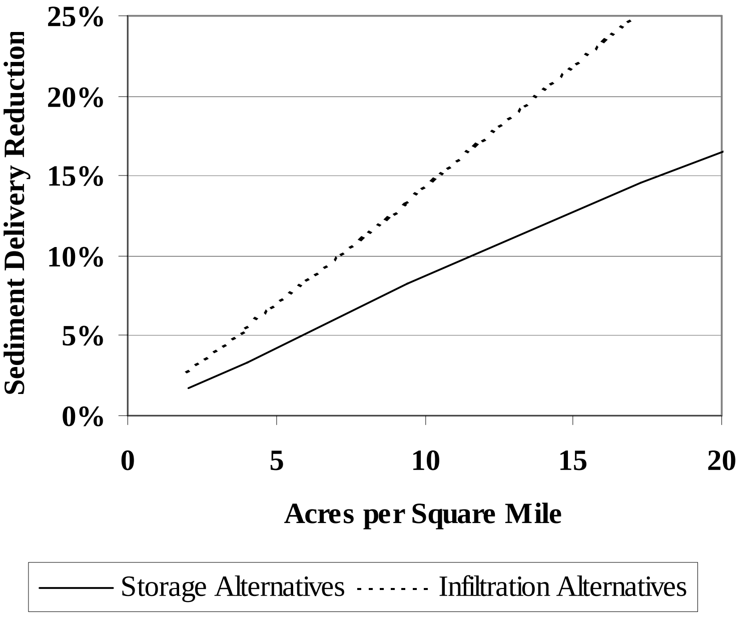


Figure 3-43. Estimated Sediment Delivery Reduction Due to Hydrologic Regime Improvements.

Hydrologic benefits estimated using BASINS model developed by Demissie et al. (2003a) as described in Measures, Tributary section of Goal 5. Relationships between daily flow and daily sediment load for Iroquois, LaMoine, Spoon and Vermillion Rivers in Demissie et al. (2003b). Sediment delivery reduction estimated by comparing loads for each alternative calculated using modeled daily flows for Water Years 1972-1995 and computing average reduction for the four modeled tributaries.

Non-ecosystem benefits that can also be attributed to hydrologic regime projects are reduced maintenance dredging costs and beneficial use of the sediment removed from the pools in preparation for pool drawdowns. These benefits were not quantified for this study.

Finally, there would be the potential to incorporate additional features into the hydrologic regime projects to support other goals. For example, the design of storage areas can be modified to more efficiently trap sediment (Goal 1). There is also the potential to incorporate water quality features into storage facilities (Goal 6). These types of added benefits would generally require additional costs as they require features that would not otherwise be included in the hydrologic regime projects.

e. Information and Further Study Needs. There are several additional study needs related to Goal 5, which could take place in the form of special studies. Further studies need to be performed on:

- effects of implementing infiltration and storage together on the tributaries and the main stem,
- reduction of the magnitude of water level fluctuations due to storm events,
- effects of additional tainter gates at Peoria and La Grange,
- effects of reconnecting the main stem to its floodplain (i.e. levee removal, etc.) on various flow regimes, including, during small floods during the summer growing season,
- effects of model refinement, and
- response of the entire system to the combined effect of all restoration measures related to Goal 5.

K. GOAL 6: WATER AND SEDIMENT QUALITY. 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 chemical pollution as well as physical, structural and hydrological changes within the basin. 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 on all surface waters of the Illinois River Basin by 2025.
- Achieve full use support for all uses on all surface waters of the Illinois River Basin in 2055.
- Remediate sites with contaminant issues that affect habitat.
- Achieve Illinois EPA nutrient standards by 2025, following standards to be established by 2008. Until then (2008), work to minimize sedimentation as a cause of impairment as defined by 305(b).
- Work to minimize sedimentation as a cause of impairment as defined by 305(b) by 2035.
- Maintain waters that currently support full use or can be considered pristine waters.

1. Inventory Resource Conditions

a. Historic Conditions. Many changes have occurred within the Illinois River Basin that have significantly impacted upon the river. During the 1850-1965 period, the number of people living in the basin increased from 500,000 to over 10,500,000. This rapid growth resulted in vast quantities of industrial wastes and human sewage being produced. Communities along the Illinois River released untreated sewage directly into the river.

By 1908, fish production of the Illinois River began to decline sharply as its waters could no longer assimilate the tremendous volume of sewage it received. As increased quantities of sewage entered the Illinois River, the effect was devastating. Upper stretches of the river were depleted of oxygen and became toxic. Mayflies, which are indicators of clean water and are an important food of many species of fish, and fingernail clams virtually disappeared from the river above Beardstown after 1950.

In addition, the increased production of row crops has resulted in a greater use of herbicides, insecticides, and fertilizers. Eroded soil also contributes to water quality impairments by transporting adsorbed compounds, such as the nutrient phosphorus, in addition to impairments from increased sediment. The upper basin has the highest yield of total phosphorus (190.5 kg/km^2/yr); the primarily agricultural lower Illinois River Basin has an estimated yield of 69 kg/km^2/yr. David and Gentry (2000) estimated that 70 percent of the phosphorus in the Illinois River was from sewage effluent. Within tributary basins without significant point source contributions, the primary source of phosphorus is cropland runoff. Phosphorus is transported in both the particulate form (adsorbed to eroded soil) and dissolved in runoff water. Recent research indicates that, if soil phosphorus concentrations are excessively high, phosphorus may also leach through soils and be transported by tile-drainage systems (Xue et al. 1998). In the Iroquois River, particulate phosphorus concentrations have decreased in the last 15 years, probably because of adoption of conservation tillage systems (used on approximately 45 percent of cropland in the Illinois River Basin). However, during the same period, dissolved phosphorus concentrations have increased.

During this same time period, the landscape was being altered significantly. In many parts of the state, wetlands were being drained or filled. The loss of wetlands has adversely impacted the rate at which water was delivered to rivers and creeks. This resulted in higher velocities of these streams, thus increasing channel erosion and allowing greater quantities of sediment to be carried. Nutrient concentrations also increased with the loss of wetlands due to the loss of wetland plants being available to use the nutrients and hold the water for longer periods of time.

In the Illinois River Basin, the primary form of nitrogen found in streams is nitrate. Nitrate does not tend to come from fields as surface runoff, but leaches through the soil and reaches high levels in outflow from tile-drainage systems. Although nitrogen is not usually the limiting nutrient for algal production and eutrophication of streams and lakes in Illinois, it has been identified as one of the principal causes of the hypoxic zone in the northern Gulf of Mexico. The U.S. Geological Survey has estimated the average annual total nitrogen flux from the Illinois River Basin, during the period 1980-1996, at 144,320 metric tons per year. The upper part of the basin, above Marseilles, which includes the metropolitan Chicago area, was estimated to have the highest total nitrogen yield in the Mississippi River basin (3,120 kg/km^2/yr).

Many of the agricultural chemicals used are persistent in nature and toxic to fish. Over the past 30 years, numerous agricultural chemical-caused fish kills have been documented within the Illinois

River Basin and its tributary streams. Fish kills have also been caused by numerous discharges from industrial and manufacturing operations, which discharge toxic heavy metals, inorganic and organic chemicals, and oxygen demanding organic waste such as wood pulp fibers, canning, and dairy and food processing wastes.

Oxygen depletion has become a problem in the backwater areas of the lower river as wind-generated waves resuspend materials from the shallow lake bottoms, exerting an oxygen demand and removing dissolved oxygen from the water. Elimination of the summer low water periods prohibits compaction of sediments. Therefore, suspended sediments settle only loosely to the lakebed, creating a soft bottom in which aquatic plants cannot take root. During periods of high turbidity, aquatic plant growth is limited, since suspended sediments interfere with light penetration into the water.

b. Existing Conditions. One of the most noticeable improvements in the environmental conditions within the Illinois River system has been improved water quality associated with national and regional efforts to meet the goals of the Clean Water Act (CWA). It is expected that water quality will continue to improve in the future because of implementation of CWA Combined Sewer Overflow and Stormwater Management requirements, and local conservation efforts, and that improved water quality will translate into improvements in other ecosystem components. For example, fish and freshwater mussel populations in the main river channel have recently shown improvements that can be attributed to better water quality.

Improvements in chemical water quality, however, have not resulted in recovery of physical and biological health of the river system. Due to several factors including the combination of water level fluctuations, loss of floodplain areas, and increased sedimentation and turbidity, aquatic vegetation has not returned to the Illinois River. Excessive amounts of sediment continue to fill backwater and side channel habitats, and fish and aquatic populations have not improved markedly in these areas as they have in the upper reaches of the main stem of the river. Resources for migratory waterfowl will continue to be degraded through a combination of problems, including sedimentation, water level fluctuations, urbanization, and industrial, agricultural, and domestic pollution.

Water Supply. The Illinois River also serves as one of the sources for the public water supply system serving Peoria, which also uses three well fields. The cities of Aurora, Elgin, Kankakee, Pontiac, Streator, Decatur, Taylorville, Springfield, Jacksonville, and Canton use water from tributaries of the Illinois River. Moreover, the Commonwealth Edison Company uses Illinois River water for cooling purposes.

Wastewater Disposal. The Illinois River is a major conduit for the transport of treated wastewater throughout Illinois. It is estimated that 2,109 outfalls are located in the Illinois River Basin today. Illinois has taken significant steps to obtain compliance for effluent limitations by dischargers in the basin. From the municipal facility perspective, approximately $5.6 billion in Federal grant dollars has been expended for treatment facility construction in the Illinois River Basin through the Construction Grants Program. It can be safely estimated that several hundred million dollars have also been expended by industrial dischargers. Although the Illinois River ranks among Illinois' top recreational resources, it has also been a primary channel for the transport of human, animal, industrial, and agricultural wastes.

Assessing the Quality of the State's Waters and Prioritizing Improvements: Clean Water Act 305(b) and 303 (d) List. As required by the Federal Clean Water Act, the Illinois EPA assesses the conditions of the State's surface and groundwater resources when new data or information regarding the waterbody status is attained. Monitoring and assessments are scheduled for each waterbody, based on its designated use(s). The assessments are reported biennially in the "Illinois Water Quality Report" (also referred to as the 305(b) report). For rivers, streams, and lakes, the Illinois EPA utilizes biological, chemical, and habitat data collected as part of several monitoring programs. Additional water quality data are obtained through agreements and contracts with other agencies and organizations.

Water quality conditions are described in terms of the level of attainment for designated use categories including aquatic life, wildlife, primary contact (swimming, water skiing), secondary contact (boating, fishing), agricultural, industrial, food processing, and drinking water uses. Each designated use category has established water quality standards for protecting these uses. Individual use assessments are then aggregated into an overall use attainment category. In addition, the Illinois EPA identifies causes (toxics, nutrients, sedimentation, etc.) for those water bodies not fully attaining designated uses and sources (point and non-point) of pollutants contributing to the problem. For purposes of this document, water quality stresses are considered to be those causes resulting in less than full support of overall use as identified in the "Illinois Water Quality Report, 2000-2001."

Water Quality Assessment for the Illinois Basin. The Illinois drainage basin is comprised of the Illinois, Sangamon, Des Plaines, Kankakee, Lamoine, Spoon, Vermillion, Mackinaw and Fox River basins. As part of the "Illinois Water Quality Report, 1990-1991," overall use support was assessed for 5,670.7 stream miles and 257 lakes within the Illinois Drainage Basin. Of the 5670.7 stream miles assessed, 44.3 percent fully support overall use (no water quality impairments). Streams with less than full support include: 44.4 percent partial support with minor impairments; 9.3 percent partial support with moderate impairments; and 2.0 percent not supporting overall use. Of the 257 lakes assessed, 11.3 percent fully supported overall use. Lakes with less than full support include: 26.5 percent partial support with minor impairments; 26.5 percent partial support with moderate impairments; and 35.7 percent not supporting overall use.

Causes (stresses) and sources of identified water quality impairments for the Illinois drainage basin are depicted in table 3-53. Major causes of impairment for streams and lakes include nutrients, siltation, suspended solids, bacteria, dissolved oxygen, metals, and changes in the hydrology of rivers and streams.

Sources of impairment are predominately from non-point sources, or pollution from diffuse, intermittent runoff. Non-point sources include agricultural runoff, urban runoff, silviculture, construction , resource extraction, land disposal, hydrologic modification, habitat modification, marinas, and recreational boating. Table 3-56 provides a detailed summary of the sources contributing to water quality impairments for lakes and streams.

Table 3-56. Summary of Sources Contributing to Water Quality Impairments in the Illinois Drainage Basin

Stream Category	Miles Major Impairment	Miles Moderate/Minor Impairment
Industrial Point Source	3.8	378.2
Municipal Point Source	198.4	1,220.6
Combined Sewer Overflows	37.4	398.0
Unspecified Agriculture	572.8	1,090.2
Non-irrigated Crop Production	23.5	852.4
Irrigated Crop Production	2.0	0.2
Pasture Land	35.1	590.4
Feedlots - All Types	1.7	4.5
Animal Holding Areas	0	7.3
Urban Runoff/Storm Sewers	24.6	734.5
Resource Extraction	0	173.2
Unspecified Hydrologic/Habitat Modification	0	147.7
Channelization	104.4	972.1
Flow Regulation/Modification	0.6	267.9
Removal of Riparian Vegetation	0	319.5
Streambank Modification	0	356.0
Dredging	0	14.2
Dam Construction	0	157.2
Highway/Road Construction	0	49.6
Land Development	0	424.7
Highway Runoff	0	91.3

Lake Category	Acres Major Impairment	Acres Moderate/Minor Impairment
Industrial Point Source	524	10,762
Municipal Point Source	256	11,224
Unspecified Non-point Source	4,442	23,178
Agriculture	159,392	4,811
Construction	1,325	12,793
Urban Runoff/Storm Sewers	2,708	28,819
Resource Extraction	155	708
Land Disposal	5,887	16,611
Hydrologic Modifications	1,339	58,999
In-Place Contaminants	42,638	27,963
Recreational Activities	5,974	12,987
Atmospheric Deposition	0	4,040
Waterfowl	200	2,995
Highway Runoff	15	614
Upstream Impoundment	202	1,231
Unknown	0	5,011
Combined Sewer Overflows	0	225
Waste Storage Tank Leaks	0	10

The Illinois drainage basin is a very diverse system, which includes highly urbanized areas in the Des Plaines River basin, to intensive agricultural uses in the Sangamon River Basin. Causes of water quality impairment (stresses) and sources vary considerably within the river basins comprising the Illinois drainage basin

Total Maximum Daily Load Program (TMDLs). The Clean Water Act Section 303(d) provides a coordinated framework between states and the U.S. EPA to systematically track and address impaired waters throughout the state and nationwide. Although much success has been achieved through the NPDES permitting program in reducing pollutants discharged to waterways by municipal treatment works and industrial discharges, some impaired waterways are not expected to recover through the application of technology-based effluent treatment alone.

States are required to list impaired waters every 2 years and to prioritize each water body for an in-depth analysis of pollutant sources and the reductions necessary so that they attain all of the uses that they are assigned (or "designated" in CWA terminology). The in-depth analysis is called a Total Maximum Daily Load or "TMDL." A stream can have many different segments within a stretch and numerous impairments representing a variety of needed improvements in its chemical, physical, and biological state.

The most recent TMDL list for the State of Illinois was approved in November 2004. The list can be found at Illinois EPA's website, http://www.epa.state.il.us/. Information for this list is in the process of geospatial referencing, therefore, a summary for the Illinois River for the 2004 list is not available as of this printing; however, the 2002 summary is available.

On the Illinois 1998 TMDL list, there were 342 segments in the Illinois River basin listed for siltation and suspended solids. Another 269 segments were listed as being impaired by excess nutrients. [1]

The five basins in the Illinois River having more than 100 total impairments are listed below.

Basin	**Total Impairments**	**Largest Number of Segments Impaired for:**	**Second Largest Number of Segments Impaired for:**
Des Plaines	266	Nutrients	Sediments
Upper & Lower Illinois Main stem	219	Sediments	Nutrients
Sangamon	171	Sediments	Nutrients
Chicago Calumet	129	Dissolved Oxygen	Nutrients
Fox River	117	Sediments	Dissolved Oxygen

The pollutant reductions called for in TMDLs may require voluntary actions and the cooperation of many programs such as the CWA 319 program, CREP program, and ecosystem restoration actions recommended in this document in order to realize the water quality improvements called for in the TMDL and realize the water quality goals of the Clean Water Act.

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[1] In some cases, more than one listing occurred in a segment, and actual listings occur for a sub-segment. New Illinois 303(d) list was finalized in November 2004.

Other Water Quality Programs. Under the authority of the Water Quality Act of 1987, Illinois operates a coordinated program of regulation and technical assistance for the effective management of urban stormwater. Section 405 of the Act requires some Illinois industries and municipalities to apply for stormwater NPDES permits. Municipalities with populations greater than 100,000 must apply for permits for their storm sewer systems. NPDES permits are also required from a wide variety of industrial activities defined in the regulations that could result in stormwater runoff. Some construction site activities are included in this definition, and permits are required for such stormwater dischargers.

The December 8, 1999, Storm Water Phase II Rule expanded the number of municipalities located in urban areas that are required to obtain NPDES permit coverage for discharges from their municipal separate storm sewer systems (MS4s). Municipalities located outside of urbanized areas may need to comply with some requirements as determined by the delegated NPDES Permitting Authority.

In addition, beginning on March 10, 2003, municipalities with a population under 100,000 were no longer exempt from the construction site storm water requirements and the industrial storm water requirements. Waste Water Treatment Plants with a discharge of 1.0 million gallons per day (mgd) or more need a General Storm Water Permit for Industrial Activities.

Industrial Activity General Permits require a pollution prevention plan, considered to be one of the most important requirements of the General Permit. A list of the 11 categories is found at: http://cfpub.epa.gov/npdes/stormwater/swcats.cfm**.** Each facility covered by this permit is required to develop a plan, tailored to the specific conditions and with the primary goal of controlling pollutants that may be discharged into storm water runoff.

Each storm water plan must include a site map and a description of the measures and controls that will be used to prevent and/or minimize pollution of storm water. Among other things, the plan must contain storm water management controls and measures to remove significant pollutants from stormwater as well as identify areas that have high potential for erosion of soil and the methods to be employed to reduce such erosion.

Complementing the NPDES stormwater permit program, Illinois offers various forms of technical and financial assistance for water quality protection through the proper management of urban runoff. Under Section 319 of the Act, grants are made available to fund projects that effectively demonstrate non-point source pollution control techniques. In addition to directly improving water quality, such projects promote wider application of urban stormwater management practices. Together with Section 319, Section 208 establishes a comprehensive State strategy for controlling urban runoff.

c. Future Without-Project Conditions. 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. Continued improvement in chemical water quality will be insufficient to prevent further degradation of many aspects of the Illinois River ecosystem. Without further reduction of sediment entering the system from degraded tributaries and management of sediment already within the system, backwater areas will continue to rapidly fill and aquatic vegetation beds will not recover.

In addition to turbidity, the quality of the sediments, particularly in the main stem, may limit macroinvertebrates such as fingernail clams. Ammonia, an agricultural fertilizer, is found in the upper layers of the sediments, sometimes in toxic amounts. Minor improvements in water quality may be made due to regulation and improvements in best management practices (BMPs). The EPA's programs to reduce nonpoint source pollution and its Targeted Watersheds Grant Program will continue to provide some improvements in general water quality and provide information on the management of physical impacts of tile drainage.

d. Desired Future Conditions. The desired future for water quality would include all of the following: achieve full use support for aquatic life on all surface waters of the Illinois River Basin by 2025; achieve full use support for all uses on all surface waters of the Illinois River Basin in 2055; remediate sites with contaminant issues that affect habitat; achieve Illinois EPA nutrient standards by 2025, following standards to be established by 2008; work to minimize sedimentation as a cause of impairment as defined by 305(b) by 2035; and maintain waters that currently support full use or can be considered pristine waters.

2. Formulation of Alternative Plans

No specific measures or alternatives were formulated for this goal specifically. However, alternatives that address or benefit water and sediment quality are discussed in previous goals for this study. It is believed that proposed actions to reduce sedimentation and nutrient loads to the basin and to attenuate the flow extremes will help to return impaired segments to their designated uses.

Constraints

- Several limiting factors to improved water quality exist such as ammonia, dissolved oxygen levels, or nitrates. An improved understanding of these factors in impaired waters is required in designing projects and measuring success.
- Expense and technical feasibility of addressing (legacy) contaminated sediments.
- Changes to the hydrology within the Illinois River drainage basin.
- Practices that address water quality may negatively impact sediments and vice versa.
- Funding availability.
- Adequate monitoring to make determination of needs/improvements.
- Permit review process.

Criteria for Prioritization

- It is believed that water quality improvements will be realized throughout the basin through implementation of many of the types of projects being proposed at the programmatic level. Future watershed assessments should consider basin water quality information at small watershed level. Those waters that do not achieve full use support will be considered an important criterion in the watershed prioritization process.
- Water bodies that meet standards, but are declining/under threat, should be given greater focus.
- Waters that are better than their designated use need to be protected to assure that they do not degrade below current conditions.

Considerations and Assumptions

- Implementation will require coordination with the Illinois EPA and US EPA, as well as other State and Federal agencies and non-governmental organizations.
- Goals and objectives with metric(s), and water quality assessment and tracking systems that support the CWA 305(b) water quality report to Congress already exist for some EPA programs and could be considered and used to reinforce project tracking and measurement of success.
- State prioritization and scheduling of TMDL development and implementation. prioritization and process.
- Load reduction targets developed and implementation of plans for federally approved TMDLs.
- U.S. EPA and the Upper Mississippi River States are developing monitoring and assessment methodologies for biological standards and criteria.
- Results of tile drain management research from EPA Targeted Watershed Project in the Sangamon River watershed

Information Needs

- Assemble and review Illinois (and other Upper Mississippi River States) EPA guidelines and available research on sediments/phosphorus/turbidity. (e.g., greater than 35 percent fine sediments in transect, turbidity TSS 116 mg/l in 1 sample in 3 years, or other appropriate number developed in future). (Info on website under 305(b).
- Information on sedimentation rates/transects.
- Base flows need to be established for all streams in the Illinois River.
- Quantification of pollutant and nutrient removal efficiencies, and changes in hydrology resulting from large-scale riparian wetland restoration.
- Assemble information on vulnerability of specific areas to sedimentation and pollutants transport to water bodies and analyze potential to ensure that correct BMP and restoration measures are being used to mitigate.
- More information is needed about the endpoints or targets for physical habitat parameters to correct biological impairments.

L. SYSTEM EVALUATIONS

1. Formulation of Alternative Plans

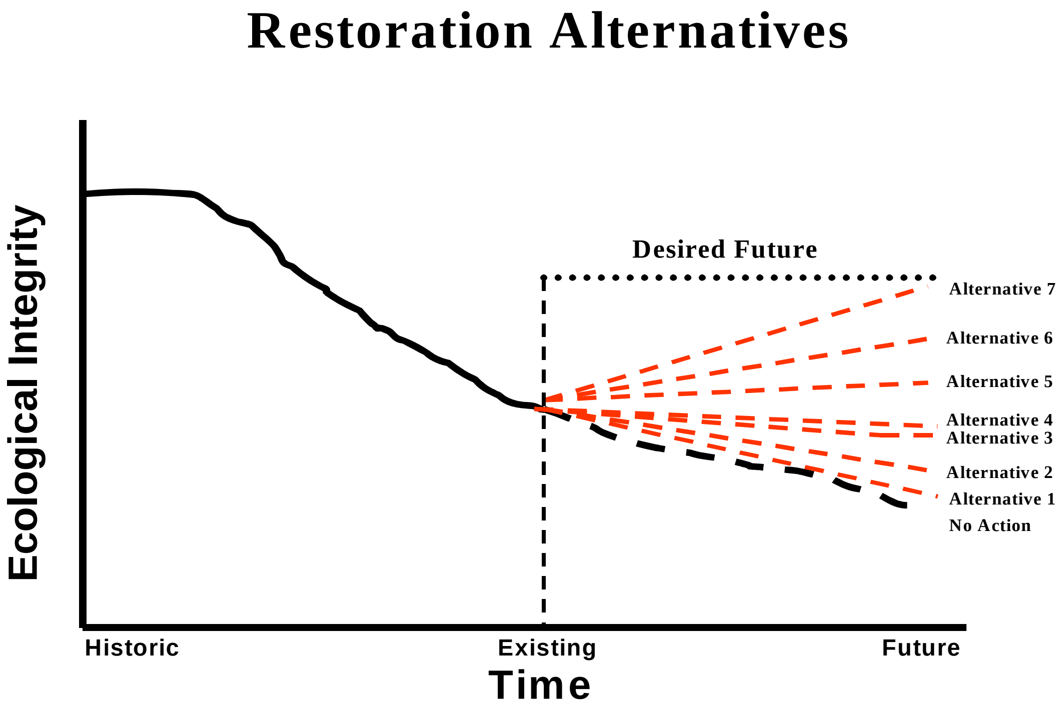
The system team developed various alternatives to restore systemic ecological integrity and fish and wildlife habitat. This portion of the report discusses the alternatives formulation.

The Comprehensive Plan is guided by the overarching goal of restoring ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them. This overarching goal directed the formulation of alternative plans for each of the six goals, specifically formulated to address the system limiting factors in the basin. Each of these goals contains specific, measurable objectives which have been developed to optimize the ecological integrity of the basin. These objectives were developed by the interagency System Team, resource managers, and stakeholders, and represent a desired future condition or virtual reference condition for the Illinois River Basin.

The System Team formed subgroups to formulate goals, measures and alternatives plans to address the identified problems for each goal. This process was described in each of the goals presented in the previous portion of this section. The subgroups studied the existing conditions and developed scenarios for the future without project conditions. Each of these subgroups then developed lists of measures to address these problems. For each of the measures, the relative cost and system benefits were identified. This information was then used to develop 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 developing a plan for sediment reduction). At this level of analysis, the various measures were evaluated, comparing their costs and benefits. The screening resulted in the alternatives being developed from cost-effective measures. These cost effective restoration measures were then combined into several alternative plans, representing a range of levels of effort and varying degrees of achieving the desired future condition for each goal over the 50-year planning horizon.

In total, eight alternative plans (including the No Action alternative) were formulated to provide a range of restoration options for consideration. These were generally assembled by increasing levels of effort and cost, with some plans representing relatively equal amounts of work under each of the goals and some alternatives emphasizing various goals more heavily. In particular, a number of the alternatives were formulated to provide specific frames of reference relating to the restoration of habitat (acres of various habitat types, etc.) and ecological integrity (structural and functional elements that support and maintain a balanced, integrated, adaptive community). Figure 3-44 was developed for illustrative purposes only, but shows conceptually the estimated benefits of the various plans relative to restoration objectives (desired future) for system ecological integrity. All alternatives, with the exception of the No Action alternative, provide regional habitat and ecological integrity benefits by slowing, stabilizing, or reversing the current decline of ecological integrity over the 50-year planning horizon.

The Illinois River Basin has been significantly altered over the course of the past 150 years. The combined effects of habitat losses through changes in land use, human exploitation, habitat degradation and fragmentation, water quality degradation, and competition from aggressive non-indigenous 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. Because of the magnitude of these past changes to the basin and the continuing landscape alteration, the levels of restoration provided by Alternatives 1-4 do not reverse the decline in systemic ecological integrity throughout the life of the project. However, these alternatives represent improvements in ecological integrity to the Illinois River Basin, primarily at the local or regional scale . It is not until the level of restoration associated with Alternative 5 that system-wide ecological integrity is predicted to stabilize or improve. Alternatives 6 and 7 represent the only alternatives to significantly reverse the current system decline of ecological integrity, increasing ecological integrity toward the desired future condition throughout the 50-year project life, by prescribing sufficient levels of ecosystem restoration to restore the system, both habitats and processes, to a more naturalized and sustainable state.



**** Not to Scale – Illustrative Purposes only***

Figure 3-44. Conceptual Restoration Benefits of Alternatives

The eight system alternative plans are listed below; describing the predicted response to restoration by goal and the resulting response in ecological integrity over the 50–year planning horizon. A summary matrix of the system benefits is included as table 3-57. In addition, table 3-58 shows a similar matrix of total first costs. Finally, annual O&M costs are described in table 3-59 for a fully implemented program. All restoration projects would be cost-shared 65 percent Federal and 35 percent non-Federal sponsor. The cost estimates are based on unit costs for construction of various restoration measures. In addition, costs for program management, monitoring, adaptive management, and further special studies have been included. These additional program components are described more fully in Section 6, *Plan Implementation*.

a. Description of System Alternatives. The following descriptions explain the system alternatives by describing the benefits associated with each goal.

No Action –Anticipated future condition, assuming no new efforts are undertaken as a result of this study.

- **Ecological Integrity.** Continue the decline in system ecological integrity and populations of native species, resulting from the continuation of habitat loss and fragmentation, the altering of natural disturbance regimes, and the continuation of non-indigenous species colonization.
- **Sediment Delivery.** Some increase in sediment delivery due to the continuation of landscape alterations, increases in impervious surfaces and resulting runoff, and the continuation of channel instability due to prior alterations.
- **Backwaters and Side Channels.** Continue to lose backwaters at an annual rate of approximately 1 percent of volume and surface area, or a 40 percent loss of backwaters over 50 years. Further degradation of side channels due to island erosion and channel sedimentation.
- **Floodplain, Riparian, and Aquatic.** Relatively minor changes in floodplain areas with some increase in the degradation of riparian and aquatic habitats due to urbanization and land-use changes.
- **Connectivity.** No significant change in the number of dams blocking fish and aquatic species migration. Some local fish passage initiatives are currently underway.
- **Water Level.** Small increase in the number of fluctuations in tributary and main stem water level regimes due to continued land-use changes.
- **Water Quality.** Minor improvements in water quality due to regulation and improvements in best management practices (BMPs).

Alternative 1

- **Ecological Integrity.** Continue the decline in system ecological integrity and populations of native species. However, in areas of focused restoration efforts, there would be regional improvements to both habitat and regional ecological integrity.
- **Sediment Delivery.** Reduction in the delivery from direct Peoria Lakes tributaries exclusively. Sediment delivery would be reduced by approximately 20 percent from these watersheds. System benefits include reduced delivery of 6.3 percent to Peoria Lakes and 2.3 percent system wide.
- **Backwaters and Side Channels.** Restoration of 3,600 acres in 40 of the approximate 100 backwaters. Dredging of 10-200 acres per backwater, with 10 backwaters dredged to the optimal level (40 percent of backwater area). This would create overwintering habitat spaced approximately every 7 miles along the system and optimal areas every 28 miles. Restoration of 10 side channels and protection of 10 islands. In total, these efforts would benefit an estimated 14,300 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 5,000 acres of main stem floodplain (approximately 1 percent of total main stem floodplain area) including approximately 2,100 acres of wetlands, 1,700 acres of forest, and 1,200 acres of prairie; tributary restoration of 5,000 acres (approximately 0.6 percent of total tributary floodplain area), approximately 3,200 acres of wetlands, 900 acres of forest, and 900 acres of prairie; and aquatic restoration including 25 miles of tributary streams (0.8 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream

aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 25 miles of stream.

- **Connectivity.** No change; same as without project.
- **Water Level.** Reduction in the fluctuations in tributary areas due to the creation of 18,000 acres of storage area at an average depth of 1.5 feet. Reduces the 5-year peak flows in tributaries by 1.5 percent but does not discernibly reduce fluctuations along the main stem Illinois River. Providing benefits to an estimated 920 miles of tributary streams.
- **Water Quality.** Local improvements in water quality due to the implementation of measures to reduce sediment delivery. Sediment and nutrient inputs to the river, such as phosphorus and nitrogen, will not measurably decline at the system level.

Alternative 2

- **Ecological Integrity.** Current habitat conditions will be maintained. However, some decline in system ecological integrity would continue to occur, especially for populations of native species that are currently declining or sensitive to continued habitat fragmentation, such as area-sensitive species.
- **Sediment Delivery.** Reduction in the delivery from direct Peoria Lakes tributaries with some efforts on tributaries downstream. On average, sediment contributions decline by 40 percent from the Peoria Lakes tributaries and 0.5 percent in the downstream tributaries. System benefits include a reduction in the delivery of 12.5 percent to Peoria Lakes and 5 percent system wide.
- **Backwaters and Side Channels.** Restoration of 6,100 acres in 60 of the approximate 100 backwaters on the system. Dredging of 10-200 acres per backwater, with 20 backwaters dredged to the optimal level (40 percent of backwater area). This would create overwintering habitat spaced approximately every 5 miles along the system and optimal areas every 14 miles. Restoration of 20 side channels and protection of 15 islands. In total, these efforts would benefit an estimated 30,950 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 5,000 acres of main stem floodplain (approximately 1 percent of total main stem floodplain area) including approximately 2,100 acres of wetlands, 1,700 acres of forest, and 1,200 acres of prairie; tributary restoration of 10,000 acres (approximately 1.2 percent of total tributary floodplain area) including approximately 6,300 acres of wetlands, 1,900 acres of forest, and 1,800 acres of prairie; and aquatic restoration including 50 miles of tributary streams (1.6 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 50 miles of stream.
- **Connectivity.** No change; same as without project.
- **Water Level.** Reduction in the fluctuations in tributary areas due to the creation of 18,000 acres of storage area at an average depth of 1.5 feet and 10,000 acres of infiltration area. Results include a 2.3 percent reduction in the 5-year peak flows in tributaries, an overall average of 5 percent increase in tributary base flows, but no discernable reduction

in fluctuations along the main stem Illinois River. Providing benefits to an estimated 2,310 miles of tributary streams.

- **Water Quality.** Some additional improvements in water quality at the local or regional level due to a reduction in sediment and phosphorus delivery resulting from sediment delivery reduction measures.

Alternative 3

- **Ecological Integrity.** Improvements in habitat conditions at the system level, with a focus on system ecological integrity, particularly in impacts of excessive sedimentation. This plan would increase backwater habitat, reduce sediment delivery, and restore additional main stem and tributary floodplain areas.
- **Sediment Delivery.** Reduction in sediment delivery from direct Peoria Lakes tributaries by 40 percent, other tributaries upstream of Peoria Lakes by 11 percent, and tributaries downstream of Peoria Lakes by 4 percent. System benefits include reduced delivery of 20 percent to Peoria Lakes and 10 percent system wide.
- **Backwaters and Side Channels.** Restoration of 8,600 acres in 60 of the approximate 100 backwaters on the system. Dredging of 10-200 acres per backwater, with 40 backwaters dredged to the optimal level (40 percent of backwater area). This would create overwintering habitat spaced approximately every 5 miles along the system and optimal areas every 7 miles. Restoration of 30 side channels and protection of 15 islands. In total, these efforts would benefit a total of 42,240 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 20,000 acres of main stem floodplain (approximately 7.9 percent of total main stem floodplain area) including approximately 8,400 acres of wetlands, 6,800 acres of forest, and 4,800 acres of prairie; tributary restoration of 20,000 acres (approximately 2.3 percent of total tributary floodplain area) including approximately 12,600 acres of wetlands, 3,800 acres of forest, and 3,600 acres of prairie; and aquatic restoration including 100 miles of tributary streams (3.3 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 100 miles of stream.
- **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), and all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams).
- **Water Level.** Reduction in fluctuations in tributary areas due to the creation of 18,000 acres of storage area at an average depth of 1.5 feet and 10,000 acres of infiltration area. Also, a reduction in fluctuations on the main stem due to increasing intensity of water level management at navigation dams using electronic controls and increased flow gaging. Results include a 2.3 percent reduction in the 5-year peak flows in tributaries, an overall average 5 percent increase in tributary base flows, and up to 65 percent reduction in the occurrence of half foot or greater fluctuations during the growing season in the main stem Illinois River. Providing benefits to an estimated 2,310 miles of tributary streams.
- **Water Quality.** Some additional improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would primarily result

from sediment delivery reduction measures, with some benefits from water level management measures.

Alternative 4

- **Ecological Integrity.** Improvements in habitat conditions at the system level, with a focus on tributary ecological integrity and secondary effects to main stem habitats. This plan would result in sediment delivery reduction, tributary floodplain and stream restoration, increased fish passage, and more naturalized water levels.
- **Sediment Delivery.** Reduction in sediment delivery from direct Peoria Lakes tributaries by 40 percent, other tributaries upstream of Peoria Lakes by 11 percent, and tributaries downstream of Peoria Lakes by 4 percent. System benefits include reduced delivery of 20 percent to Peoria Lakes and 10 percent system wide.
- **Backwaters and Side Channels.** Restoration of 6,100 acres in 60 of the approximate 100 backwaters on the system. Dredging of 10-200 acres per backwater, with 20 backwaters dredged to the optimal level (40 percent of backwater area). This would create overwintering habitat spaced approximately every 5 miles along the system and optimal areas every 14 miles. Restoration of 20 side channels and protection of 15 islands. In total, these efforts would benefit a total of 30,950 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 5,000 acres of main stem floodplain (approximately 1 percent of total main stem floodplain area) including approximately 2,100 acres of wetlands, 1,700 acres of forest, and 1,200 acres of prairie; tributary restoration of 20,000 acres (approximately 2.3 percent of total tributary floodplain area) including approximately 12,600 acres of wetlands, 3,800 acres of forest, and 3,600 acres of prairie; and aquatic restoration including 100 miles of tributary streams (3.3 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 100 miles of stream.
- **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams), Wilmington and Kankakee Dams on the Kankakee River, Bernadotte Dam on the Spoon River, and the Aux Sable Dam.
- **Water Level.** Create 60,000 acres of storage area at an average depth of 1.5 feet and 38,400 acres of infiltration area. Increase intensity of water level management at navigation dams using electronic controls and increased flow gaging. Results include an 8 percent reduction in the 5-year peak flows in tributaries, an overall average 20 percent increase in tributary base flows, and up to a 65 percent reduction in the occurrence of half-foot or greater fluctuations during the growing season in the main stem Illinois River. Providing benefits to an estimated 8,580 miles of tributary streams.
- **Water Quality.** Anticipate improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would result from sediment delivery reduction measures and water level management measures.

Alternative 5

- **Ecological Integrity.** Improves the amount of current habitats and their functions at the system level. No further declines in system ecological integrity are foreseen at this level of restoration. System health and ecological integrity are stable or improving.
- **Sediment Delivery.** Reduction in sediment delivery from direct Peoria Lakes tributaries by 40 percent, other tributaries upstream of Peoria Lakes by 11 percent, and tributaries downstream of Peoria Lakes by 4 percent. System benefits include reduced delivery of 20 percent to Peoria Lakes and 10 percent system wide.
- **Backwaters and Side Channels.** Restoration of 8,600 acres in 60 of the approximate 100 backwaters on the system. Dredging of 10-200 acres per backwater, with 40 backwaters dredged to the optimal level (40 percent of backwater area). This would create overwintering habitat spaced approximately every 5 miles along the system and optimal areas every 7 miles. Restoration of 30 side channels and protection of 15 islands. In total, these efforts would benefit a total of 42,240 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 40,000 acres of main stem floodplain (approximately 7.9 percent of total main stem floodplain area) including approximately 16,800 acres of wetlands, 9,600 acres of forest, and 13,600 acres of prairie; tributary restoration of 40,000 acres (approximately 4.6 percent of total tributary floodplain area) including approximately 25,200 acres of wetlands, 7,200 acres of forest, and 7,600 acres of prairie; and aquatic restoration including 250 miles of tributary streams (8.3 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 250 miles of stream.
- **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams), Wilmington and Kankakee Dams on the Kankakee River, Bernadotte Dam on the Spoon River, and the Aux Sable Dam.
- **Water Level.** Create 60,000 acres of storage area at an average depth of 1.5 feet and 38,400 acres of infiltration. Increase water level management at navigation dams using electronic controls and increased flow gaging. Results include an 8 percent reduction in the 5-year peak flows in tributaries, an overall average 20 percent increase in tributary base flows, and up to a 65 percent reduction in the occurrence of half-foot or greater fluctuations during the growing season in the main stem Illinois River. Providing benefits to an estimated 8,580 miles of tributary streams.
- **Water Quality.** Anticipate improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would result from sediment delivery reduction measures and water level management measures.

Alternative 6

- **Ecological Integrity.** Restoration would provide a measurable increase in level of habitat and ecological integrity at the system level.

- **Sediment Delivery.** Reduction in sediment delivery from direct Peoria Lakes tributaries by 40 percent, other tributaries upstream of Peoria Lakes by 11 percent, and tributaries downstream of Peoria Lakes by 20 percent. System benefits include reduced delivery of 20 percent to Peoria Lakes and 20 percent system wide.
- **Backwaters and Side Channels.** Restoration of 12,000 acres in 60 of the approximate 100 backwaters on the system. Dredging an average of 200 acres per backwater, the optimal level of 40 percent of the approximate 500-acre average backwater area. This would create optimal backwater and over-wintering habitat spaced approximately every 5 miles along the system. Restoration of 35 side channels and protection of 15 islands. In total, these efforts would benefit a total of 56,020 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 75,000 acres of main stem floodplain (approximately 14.9 percent of total main stem floodplain area) including approximately 31,700 acres of wetlands, 25,300 acres of forest, and 18,000 acres of prairie; tributary restoration of 75,000 acres (approximately 8.8 percent of total tributary floodplain area) including approximately 47,600 acres of wetlands, 13,900 acres of forest, and 13,500 acres of prairie; and aquatic restoration including 500 miles of tributary streams (16.6 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 500 miles of stream.
- **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams), Wilmington and Kankakee Dams on the Kankakee River, Bernadotte Dam on the Spoon River, and the Aux Sable Dam.
- **Water Level.** Create 107,000 acres of storage area at an average depth of 1.5 feet and 38,400 acres of infiltration. Increase water level management at navigation dams using electronic controls and increased flow gaging. Results include an 11 percent reduction in the 5-year peak flows in tributaries, an overall average 20 percent increase in tributary base flows, and up to 65 percent reduction in the occurrence of half-foot or greater fluctuations during the growing season in the main stem Illinois River. This alternative also would see benefits accrue from drawdowns in La Grange or Peoria Pools. Providing benefits to an estimated 11,000 miles of tributary streams.
- **Water Quality.** Anticipate improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would result from sediment delivery reduction measures and water level management measures.

Alternative 7

- **Ecological Integrity.** Restoration would provide a measurable increase in level of habitat and ecological integrity at the system level, at or near the vision for the Illinois River Basin. This level of effort was developed to provide an upper limit of potential restoration (or desired future condition) considering current political, social, and fiscal constraints.
- **Sediment Delivery.** Reduction in sediment delivery from direct Peoria Lakes tributaries by 40 percent, other tributaries upstream of Peoria Lakes by 11 percent, and tributaries

downstream of Peoria Lakes by 20 percent. System benefits include reduced delivery of 20 percent to Peoria Lakes and 20 percent system wide.

- **Backwaters and Side Channels.** Restoration of 18,000 acres in 60-90 of the approximate 100 backwaters on the system. Dredging of 200-300 acres per backwater. This would create backwater and overwintering habitat spaced approximately every 3 to 5 miles along the system. Restoration of 40 side channels and protection of 15. In total, these efforts would benefit a total of 66,580 acres.
- **Floodplain, Riparian, and Aquatic.** Restoration of 150,000 acres of main stem floodplain (approximately 29.9 percent of total main stem floodplain area) including approximately 63,300 acres of wetlands, 50,700 acres of forest, and 36,000 acres of prairie; tributary restoration of 150,000 acres (approximately 17.6 percent of total tributary floodplain area) including approximately 95,200 acres of wetlands, 27,800 acres of forest, and 27,000 acres of prairie; and aquatic restoration including 1,000 miles of tributary streams (33.3 percent of the approximately 3,000 miles of channelized streams) with a mix of improved in-stream aquatic habitat structure and channel remeandering. Indirect benefits would extend to an additional 1000 miles of stream.
- **Connectivity.** Restore fish passage at all main stem dams on the Fox River (12 dams), all dams on the West Branch of the DuPage River (5 dams), all main stem dams and one tributary (Salt Creek) of the Des Plaines River (17 dams), Wilmington and Kankakee Dams on the Kankakee River, Bernadotte Dam on the Spoon River, Aux Sable Dam, and Starved Rock, Marseilles, and Dresden Locks and Dams on the Illinois River main stem (3 dams).
- **Water Level.** Create 250,000 acres of storage area at an average depth of 1.5 feet and 96,000 acres of infiltration area. Increase water level management at navigation dams using electronic controls and increased flow gaging. Results include a 23 percent reduction in the 5-year peak flows in tributaries, an overall average increase of 50 percent in tributary base flows, and up to a 73 percent reduction in the occurrence of half-foot or greater fluctuations during the growing season in the main stem Illinois River. This alternative also would see benefits accrue from drawdowns in La Grange or Peoria Pools and replacement of wickets at Peoria and La Grange with automatic gate dams to eliminate wicket-related fluctuations. Providing benefits to an estimated 22,000 miles of tributary streams.
- **Water Quality.** Anticipate improvements in water quality due to reduced sediment, phosphorus, and nitrogen delivery. These improvements would result from sediment delivery reduction measures and water level management measures.

b. Alternative Costs. The following tables summarize the system alternative costs, if fully implemented, over the full 50 year time horizon. The first cost estimates are based on unit costs for construction of various restoration measures. In addition, costs for program administration, monitoring, adaptive management, and further special studies have been included. All restoration would be cost-shared 65 percent Federal and 35 percent non-Federal sponsor. The costs of attaining the Overarching Goal Ecological Integrity and Goal 6 Water Quality will be addressed through the activities undertaken associated with the other goals and through the prioritization process and restoration specifications.

The costs of construction were calculated first, based on attaining the desired level of ecological benefits. The construction cost estimates include all costs related to the implementation of restoration projects including a 35 percent contingency; 30 percent for planning, engineering, and design; 9 percent construction oversight; and real estate estimates. However, total program costs require the inclusion of administration, monitoring, etc. Average system management costs are estimated to range from $600,000 to $1.25 million per year based on level of effort associated with each alternative plan. These funds are anticipated to cover both the Corps on Engineers staff time as well as the in-kind services of the sponsor. A technologies and innovative approaches component addressing items called for in the legislation, was estimated to require funding of approximately 6 percent of the construction costs. The program also seeks to utilize an adaptive management framework and, as such, includes 3 percent of the construction costs for this purpose. Special studies are anticipated to further define watershed issues and address specific questions regarding various resource issues; the various plans allow from $500,000 to $1 million per year for these activities based on the level of effort associated with the overall plans.

The systemic O&M Cost is the responsibility of the non-Federal sponsor. Estimates of O&M were developed based on the specific practices recommended under each category and developed into a single system-wide cost. Table 3-59 summarizes the anticipated annual O&M cost associated with each of the alternatives assuming full implementation. This level of O&M, ranging from $613,271 to $16,179,318 annually, would be associated with the fully implemented plan. The actual annual O&M costs in years leading up to full implementation would be proportional to the percent of the restoration activities undertaken.

Table 3-57. System Plan – Benefits Summary

	Overarching Goal	**Goal 1**	**Goal 2**	**Goal 3**	**Goal 4**	**Goal 5**	**Goal 6**
Alternative	**Ecological Integrity**	**Sediment Delivery**	**Backwaters and Side Channels**	**Floodplain, Riparian, and Aquatic**	**Connectivity**	**Water Level Management**	**Water Quality**
No Action	decline	some increase delivery	decline 1%/ yr	No Change	potential improvement	more fluctuations	minor improvement
1	regional improvements	0% upper Tribs 20% Peoria Tribs 0% lower Tribs	3,600 BW acres 10 side channel 10 island protect	5,000 acres MS 5,000 acres Trib 25 stream miles		-1.5% TPF 0% TBF 0% MSF	minor regional improvements
2	maintain current habitat at system level	0% upper Tribs 40% Peoria Tribs 0.5% lower Tribs	6,100 BW acres 20 side channel 15 island protect	5,000 acres MS 10,000 acres Trib 50 stream miles		-2.3% TPF +5% TBF 0% MSF	regional improvement
3	begin system improvements - sediment focus	11% upper Tribs 40% Peoria Tribs 4% lower Tribs	8,600 BW acres 30 side channel 15 island protect	20,000 acres MS 20,000 acres Trib 100 stream miles	Fox, DuPage, Des Plaines	-2.3% TPF +5% TBF 66% MSF	some system improvement
4	begin system improvements - tributary focus	11% upper Tribs 40% Peoria Tribs 4% lower Tribs	6,100 BW acres 20 side channel 15 island protect	5,000 acres MS 20,000 acres Trib 100 stream miles	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable	-8% TPF +20% TBF 66% MSF	some system improvement
5	ecosystem integrity stable	11% upper Tribs 40% Peoria Tribs 4% lower Tribs	8,600 BW acres 30 side channel 15 island protect	40,000 acres MS 40,000 acres Trib 250 stream miles	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable	-8% TPF +20% TBF -66% MSF	some system improvement
6	measurable increase at system level	11% upper Tribs 40% Peoria Tribs 20% lower Tribs	12,000 BW acres 35 side channel 15 island protect	75,000 acres MS 75,000 acres Trib 500 stream miles	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable	-11% TPF +20% TBF -66% MSF	some system improvement
7	reasonable upper bound to system improvements	11% upper Tribs 40% Peoria Tribs 20% lower Tribs	18,000 BW acres 40 side channel 15 island protect	150,000 acres MS 150,000 acres Trib 1000 stream miles	Fox, DuPage, Des Plaines, Kankakee, Spoon, Aux Sable, 3 Main Stem Dams	-23% TPF +50% TBF -73% MSF	some system improvement

Overarching Goal – Ecological Integrity will be addressed by the other goals through prioritization and specifications on restoration measures.
Goal 1 - Sediment delivery benefits are expressed in percentage reductions in tributary delivery resulting from in-channel stabilization and upland practices.
Goal 2 - Backwater (BW) Benefits are expressed in acres dredged, but will benefit larger reaches. Side Channel benefits associated with increased structure and some dredging.
Goal 3 - Main stem (MS) floodplain and riparian (trib) areas are expressed as acreages. Aquatic areas are expressed in stream miles.
Goal 4 - Connectivity (Fish Passage) lists reaches to be addressed. Main stem passage is at Starved Rock, Marseilles, and Dresden Island.
Goal 5 - TPF and TBF are tributary peak flow and base flow, respectively. MSF is the change in the main stem fluctuation regime, representing an average of 5-day windows in the lower river fluctuations over the course of the average growing season. Auto gates allow increased management to smooth flow releases and are included in Alternatives 6 and 7. Wicket dam replacements are considered for the Peoria and La Grange pools in Alternative 7.
Goal 6 - Water quality issues will be addressed through other goals. Greatest benefits likely associated with Goals 1 and 3.

Only rough benefits estimations are included in table; see write-up for additional details.

Table 3-58. First Costs by Goal Category Over 50-Year Implementation

	Overarching Goal	**Goal 1**	**Goal 2**	**Goal 3**	**Goal 4**	**Goal 5**	**Goal 6**	**Cost ($ Millions)**	
Alternative	**Ecological Integrity**	**Sediment Delivery**	**Backwaters and Side Channels**	**Floodplain, Riparian, and Aquatic**	**Connectivity**	**Water Level Management**	**Water Quality**	**Construction Total [1]**	**Total Program [2]**
No Action	–	–	–	–	–	–	–		
1	Achieved through other goals	$95	$365	$160	–	$135	Achieved through other goals	$790	$945
2	Achieved through other goals	$210	$620	$275	–	$305	Achieved through other goals	$1,410	$1,660
3	Achieved through other goals	$560	$870	$640	$50	$310	Achieved through other goals	$2,430	$2,905
4	Achieved through other goals	$560	$620	$505	$55	$1,105	Achieved through other goals	$2,845	$3,355
5	Achieved through other goals	$560	$870	$1,390	$55	$1,105	Achieved through other goals	$3,980	$4,605
6	Achieved through other goals	$1,040	$1,205	$2,675	$55	$1,625	Achieved through other goals	$6,600	$7,440
7	Achieved through other goals	$1,040	$1805	$5,350	$290	$4,325	Achieved through other goals	$12,810	$14,155

Note: Overarching Goal Ecological Integrity and Goal 6 Water Quality will be addressed under other goals through prioritization and practice specifications.

[1] Construction cost estimates include: 35% contingency, 30% planning, engineering, & design, and 9% construction oversight. Real Estate estimates are included.

[2] Total program calculations include:
Management = $600k to $1.25 million/year based on level of effort (approx 2/3 Corps 1/3 in-kind services)
Technologies and Innovative Approach components costs are approximately 8% of construction total
Adaptive Management costs are approximately 3% of construction total
Special Studies and Watershed Studies ($500k to $1 million based on level of effort)
Excludes O&M Costs - which are shown separately

Table 3-59. Annual O&M Costs Assuming Full Implementation

	Overarching Goal	**Goal 1**	**Goal 2**	**Goal 3**	**Goal 4**	**Goal 5**	**Goal 6**	
Alternative	**Ecological Integrity**	**Sediment Delivery**	**Backwaters and Side Channels**	**Floodplain, Riparian, and Aquatic**	**Connectivity**	**Water Level Management**	**Water Quality**	**Annual O&M Costs**
No Action	–	–	–	–	–	–	–	
1	Achieved through other goals	$97,000	$11,990	$369,281	$0	$135,000	Achieved through other goals	$613,271
2	Achieved through other goals	$212,000	$18,805	$581,363	$0	$200,000	Achieved through other goals	$1,012,168
3	Achieved through other goals	$645,000	$20,445	$1,486,525	$152,463	$325,000	Achieved through other goals	$2,629,433
4	Achieved through other goals	$645,000	$18,805	$1,000,825	$156,691	$835,000	Achieved through other goals	$2,656,321
5	Achieved through other goals	$645,000	$20,445	$3,130,213	$156,691	$835,000	Achieved through other goals	$4,787,329
6	Achieved through other goals	$1,125,000	$21,265	$5,941,525	$156,691	$1,185,000	Achieved through other goals	$8,429,481
7	Achieved through other goals	$1,125,000	$22,085	$11,887,750	$494,483	$2,650,000	Achieved through other goals	$16,179,318

2. Evaluation and Comparison of Plans

Description of the Evaluation and Comparison Process

The purpose of the evaluation and comparison steps is to determine to what extent the various plans achieve ecosystem goals and objectives and reasonably maximize ecosystem benefits to the Nation. The evaluation of each alternative consists of measuring or estimating the ecosystem benefits (acres of habitat, stream miles restored, tons of sediment not delivered to the system, etc.) and the resulting effect on ecological integrity, costs, and determining the difference between the without- and with-project conditions. In particular, each alternative is formulated and evaluated in relationship to five criteria: completeness, effectiveness, efficiency, acceptability, and risk and uncertainty. The effectiveness and efficiency of each alternative is determined based on percent attainment of the desired future (represented by Alternative 7) and area benefited (acres or stream miles).

- **Completeness** is the extent to which the alternative plans provide and account for all necessary investments of other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities.
- **Effectiveness** is the extent to which the alternative plans contribute to achieve the planning objectives.
- **Efficiency** is the extent to which an alternative plan is the most cost-effective means of achieving the objectives.
- **Acceptability** is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies.
- **Risk and uncertainty** is the identification of the areas of sensitivity where actual outcomes are uncertain due to unpredictable biological or economic elements.

The selection of a preferred comprehensive plan alternative requires that individual alternative plans be compared against the without-project condition and against one another. Alternative plan comparisons were largely driven by the evaluation of information generated during the formulation of the alternatives (e.g., costs, ecosystem benefits, extent of achieving objectives, etc.). Additional information regarding alternative completeness, sustainability and level of risk and uncertainty also were assessed.

The primary criteria used by the Corps of Engineers for ecosystem restoration projects is cost effectiveness and incremental analysis. The National Ecosystem Restoration (NER) plan is selected from the cost-effective plans as the alternative that reasonably maximizes ecosystem restoration benefits compared to costs. The selected plan is chosen after considering the cost-effectiveness and incremental costs of other plans.

a. Completeness. All of the plans formulated provide relatively equal levels of completeness. All plans could be fully attained through an expanded authorization under this authority; however, considerable opportunities exist for partnerships with other Federal and State agencies. The extent of these partnerships will depend on future authorizations and appropriations for the various partner agencies.

b. Effectiveness. The effectiveness of alternative plans is related to the extent to which they achieve the planning objectives or desired future conditions. Ecosystem restoration project benefits are typically non-monetary outputs expressed in terms of increased quality and quantity of habitat. These outputs are typically measured as annualized habitat units (combination of acreage and habitat suitability). However, it was not feasible to quantify annualized habitat benefits using a formal Habitat Evaluation Procedures (HEP) approach over the 30,000-square-mile project area given the range of habitat types and limiting factors being addressed by the system alternatives. The defined outputs varied by goal category and included acres, stream miles, reductions in sediment delivery, and improved hydrologic regimes. As a result, a complete cost effectiveness and incremental cost effectiveness analysis based on habitat units could not be conducted.

Early on in the study process, detailed objectives were identified for each goal category by the system team, resource managers, and stakeholders. These objectives represent a desired future condition of ecological condition for the Illinois River Basin.

The best quantifiable measure of system output that provides comparability across all goal categories was the percentage attainment of restoration objectives (desired future). However, the benefit area was also able to be quantified in terms of acres and stream miles. These measures of benefits allow for the completion of a cost effectiveness-incremental cost analysis for five of the seven goal categories (Goals 1 through 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 will be conducted.

The remainder of this section highlights the values identified for effectiveness. By examining the number, type, and potential results of restoration alternatives, the effectiveness of ecosystem alternatives was quantitatively and qualitatively assessed. This process included identifying the extent to which the alternative plan:

- Maintains or exceeds the existing condition
- Accounts for planning objectives (desired future conditions)
- Affects ecosystem integrity (EOPs, sustainability).

Overarching Goal: Ecosystem Integrity

The goal of ecosystem restoration is to restore and sustain ecosystem integrity by protecting native biodiversity and the ecological and evolutionary processes that create and maintain that diversity. Ecological integrity is the overarching goal for this restoration program and should drive the identification, development, and selection of all restoration measures and alternatives; all alternatives and objectives formulated under all of the other program goals would contribute toward restoring the ecological integrity of the Illinois River Basin.

Ecological integrity is defined as 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 environmental quality of the restoration alternatives was evaluated by examining how they contribute to the Illinois River Basin ecosystem integrity. The parameters, compared to the existing conditions at both the regional and system scale, were:

1) Maintain or exceed the existing condition,
2) Increase the amount of quality habitat and,
3) Improve the ecological integrity (habitat, biodiversity, function, and sustainability).

The proposed ecosystem restoration alternatives address increasing amounts of quality habitat through restoration and preservation. Some alternatives address restoration of ecosystem function, and thus increasing levels of sustainability. In this evaluation, all of the alternatives, except no action, were presumed to positively affect the habitat and ecological integrity, either at the regional or system level or both, with varying degrees of effectiveness. A summary of the effectiveness of the alternatives on ecosystem integrity is shown in table 3-57. Ecosystem integrity can be achieved at the regional scale or system scale and is a function of the level of restoration and project placement (i.e., concentration in a watershed). As ecological integrity is improved, particularly through sediment reduction and water level management, habitats and projects become more sustainable.

No Action (anticipated future condition without project). Continue the decline in system ecological integrity and populations of native species, resulting from the continuation of habitat loss and fragmentation, the altering of natural disturbance regimes, and the continuation of non-indigenous species colonization.

Alternative 1. Continue the decline in system ecological integrity and populations of native species. However, in areas of focused restoration efforts, there would be regional improvements to both habitat and regional ecological integrity.

Alternative 2. Current habitat conditions will be maintained. However, some decline in system ecological integrity would continue to occur, especially for populations of native species that are currently declining or sensitive to continued habitat fragmentation, such as area-sensitive species.

Alternative 3. Improvements in habitat conditions at the system level, with a focus on system ecological integrity, particularly in impacts of excessive sedimentation. This plan would increase backwater habitat, reduce sediment delivery, and restore additional main stem and tributary floodplain areas.

Alternative 4. Improvements in habitat conditions at the system level, with a focus on tributary ecological integrity and secondary effects to main stem habitats. This plan would result in sediment delivery reduction, tributary floodplain and stream restoration, increased fish passage, and more naturalized water levels.

Alternative 5. Improves the amount of current habitats and their functions at the system level. No further declines in system ecological integrity are foreseen at this level of restoration. System health and ecological integrity are stable or improving.

Alternative 6. Restoration would provide a measurable increase in level of habitat and ecological integrity at the system level.

Alternative 7 (desired future condition). Restoration would provide a measurable increase in level of habitat and ecological integrity at the system level, at or near the vision for the Illinois River

Basin. This level of effort was developed to provide an upper limit of potential restoration considering current political, social, and fiscal constraints.

Sustainability is the ability of the ecosystem to maintain its structure and function and to remain resilient in order to continue to give and support life. The sustainability of the various plans was measured as a way to address the extent to which the various alternatives address the system ecological integrity. In general, it will take extensive work to reach an increased level of sustainability of ecological processes and functions. Significant increases in sustainability are anticipated with Goals 6 and 7.

Goals 1 through 5

For Goals 1 through 5, the effectiveness of the various alternatives in attaining the study objectives could be expressed in two ways: (1) percentage of the desired future condition and (2) area benefited (acres or stream miles).

1. Percent Attainment of the Desired Future Condition. Benefits were first quantified as a percentage of the desired future condition established as part of the study and expressed in Alternative 7. The following paragraphs and table 3-61 briefly summarize the reference for each goal category in terms of the benefit measures shown and percent attainment. The various percentages were averaged (e.g. given equal weighting) in order to provide some understanding of the system level of attainment of the study objectives. Across all categories, the range of effectiveness in attaining the system objectives ranged from a low of 7 percent for Alternative 1 to a high of 97 percent for Alternative 7.

Goal 1. The sediment delivery restoration objective calls for a 20 percent reduction system-wide. Each of the alternatives has an estimated reduction, (i.e., Alternative 1 - 2.3 percent system reduction) which can be converted to a percentage of the objective (12 percent of the system goal of 20 percent). This is only a summary since the regional benefits associated with some of the smaller plans are lost, because only the overall system reduction was calculated.

Goal 2. Backwater and Side Channel restoration alternatives were evaluated under three different criteria. These included backwater restoration measures against the system objective of 19,000 acres and side channel restoration measures against the system objective of 40 areas (established by the UMR-IWW System Navigation Study objectives database). The formulation also included island protection projects, but because the levels are nearly the same for all alternatives and the affected area is very small, this measure was not included in the effectiveness matrix.

Goal 3. The effectiveness was best measured by looking at the performance by alternative against the three separate restoration objectives. The actual numbers were calculated by again looking at each alternatives percentage attainment of the objectives: main stem floodplain with an objective of 150,000 acres, tributary floodplain with an objective of 150,000 acres, and aquatic stream restoration with an objective of 1,000 miles.

Goal 4. Connectivity (fish passage) was not as easily converted to a percentage basis, since no single system stream mile objective was developed. The total stream miles connected by alternative was divided by the maximum number of stream miles—3,792—connected under Alternative 7. This does not clearly reflect the total value of various individual projects, since the extent to which various dams block migrations varies considerably by dam site. However, it does provide a sense of the relative magnitude. It was also noted by those working directly on the fish passage issues that given Midwest fish communities, in many cases addressing long stretches separated by only a single dam may not represent as great of benefits as addressing more closely spaced dams that are more completely limiting habitat in a tributary or stream reach. This was the basis for addressing the Fox, Des Plaines, and DuPage in the first increment of passage.

Goal 5. The naturalization of water levels to more closely match ecosystem needs is one of the most complex areas of study. The actual physical processes are complex and the biological responses are not precisely understood. However, the outputs of the various alternative plans were able to be measured in three different fashions to address progress toward the study objectives. Main stem benefits were measured in terms of percent reductions in 1-foot fluctuations, tributary benefits measured in terms of increases in base flow (based on a maximum of 50 percent reduction shown as 100 percent attainment of the objective), and peak flow reductions (based on a maximum of 23 percent again shown as 100 percent attainment of the objective).

Table 3-60. Alternative Effect on Ecosystem Integrity

	No Action	Alternative. 1	Alternative. 2	Alternative. 3	Alternative. 4	Alternative. 5	Alternative. 6	Alternative. 7
Quality Habitat Improvement	decline	regional only	maintain current	minor	minor	minor	major	major
Ecosystem Integrity Regional Scale	decline	improve	improve	improve	improve	improve	improve	improve
Ecosystem Integrity System Scale	decline	decline	decline	sediment improve	tributary improve	improve	improve	improve
Sustainability	no	low	low	low/mod	low/mod	moderate	high	high

Table 3-61. Summary of the Effectiveness of Alternatives as Percent of Desired Future Conditions

Effectiveness	No Action	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Goal 1 - Sediment Reduction (20% reduction)	0%	12%	25%	50%	50%	50%	100%	100%
Goal 2 - Backwaters (19,000 acres)	0%	19%	32%	45%	32%	45%	63%	95%
Goal 2 - Side Channels (40 no.)	0%	25%	50%	75%	50%	75%	88%	100%
Goal 3 - Main Stem Floodplain (150k acres)	0%	3%	3%	13%	3%	27%	50%	100%
Goal 3 -Tributary Floodplain (150k acres)	0%	3%	7%	13%	13%	27%	50%	100%
Goal 3 - Aquatic Restoration (1k miles)	0%	3%	5%	10%	10%	20%	50%	100%
Goal 4 - Fish Passage (miles)	0%	0%	0%	23%	78%	78%	78%	100%
Goal 5 - Water Level - Main Stem % reduction 1-foot fluctuations)	0%	0%	0%	65%	65%	65%	65%	73%
Goal 5 - Water Level – Tributary (% increase in base flow) (max 50%)	0%	0%	10%	10%	40%	40%	40%	100%
Goal 5 - Water Level - Tributary (% reduction in peak flow) (max 25%)	0%	7%	10%	10%	35%	35%	48%	100%
Combined Goals (equal weighting)	0%	7%	14%	31%	38%	46%	63%	97%

2. Area Benefited (acres or stream miles). In addition to the percent attainment quantification, the system team also determined the area of beneficial influence in terms of stream miles and acres. Some individual goals produce benefits in one category or both while system alternative plans produce a mixture of both benefit categories (table 3-62).

Goal 6. Water and Sediment Quality

Similar to the Overarching Goal, no specific restoration was planned to directly address Goal 6 Water and Sediment Quality. However, benefits are anticipated to result from the practices included under the other goals (table 3-63). In particular, the reduction of sediment will address one of the key impairment to many reaches. The nutrient phosphorus is adsorbed to sediment, and reductions are anticipated associated with any sediment reductions. Similarly, reductions in nitrogen are anticipated as a result of wetland restoration and improved riverine corridors and buffers. The benefits are not likely to be more than regional with Alternatives 1 and 2. The levels associated with Alternatives 3 through 5 should provide some system improvements. However, more significant system improvements are anticipated with the levels associated with Alternatives 6 and 7, which more fully address sediment delivery and floodplain and riparian restoration.

c. Efficiency. For ecosystem restoration studies, efficiency is measured in terms of cost effectiveness. The National Ecosystem Restoration (NER) plan is the plan that reasonably maximizes ecosystem restoration benefits compared to costs, considering the cost effectiveness and incremental cost of implementing other restoration options. Corps of Engineers guidance requires the use of incremental cost analyses to select the NER plan. Two analytical processes are conducted to meet these requirements. First, a cost-effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of ecosystem output. Cost effectiveness means that no plan can provide the same benefits for less cost or more benefits for the same cost. Then, incremental cost analysis of the least cost solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. Plans that provide the greatest increase in benefits for the least increase in costs are identified as “best buy” plans. In the absence of a common measurement unit for comparing the non-monetary benefits with the monetary costs of ecosystem restoration plans, cost effectiveness and incremental analysis are valuable tools to assist in decision making.

1. Percent Attainment of the Desired Future Condition. The traditional Corps of Engineers ecosystem restoration project evaluations include an assessment of increases in ecosystem quality and quantity (often habitat), as well as a cost effectiveness-incremental cost analysis (CE/ICA). For a project that encompasses more than 30,000 square miles and multiple habitat types, it was not feasible to conduct habitat evaluation procedures. In addition, the benefits differed across the goals and were not directly comparable. The percent attainment measure of benefits allowed for the completion of a cost effectiveness-incremental cost analysis for five of the seven goal categories (Goals 1 through 5). Table 3-64 shows the combined percent attainment of the system objectives using an equal weighting of the various outputs. The outputs for the Overarching Goal and Goal 6 could not be fully quantified and, as a result, were separately assessed qualitatively.

Table 3-62. Acreage and Stream Mile Benefits of System Alternatives

	Goal 1 Sediment Delivery (Miles)	**Goal 2 Backwaters and Side Channels (Acres)**	**Goal 3 Floodplain, Riparian and Aquatic (Acres)**	**Goal 3 Floodplain, Riparian and Aquatic (Miles)**	**Goal 4 Connectivity (Miles)**	**Goal 5 Water Level Mgmt (Acres)**	**Goal 5 Water Level Mgmt (Miles)**
No Action	0	0	0	0	0	0	0
Alt 1	1,700	14,300	10,000	50	0	0	920
Alt 2	3,220	30,950	15,000	100	0	0	2,310
Alt 3	9,570	42,240	40,000	200	2,140	8,600	2,310
Alt 4	9,570	30,950	25,000	200	4,280	8,600	8,580
Alt 5	9,570	42,240	80,000	500	4,280	8,600	8,580
Alt 6	16,750	56,020	150,000	1,000	4,280	20,900	11,000
Alt 7	16,750	66,580	300,000	2,000	6,730	23,700	22,000

Table 3-63. Alternative Effect on Water and Sediment Quality

Effectiveness	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**
Goal 6 - Water Quality	None	Low	Low	Moderate	Moderate	Moderate	Mod/High	Mod/High

Table 3-64. Cost Effectiveness - System Benefits (Percent of Desired Future) and System Costs

Efficiency	**No Action**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**
Combined Goals 1 through 5 (equal weighting)	0%	7%	14%	31%	38%	46%	63%	97%
Total First Cost ($ million)	-	$945	$1,660	$2,905	$3,355	$4,605	$7,440	$14,155
Cost Effectiveness. - Goals 1 through 5 (cost per % improvement, $ million)	-	$135	$119	$94	$88	$100	$118	$146

Figures 3-45 and 3-46 and table 3-65 show the output of the cost effectiveness-incremental cost analysis using the percentage attainment of the desired future condition and total first cost. As figure 3-45 illustrates, all plans formulated for the study were cost effective and were built only from cost effective measures. Four plans in addition to the No Action Alternative were identified as best buys: Alternatives 4, 5, 6, and 7. These plans provide the greatest increase in benefits for the least increase in cost (lowest incremental costs).

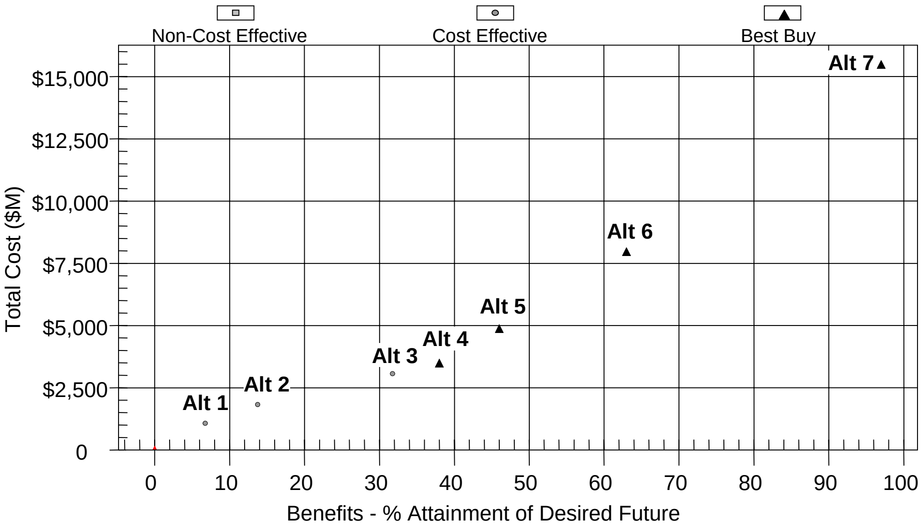


Figure 3-45. Cost Effectiveness of Plans

Table 3-66 and figure 3-46 highlight the results of the incremental cost analysis of the best buy plans. As the figures show, Alternative 4 provides restoration at a cost effectiveness of $88 million per percent of the desired future attained for the first 38 percent. Alternative 5 provides a gain of an additional 8 percent attainment of objectives for an additional $1.25 billion investment, at an incremental cost of $156 million per percent. A similar incremental cost of $166 million per percent is incurred in moving from Alternative 5 to Alternative 6. However, in order to attain the final 34 percent increase in objective benefits, an additional, $6.7 billion would be required at an incremental cost of $198 million per percent.

Table 3-65. Summary of Incremental Cost Analysis

Alternative	Cost ($ Millions)	% Attainment of Desired Future	Incremental Cost	Incremental Benefit	Incremental Cost Per Output
Alternative 0	$0	0	$0	0	$0
Alternative 4	$3,355	38	$3,355	38	$88
Alternative 5	$4,605	46	$1,250	8	$156
Alternative 6	$7,440	63	$2,835	17	$166
Alternative 7	$14,155	97	$6,715	34	$198

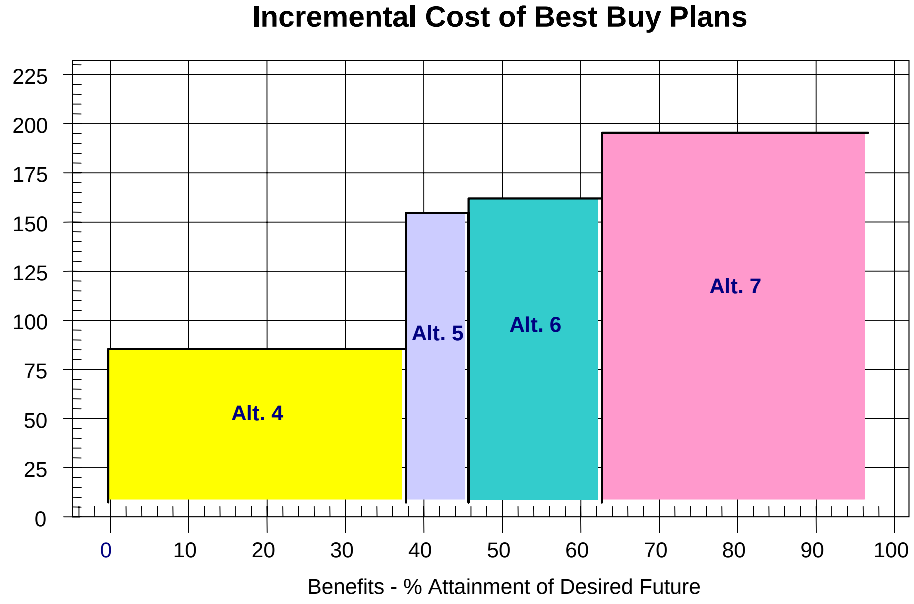


Figure 3-46. Incremental Cost of Best Buy Plans

2. Acres Benefited (acres or stream miles). In addition to the percent of goal attainment analysis, cost effectiveness and incremental costs analysis (CE/ICA) was also conducted to evaluate the area of influence benefits, in acres and stream miles. The CE/ICA looks separately at the benefits produced by each alternative plan in terms of acres and stream miles. The result is an analysis that identified the most efficient or "best buy" system alternatives for each benefit category at the goal and system level.

The alternatives developed and analyzed by goal were built from cost effective practices and therefore the range of alternatives within each Goal category were all considered cost effective. The purpose of this analysis is to show which system alternatives have the largest share of best buy components across the goal categories. Those system alternatives composed of "best buy" levels of restoration for acres, stream miles, and percent of goal attainment are considered to be more effective system restoration alternatives.

Table 3-66 summarizes the acres and stream mile benefits of the proposed system alternatives by goal and alternative. All alternatives are cost effective; in addition, figures in bold indicate "best buy" alternatives.

The results of the cost effectiveness analysis for the system alternative plans showed that all alternative plans were cost-effective plans. Cost effectiveness means that no plan can provide the same benefits for less cost or more benefits for the same cost. Alternative 6 exhibited the lowest cost per unit of all alternatives, $683 per acre of benefit (table 3-67). Alternative 3 exhibited the lowest cost per unit of all cost effective alternatives, $5,080 per stream mile of benefit.

For both acres and stream mile benefit categories, "best buy" plans were identified. Table 3-68 and figure 3-47 show the best buy plans based on acres. These plans provide the greatest increase in benefits for the least increase in costs. For system alternatives producing acres of habitat benefits, Alternative 6 provides 226,920 acres of habitat benefit to the Basin at an annualized incremental cost of $683 per acre of habitat benefit. Alternative 7 provides an additional 163,360 acres of habitat benefit at an annualized incremental cost of $935 per acre of habitat benefit.

Table 3-66. Cost Effective Summary of Acreage and Stream Mile Benefits

	Goal 1	**Goal 2**	**Goal 3**	**Goal 3**	**Goal 4**	**Goal 5**	**Goal 5**
System Alternative	**Sediment Delivery (miles)**	**Backwaters & Side Channels (acres)**	**Floodplain, Riparian & Aquatic (acres)**	**Floodplain, Riparian & Aquatic (miles)**	**Connectivity (miles)**	**Water Level Management (acres)**	**Water Level Management miles)**
No Action	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Alt 1	**1,700**	14,300	10,000	50	**0**	**0**	920
Alt 2	3,220	**30,950**	15,000	100	**0**	**0**	2,310
Alt 3	9,570	**42,240**	40,000	200	2,140	**8,600**	2,310
Alt 4	9,570	**30,950**	25,000	200	**4,280**	**8,600**	**8,580**
Alt 5	9,570	**42,240**	80,000	500	**4,280**	**8,600**	**8,580**
Alt 6	**16,750**	**56,020**	150,000	**1,000**	**4,280**	**20,900**	**11,000**
Alt 7	**16,750**	**66,580**	**300,000**	**2,000**	**6,730**	**23,700**	**22,000**

All alternatives are cost effective; figures in bold indicate "best buy" alternatives.

Table 3-67. System Alternative Plans Evaluation

Alternative	**Plan Total Benefit (acres)**	**Plan Total Benefit (miles)**	**Acres – Total First Cost of Construction ($millions)**	**Miles – Total First Cost of Construction ($ millions)**	**Acres – Annualized Cost ($ 1,000s)**	**Miles - Annualized Cost ($ 1,000s)**	**Annualized Cost/System Acre ($ dollars)**	**Annualized Cost/System Mile ($ dollars)**
No Action	0	0	$0	$0	$0	$0	$0	$0
Alt 1	24,300	2,670	$463	$328	$26,845	$19,015	$1,104	$7,122
Alt 2	45,950	5,630	$770	$638	$44,645	$36,990	$971	$6,570
Alt 3	90,840	14,220	$1,268	$1,246	$73,520	$72,245	$809	$5,080
Alt 4	64,550	22,630	$883	$2,046	$51,195	$118,630	$793	$5,242
Alt 5	130,840	22,930	$1,650	$2,418	$95,670	$140,195	$731	$6,114
Alt 6	226,920	33,030	$2,676	$3,958	$155,155	$229,485	$683	$6,947
Alt 7	390,280	47,480	$5,312	$7,585	$307,995	$439,780	$789	$9,262

Note: Some acres and stream mile benefits may be double counted within a particular alternative if some of the same areas would be addressed by more than one goal.

Table 3-68. Incremental Cost Analysis of Best Buy System Alternative Plans (Acres of Benefit)

Alternative Plan	Acre Output [1]	Annualized Cost [2]	Incremental Cost	Incremental Output Acres	Incremental Cost/Acre of Benefit
No Action	0	$0	$0	0	$0
Alternative 6	226,920	$155,156,124	$155,156,100	226,920	$683
Alternative 7	390,280	$307,993,023	$152,836,900	163,360	$935

[1] Outputs are calculated as Acre of Benefit.
[2] Annualized cost is initial construction cost, based on a 50-year period of analysis, .05375% interest rate.

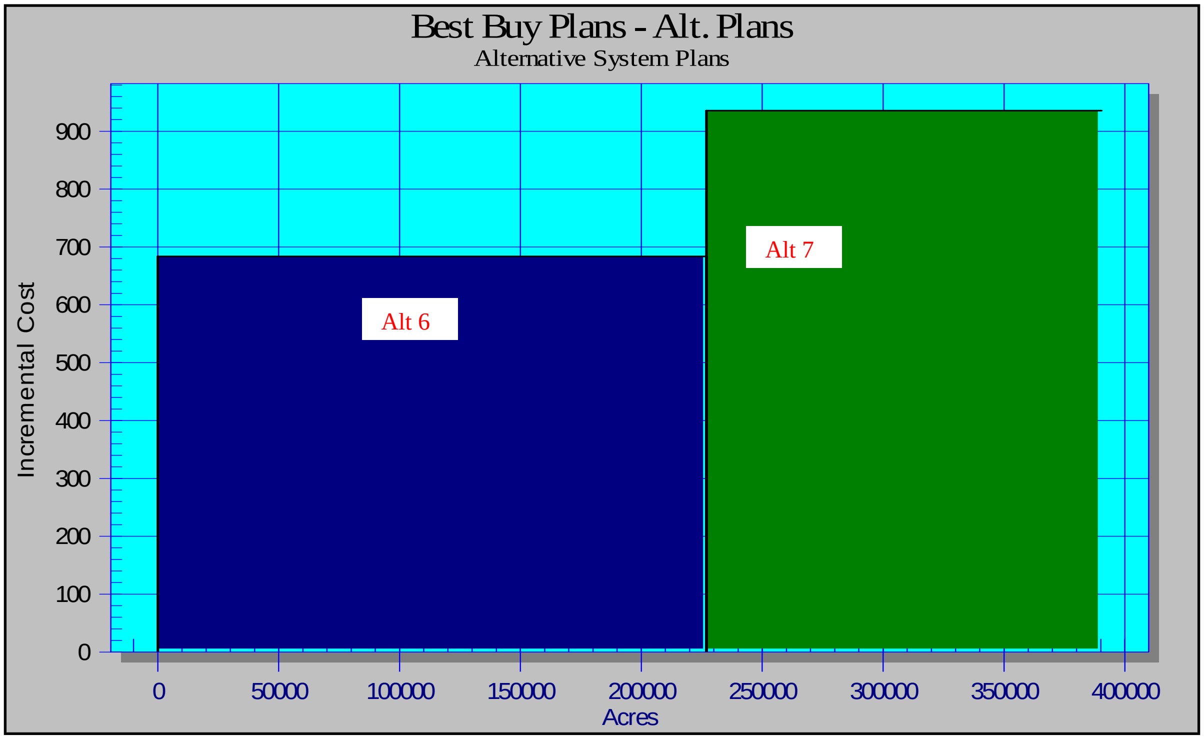


Figure 3-47. Incremental Analysis of Best Buy Plans (Acres of Benefit)

For system alternative producing stream miles of habitat benefits, there were four best buys; Alt 3, 4, 6, and 7 (table 3-69 and figure 3-48). Alternative 3 provides 14,220 miles of habitat benefit to the Basin at an annualized incremental cost of $5,080 per mile of habitat benefit. Alternative 4 provides an additional 8,410 miles of habitat benefit at an annualized incremental cost of $5,515 per mile of habitat benefit. Alternative 6 provides an additional 10,400 miles of habitat benefit at an annualized incremental cost of $10,659 per mile of habitat benefit. Finally, Alternative 7 provides an additional 14,450 miles of habitat benefit at an annualized incremental cost of $14,553 per mile of habitat benefit. While incremental costs increase significantly between Alt 4 and Alt 6, Alternative 6 adds considerably more benefits by addressing sediment delivery along the lower Illinois River and adding 800 miles of instream aquatic habitat restoration. The major addition in moving from Alt 6 to Alt 7 is an additional 1,000 miles of instream aquatic habitat restoration and providing fish passage on the main stem Illinois River.

Table 3-69. Incremental Cost Analysis of Best Buy System Alternative Plans (Miles of Benefit)

Alternative Plans	Miles Output [1]	Annualized Cost [2]	Incremental Cost	Incremental Output Miles	Incremental Cost/Mile of Benefit
No Action	0	$0	$0	0	$0
Alternative 3	14,220	$72,243,845	$72,243,850	14,220	$5,080
Alternative 4	22,630	$118,628,337	$46,384,490	8,410	$5,515
Alternative 6	33,030	$229,487,271	$110,858,900	10,400	$10,659
Alternative 7	47,480	$439,782,959	$210,295,700	14,450	$14,553

[1] Outputs are calculated as Acre of Benefit.
[2] Annualized cost is initial construction cost, based on a 50-year period of analysis, .05375% interest rate.

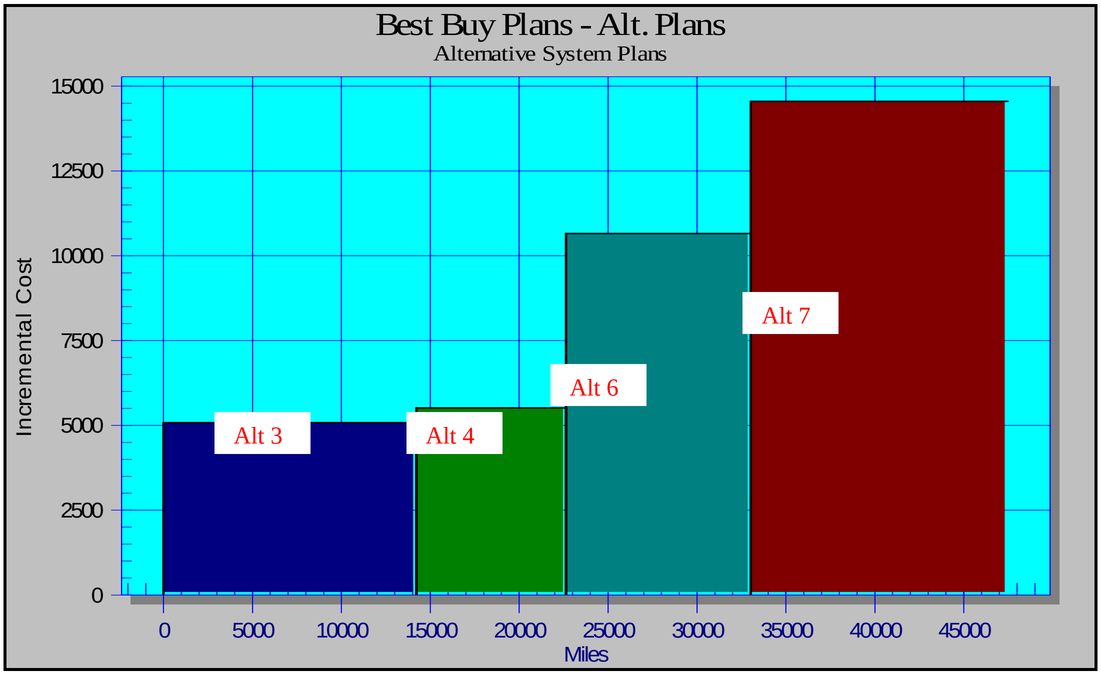


Figure 3-48. Incremental Analysis of Best Buy Plans (Miles of Benefit)

The most efficient alternatives, or best buy plans, varied somewhat by analysis acres, stream miles, and percent attainment. In total, they included the No Action and Alternatives 3, 4, 5, 6, and 7 (table 3-70). Alternative 3 was a best buy only in terms per cost per stream mile at $5,080 per stream mile. Alternative 4 was a best buy in terms of stream miles and percent attainment of goals. It provides restoration at a cost effectiveness of $5,515 per mile and $88 million per percent of the desired future condition attained for the first 38 percent. Alternative 5 was a best buy only for percent of goal attainment, providing a gain of an additional 8 percent, at an incremental cost of $156 million per percent. Only, Alternative 6 and 7 were best buy plans under all three forms of system analysis.

Table 3-70. Best Buy Plans from All System Analysis Methods

Alternative	**Incremental Annual Cost/Acre**	**Incremental Annual Cost/Mile**	**Incremental Cost Per % Goal Attained (Millions)**
No Action	**$0**	**$0**	**$0**
Alternative 1	$1,104	$7,122	$135
Alternative 2	$971	$6,920	$119
Alternative 3	$809	**$5,080**	$94
Alternative 4	$793	**$5,515**	**$88**
Alternative 5	$731	$71,883	**$156**
Alternative 6	**$683**	**$10,659**	**$166**
Alternative 7	**$935**	**$14,553**	**$198**

Note: Best Buy Plans are shaded. Incremental costs are shown from previous best buy plan.

d. Acceptability. Acceptability is the workability and viability of the alternative plan with respect to acceptance by Federal, State, and local entities; the general public; and compatibility with existing laws regulations and public policies [*Principles and Guidelines for Water and Related Land Resources,* Section VI.1.6.2(c)(4)]. To be acceptable, a plan has to have a perceived value, cost effectiveness, and a high probability of success. Many factors can render a plan infeasible in the minds of individuals. These factors can generally be categorized as technical (engineering or natural world limitations), economic, financial, environmental, social, political, legal and institutional.

While a wide range of comments was recorded during the study public meetings in December 2003, many comments supported plans that provide measurable system improvements in habitat and ecosystem integrity. These comments would be consistent with Alternatives 3 through 7 in considering habitat, but more specifically Alternatives 5 through 7 when considering ecological integrity.

e. Risk and Uncertainty. Risk and uncertainty are inherent in water resources planning and ecosystem restoration. Planners, resource managers, and decision makers rarely have all the information needed to make necessary public investment decisions. They often do not know how much confidence to place in the information they have; and must make decisions in an uncertain political, social, and economic environment. In addition, human intervention in natural processes involves unpredictable economic and biological elements.

Principles and Guidelines for Water and Related Land Resources, dated March 10, 1983, states that "the planner's primary role in dealing with risk and uncertainty is to identify the areas of sensitivity and describe them clearly so that decisions can be made with knowledge of the degree of reliability of available information." The alternatives and their effects should be examined to determine the uncertainty inherent in the data or various assumptions of future economic, demographic, social, public, environmental, and technological trends.

Risk and uncertainty was addressed as part of the formulation of measures and alternatives under each goal category. While there are uncertainties associated with some of the practices and approaches proposed in the Comprehensive Plan, the measures used to develop alternatives have been implemented at a number of locations and demonstrated to provide the desired benefits. Based on the approach of building all alternatives from similar measures, there are similar levels of risk and uncertainty associated with each alternative. As a result, risk and uncertainty does not represent a direct selection criterion in choosing among alternatives.

At the system level, however, risk and uncertainty is inherent in a study of a large basin, particularly in regard to ecological thresholds. Of concern is determining the thresholds associated with reductions in sediment delivery and reductions in water level fluctuations that will produce desired biological responses, such as increased aquatic plant growth and increased populations of macroinvertebrates. Since these thresholds cannot be known with certainty, the proposed approach is to implement restoration actions using sound site-specific project planning, adaptive management, long-term systemic monitoring, project-specific monitoring, and additional studies to address the uncertainties present during the implementation of the project components.

As a result, these elements have been included as part of the implementation framework for this restoration project and are described in greater detail in the following sections. Further specific studies will be developed to provide additional information needed for detailed design and refinement of specific components of the Comprehensive Plan.

The data collected and experiences learned through executing the restoration activities are recommended to be periodically reviewed and summarized for decision makers. This evaluation would provide the basis for potential identification of improved techniques or approaches; revised sediment reduction targets; improved hydrologic modifications; new restoration approaches; and modifications to the monitoring and adaptive management framework. It is likely that new technologies and techniques will emerge during the implementation process. New technologies and techniques for ecosystem restoration offer the possibility of improving the Comprehensive Plan over and above the measures identified to date. The implementation process will allow flexibility to consider and include new technologies as they become available.

3. Selection of the Preferred Comprehensive Plan Alternative

By reviewing the various alternative plan qualitative and quantitative outputs in comparison to the criteria of completeness, effectiveness, efficiency, acceptability (and risk and uncertainty), the relative benefits of the various alternative plans become clearer. Table 3-71 and the following sections provide additional explanation of the selection of the preferred comprehensive plan alternative in regards to completeness; effectiveness in achieving objectives; and efficiency - Cost Effectiveness (NER).

In terms of completeness, all plans were essentially equal. In terms of effectiveness in addressing the overarching goal of restoring ecological integrity and Goal 6, Alternatives 3, 4, 5, 6, and 7 provide improvements in terms of improving system habitats compared to existing conditions. However, only Alternatives 5, 6, and 7 fully address the study vision for a system sustainable by natural processes and the overarching goal of restoring and maintaining ecological integrity. Evaluation of the ecosystem alternative contribution to the planning objectives determined that Alternatives 6 and 7 most directly achieve the planning goals and objectives. Therefore, they received the highest ranking. While less defined, water and sediment quality improvements are also anticipated to be the greatest with Alternatives 6 and 7.

Table 3-71. Summary of Evaluation Criteria of Best Buy Plans

Completeness						
	No Action	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**
	-	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Effectiveness						
	No Action	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**
Overarching Goal - Habitat	decline	minor	minor	minor	major	Major
Overarching Goal – Ecosystem Integrity Region	decline	improve	improve	improve	improve	Improve
Overarching Goal – Ecosystem Integrity System	decline	sediment improve	tributary improve	improve	improve	Improve
Overarching Goal - Sustainability	no	low/mod	low/mod	mod	high	High
Goal 6 - Water Quality	-	mod	mod	mod	mod/high	mod/high
Combined Goals (equal weighting)	0%	31%	38%	46%	63%	97%
Acres Benefited	-	90,840	64,550	130,840	226,920	390,280
Stream Miles Benefited	-	14,220	22,630	22,930	33,030	47,480

Efficiency						
	No Action	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**	**Alt 7**
Project Cost ($ in millions)	-	$2,905	$3,355	$4,605	$7,440	$14,155
Best Buy Plans Percent Attainment	Yes	-	Yes	Yes	Yes	Yes
Best Buy Plans Acres Restored	Yes	-	-	-	Yes	Yes
Best Buy Plans Stream Miles Restored	Yes	Yes	Yes	-	Yes	Yes

The most efficient alternatives, or best buy plans, varied somewhat by analysis (acres), stream miles, and percent attainment. In total, they included the No Action and Alternatives 3, 4, 5, 6, and 7. Alternative 3 was a best buy only in terms per cost per stream mile at $5,080 per stream mile. Alternative 4 was a best buy in terms of stream miles and percent attainment of goals. It provides restoration at a cost effectiveness of $5,515 per mile and $88 million per percent of the desired future condition attained for the first 38 percent. Alternative 5 was a best buy only for percent of goal attainment, providing a gain of an additional 8 percent, at an incremental cost of $156 million per percent. Only Alternatives 6 and 7 were both best buy plans under all three forms of system analysis.

Acceptability also points to the strong desire to see plans that result in significant system improvements (i.e. Alternatives 5, 6, and 7). Since all plans have similar levels of risk and uncertainty, it did not provide a basis for selecting a particular plan.

Based on an assessment of all evaluation criteria, Alternative 6 was selected as the preferred comprehensive plan alternative. Alternative 3 and 4 were not selected since they do not provide enough restoration to make systemic ecological integrity improvements over current conditions, especially in relation to system ecological thresholds. Alternative 6 was selected over Alternative 5, since it was a best buy in terms of both cost per acre and stream miles, while Alternative 5 was not. Alternative 6 also provides a higher level of attainment of the desired future (63 percent) than Alternative 5 (46 percent) with similar incremental costs. Alternative 6 is anticipated to result in achievement of desired system outputs including restoration above threshold levels required for the return of aquatic plants and diving ducks and addressing system limiting factors allowing for improvements in fish, waterfowl, and threatened and endangered species populations.

As shown in the summary table of the best buy plans (table 3-71), only Alternatives 6 and 7 achieved significant improvements to ecosystem integrity over current conditions and high levels of sustainability. Alternative 7, while also a best buy under all three benefit evaluations and attaining near 100 percent achievement of the desired future, was also not preferred due to the relatively large increase in incremental and total cost per stream mile, acre, and percent attainment, with fewer benefits per dollar than the components in Alternative 6. Alternative 7 is not anticipated to reach new thresholds, but would increase the likelihood that the desired levels would be reached and maintained, and would provide greater areas of high quality habitat outputs. Alternative 6 includes 63 percent of the quantifiable desired future condition at roughly 51 percent of the cost of Alternative 7. The interagency System Team believes that the level of restoration achieved by Alternative 6 best meets the Federal objective of contributing to increases in the net quantity and quality of desired ecosystem restoration.

Alternative 6, if fully implemented over the next 50 years, would provide a measurable increase in system ecological integrity. Specifically, this alternative would reduce systemic sediment delivery by 20 percent, restore 12,000 acres of backwaters, restore 35 side channels, protect 15 islands, restore 75,000 acres of main stem floodplain, restore 75,000 acres of tributary floodplain, restore 1,000 stream miles of aquatic habitat, provide fish passage along the Fox, DuPage, Des Plaines, Kankakee, Spoon, and Aux Sable Rivers, produce an 11 percent reduction in the 5-year peak flows in tributaries, increase tributary base flows by 20 percent, produce a 66 percent reduction in half-foot or greater water level fluctuations along the main stem during the growing season, and provide system level improvements in water quality.

In total, this plan would provide benefits to approximately 225,000 acres and 33,000 stream miles. In addition to direct restoration activities, the plan includes components for system management and a technologies and innovative approaches component that includes (monitoring, computerized inventory and analysis, innovative dredging and beneficial use technologies, and special studies). Sections 6 and 7 describe these aspects of the plan in greater detail.

Due to the scope of the preferred comprehensive plan alternative and the long time period for implementation, a tiered implementation approach is recommended. Corps of Engineers cost-shared restoration efforts would begin with $131,200,000 ($85,300,000 Federal funds) in restoration funds through 2011 (Tier I), with the potential to expand to $345,600,000 ($224,600,000 Federal funds) in restoration efforts through 2015 (Tier II). The funding and activities would begin significant restoration consistent with eventual implementation of Alternative 6. These initial phases are proposed to demonstrate the benefits of the various practices and project components prior to seeking additional funding.

Tier I efforts would be cost shared 65 percent Federal ($85.3 million) and 35 percent non-Federal ($45.9 million). This funding level would provide approximately $122.3 million for planning, design, construction and adaptive management of restoration projects; $6.1 million for the technologies and innovative approaches component; and $2.75 million for system management. The estimated annual O&M Cost when all projects constructed under Tier 1 features are in place is $125,000. If funding is available, a report to Congress will be submitted in the 2011 timeframe, documenting the project successes and the results from Tier I restoration efforts. The implementation of this plan is more fully described in Section 6 of the report.