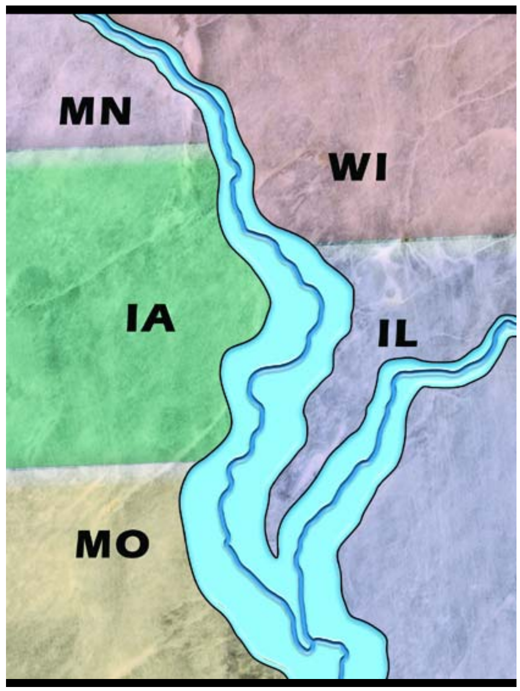
UPPER MISSISSIPPI RIVER COMPREHENSIVE PLAN

Draft for Public Review



MAIN REPORT

Prepared by the
U.S. Army Corps of Engineers
Rock Island, St. Louis, and St. Paul Districts

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US Army Corps of Engineers
Rock Island District
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UPPER MISSISSIPPI RIVER COMPREHENSIVE PLAN
FOR SYSTEMIC FLOOD DAMAGE REDUCTION AND
ASSOCIATED ENVIRONMENTAL SUSTAINABILITY

EXECUTIVE SUMMARY

Background

The Flood of 1993 provided a vivid demonstration of the vulnerabilities of the existing flood control systems on the Upper Mississippi River System. Forty-seven deaths were attributed to the Flood of 1993, and assessments of the economic damages range from $15 to 20 billion including more than $2.9 billion in damages along the Mississippi River and its floodplain. The social disruption was beyond measure, with more than 70,000 homes damaged or destroyed and approximately 74,000 persons evacuated from flooded areas. In-place flood damage reduction facilities built by the U.S. Army Corps of Engineers prevented an estimated $19 billion in potential additional damages. While the size and impact of the Flood of 1993 was unprecedented in recent history, floods of equal or greater magnitude will likely occur in the future, and the region will likely again be exposed to the destructive potential of the Mississippi and Illinois Rivers.

The flood damage reduction facilities (Federal and non-Federal) of the Upper Mississippi River System were not constructed in accordance with any overall systemic plan. These facilities have varying structural integrity, and provide varying levels of flood protection for similar land uses. Not since 1981 (with the termination of the Upper Mississippi River Basin Commission) has there been an overall planning authority for Upper Mississippi River System resources management. There is no systemic flood damage reduction implementation authority in place.

The Flood of 1993 awakened renewed interest in developing a systemic approach to flood damage reduction on the Upper Mississippi River System. In authorizing this study, Congress recognized the need for a planning effort that develops an implementable floodplain management plan in which there may be a Corps of Engineers interest.

There are currently over 140 flood protection systems in place in the Mississippi and Illinois River floodplains protecting urban and agricultural areas. Most of the systems—approximately 100 total—are federally-constructed, locally-owned and operated (100 percent non-Federal), with the remaining systems having been constructed over the years by private interests. In total, these systems include over 2,200 miles of floodwalls and levees. In addition, there are numerous environmental areas, managed by Federal, state or local governments.

The Importance of the Upper Mississippi River Basin

The study area is the Upper Mississippi River Basin drainage area above Cairo, IL, at the confluence of the Mississippi and Ohio Rivers exclusive of the Missouri River Basin, and encompasses approximately 185,000 square miles.

The Upper Mississippi River System and associated environments have a rich record of human history spanning over 12,000 years. The abundant and diverse ecological resources found along the Upper Mississippi River System have attracted and sustained human populations for thousands of years, providing food, water, and transportation. Today, the Upper Mississippi River System continues to provide a multitude of goods and services, which include: serving as a vital transportation network, riverine ecosystem, and commercial and recreational fishery; providing recreational and tourism opportunities; and operating as a source of industrial and municipal water supply.

The Comprehensive Plan

The authority for and purpose of the Upper Mississippi River Comprehensive Plan (Comprehensive Plan) is contained in Section 459 of the Water Resources Development Act of 1999, which states that *"The Secretary shall develop a plan to address water resource and related land resource problems and opportunities in the upper Mississippi and Illinois River basins, from Cairo, Illinois, to the headwaters of the Mississippi River, in the interest of systemic flood damage reduction…."*

Due to the very large study area, the watershed encompasses about 185,000 square miles and about 1,000 river miles, and in consideration of fiscal and time constraints, it was determined that the scope would be limited to the major river floodplain and not be a comprehensive watershed analysis. Likewise, this analysis could only be performed to about a reconnaissance phase level, also known as Section 905(b) analysis.

The main objectives of the Comprehensive Plan include:

- minimize the threat to health and safety resulting from flooding by using structural and non-structural flood damage reduction measures;
- reduce damages and costs associated with flooding;
- identify opportunities to support environmental sustainability/restoration goals of the Upper Mississippi River and Illinois River floodplain as part of any systemic flood damage reduction plan;
- seek opportunities to address, in concert with flood damage reduction measures, other floodplain specific problems, needs and opportunities to include:
    - continued maintenance of the navigation project and related commercial infrastructure;
    - reduction of nutrient input and sedimentation into the rivers;
    - improved habitat management;
    - bank caving and erosion reduction;
    - improved recreation opportunities; and
- identify and recommend appropriate follow-on studies.

The Comprehensive Plan used recently-updated frequency water surface profiles obtained from the Upper Mississippi, Missouri and Illinois River Flow Frequency Study for frequency flood events between 50 percent chance annual (2-year) and 0.2 percent chance annual (500-year). This is the first time since the Flood of 1993 that updated frequency analysis is being used on a systemic basis.

The Upper Mississippi River Comprehensive Plan investigated systemic flood damage reduction plans for the Upper Mississippi and Illinois Rivers. In developing the plans, both structural and nonstructural flood damage reduction alternatives were considered. Work accomplished within the Comprehensive Plan was an effort involving a Collaboration Team consisting of the Corps of Engineers Rock Island, St. Louis, and St. Paul Districts, and a number of other Federal and state agencies, and included attendance and participation by non-governmental organizations.

Conclusions

General Overview

Two significant events occurred during the period of preparation of the draft report in 2005. First, severe hurricanes hit the southern United States. The hurricane experience last year in addition to the lessons of the flood of 1993 resulted in a reexamination of approaches to floodplain management and flood mitigation, changing some perspectives and opening opportunities. Secondly, during the development of the report, the Corps of Engineers issued several engineering circulars, emphasizing collaborative approaches to planning and reaffirming the assessment of plans from a basis of four accounts.

Historically, many entities have influenced floodplain development. But when a significant natural disaster occurs, significant federal resources are invested to recover from the disaster, along with considerable resources from state, local and private entities.. Collaboratively laying out a process to guide where floodplain development may occur while minimizing residual risks for those targeted areas will, in the end, lower the recovery funds required from all sources.

This planning effort has not resulted in the selection of a systemic plan which can be recommended for implementation by the Army Corps of Engineers at this time. However, this effort has identified the need for a partnership of federal, state and local interests to periodically come together and review the need for changes in floodplain usage and to examine options to address those needs. The Corps can bring hydraulic, hydrologic, economic, environmental and engineering expertise to such a collaborative partnership.

Conclusions

- The study successfully developed a set of tools capable of analyzing the hydraulic, economic, and environmental effects of systemic flood damage reduction alternatives.
- The existing flood damage reduction systems currently prevent 95-97% of the potential (average annual) flood damages on the system.
- The hydrologic body of knowledge of the Upper Mississippi and Illinois Rivers has dramatically increased as a direct result of the previous Flow Frequency Study and the Comprehensive Plan. The systemic modeling is a useable product for the future, if maintained for the Corps and other Federal, state, and local agencies. It allows the determination of system-wide hydrologic impacts to actual and proposed changes. This modeling has the potential to substantially change the way this river system is managed.
- Specific findings of the hydraulic analysis of alternatives include:
    - The levees above Lock and Dam 19 at Keokuk, Iowa (study reaches 1 and 2) can be raised without causing more than a one-foot increase in 100-yr flood profile. Likewise, the levees on the Illinois River (reach 4) can be raised without causing more than one foot of rise in the 100-yr flood profile.
    - Several flood damage reduction measures (levee setbacks, realignments, and removal of bridge obstructions) have only a very localized reduction of water surface profiles.

    - Temporary emergency actions such as flood fighting and emergency operations can generally occur, but there are some locations that the emergency raise can cause significant negative impacts on the water surface profile.

- None of the twelve systemic flood damage reduction plans had positive national economic development (NED) benefits. For many plans, the benefit-to-cost ratio (BCR) was below 0.1.

- Implementation of a large, systemic flood reduction plan would result in significant regional economic benefits related to the short-term increase in employment and construction spending. The Tennessee Valley Authority estimated that every dollar spent on comprehensive flood control at the 500-year (for urban areas) and 100-year or greater (agricultural areas), which includes Plans A, B and D, would generate as much as $5 in increased gross regional product. Also, employment is projected to increase by more than 20,000 jobs annually in the five-state Upper Mississippi Valley Region resulting from upgraded levee protection provided by implementation of either Plan A, B, or D.

- Significant systemic ecosystem restoration opportunities exist within the Upper Mississippi River System floodplain; however, there are no cost-justified systemic flood damage reduction plans that would support the inclusion of ecosystem restoration projects.

- Examination of the need for reconstruction of components the existing flood control systems should be undertaken to insure that the existing system functions into the future providing billions of dollars of benefits.

- The Army Corps of Engineers is willing and interested in serving a continued facilitation role in the interest of flood damage reduction if requested by one or more Upper Mississippi River Basin states. The purpose would be to regularly review the water resources problems, needs, and opportunities in a collaborative framework working with other Federal, state, and local agencies and non-governmental organizations, stakeholders, and interested publics. The Corps could likewise, through this continuing process, be a catalyst to address the problems and needs collaboratively. This activity could require authorization and would require appropriation. The Corps would bring its leadership and expertise in technical areas such as hydrology and hydraulics, economic and environmental analysis, and engineering to bear to address the changing problems, needs, and opportunities of the region.

Potential Follow-on Studies

1. The hydrologic modeling for the Upper Mississippi River System should be maintained and updated as changes occur and new data is available. This would make the modeling and results available and useful to all Federal, state and local agencies, in the future and would allow additional personnel to use the modeling and incorporate new tools as available on a regular basis. Existing information used to evaluate project benefits is, on the average, over 30 years old. Updating this information would provide decision-makers and the public with better quality data upon which to manage the system on a long-term basis.

2. To close data gaps in our understanding of the river system, investments should be made in: GIS-based computer modeling, a second generation Habitat Needs Assessment, long-term sediment monitoring, and pilot projects for evaluating wetlands creation as a management tool for nutrients control.

3. A feasibility phase analysis of the Quincy Bridge approach, located in the Fabius Drainage and Levee District, should be accomplished. The purpose would be to evaluate the increase in the level of protection for the bridge approach in Missouri to the bridge across the Mississippi River at Quincy, IL. The approach lies in the Fabius Levee and Drainage District. The major flood damage reduction benefit obtained would be transportation savings or detour cost avoided. Other flood damage reduction benefits and potential ecosystem restoration opportunities could further enhance the feasibility phase study results.

4. Reconstruction feasibility phase studies of individual drainage and levee districts will insure that the existing aging systems provide their substantial benefits into the future.

Recommendations

It is recommended that a feasibility study for the Fabius Levee and Drainage District, Missouri, be conducted upon negotiations and signing of a Feasibility Cost Sharing Agreement (FCSA) with a study sponsor.

It is recommended that a reconstruction authorization be established for the Upper Mississippi and Illinois Rivers drainage and levee districts. Further, it is recommended that up to $1,000,000 total (up to $50,000 per district) be authorized to initiate reconstruction analysis with development of the Project Management Plan and the Feasibility Cost Sharing Agreement for individual drainage and levee districts. The cost shared feasibility phase reconstruction analysis would then be accomplished on individual flood damage reduction systems to evaluate whether rehabilitation of the aging infrastructure is needed to ensure that the systems provide their substantial benefits in the future.

**UPPER MISSISSIPPI RIVE-R COMPREHENSIVE PLAN
FOR SYSTEMIC FLOOD DAMAGE REDUCTION AND
ASSOCIATED ENVIRONMENTAL SUSTAINABILITY**

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UPPER MISSISSIPPI RIVER COMPREHENSIVE PLAN

I. STUDY AUTHORITY

Authority for the Upper Mississippi River Comprehensive Plan (Comprehensive Plan) is contained in Section 459 of the Water Resources Development Act of 1999, which states:

SEC. 459. UPPER MISSISSIPPI RIVER COMPREHENSIVE PLAN.

(a) DEVELOPMENT. - The Secretary shall develop a plan to address water resource and related land resource problems and opportunities in the upper Mississippi and Illinois River basins, from Cairo, Illinois, to the headwaters of the Mississippi River, in the interest of systemic flood damage reduction by means of -
(1) structural and nonstructural flood control and floodplain management strategies;
(2) continued maintenance of the navigation project;
(3) management of bank caving and erosion;
(4) watershed nutrient and sediment management;
(5) habitat management;
(6) recreation needs; and
(7) other related purposes.

(b) CONTENTS. - The plan under subsection (a) shall -
(1) contain recommendations on management plans and actions to be carried out by the responsible Federal and non-Federal entities;
(2) specifically address recommendations to authorize construction of a systemic flood control project for the upper Mississippi River; and
(3) include recommendations for Federal action where appropriate and recommendations for follow-on studies for problem areas for which data or current technology does not allow immediate solutions.

(c) CONSULTATION AND USE OF EXISTING DATA. - In carrying out this section, the Secretary shall -
(1) consult with appropriate Federal and State agencies; and
(2) make maximum use of data in existence on the date of enactment of this Act and ongoing programs and efforts of Federal agencies and States in developing the plan under subsection (a).

(d) COST SHARING. -
(1) DEVELOPMENT. - Development of the plan under subsection (a) shall be at Federal expense.
(2) FEASIBILITY STUDIES. - Feasibility studies resulting from development of the plan shall be subject to cost sharing under section 105 of the Water Resources Development Act of 1986 (33 U.S.C. 2215).

(e) REPORT.—Not later than 3 years after the date of enactment of this Act, the Secretary shall submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate a report that includes the plan under subsection (a).

Section 404 of the Water Resources Development Act of 2000 modified the study completion date as follows:

SEC. 404. UPPER MISSISSIPPI RIVER COMPREHENSIVE PLAN.
Section 459(e) of the Water Resources Development Act of 1999 (113 Stat. 333) is amended by striking ''date of enactment of this Act'' and inserting ''first date on which funds are appropriated to carry out this section''.

II. PURPOSE AND SCOPE

Post-1993 flood reports, the regional summit meetings of the mid-1990s, several subsequent studies, and various stakeholders recognized the lack of, and subsequent need for, a comprehensive, systemic plan for flood damage reduction and floodplain management along the Upper Mississippi and Illinois Rivers. This recognition ultimately led to the authorization of the Upper Mississippi River Comprehensive Plan (Comprehensive Plan) in the Water Resources Development Act (WRDA) of 1999 (Section 459). The primary purpose of this effort was the development of an integrated strategy and implementation plan for flood damage reduction on the Upper Mississippi River System. It is also intended to address, as applicable, other components of floodplain management, including: continued maintenance and improvement of the navigation project; improved management of nutrients and sediments; environmental stewardship; and recreational opportunities.

Flood damages continue to be incurred throughout the Upper Mississippi River System. Opportunities to develop and implement a systemic plan that reduces cumulative flood protection costs and annual flood damages while simultaneously providing long term improvements to other system values and uses (ecological, economic, recreation, transportation, etc.) were investigated. Multiple studies have been completed since the Flood of 1993. These efforts provided the foundation for evaluation of a comprehensive systemic plan for flood protection and flood damage reduction.

A. Purpose

The purpose of the Comprehensive Plan is to "develop a plan to address water resource and related land resource problems and opportunities in the upper Mississippi and Illinois River basins,….in the interest of systemic flood damage reduction…" Due to the very large study area, the watershed encompasses about 185,000 square miles and about 1,100 river miles, and in consideration of fiscal and time constraints, it was determined that the scope would be limited to the major river floodplain and not be a comprehensive watershed analysis. Likewise, this analysis could only be performed to about a reconnaissance phase level, also known as Section 905(b) analysis. Any recommendation for authorization would typically require more detailed analysis in a follow on phase.

The Comprehensive Plan used recently-updated frequency water surface profiles obtained from the Upper Mississippi, Missouri and Illinois River Flow Frequency Study for frequency flood events between 50 percent chance annual (2-year) and 0.2 percent chance annual (500-year). This is the first time since the Flood of 1993 that updated frequency analysis is being used on a systemic basis.

Long-term ecosystem management and sustainability planning also benefits from the development of a systemic conceptual plan for flood protection and flood damage reduction. For example, fish and wildlife management, particularly in the lower reaches of the system, depends heavily upon active water level management. Any flood damage reduction planning could benefit these facilities.

The Comprehensive Plan investigated systemic flood damage reduction plans for the Upper Mississippi and Illinois Rivers. In developing the plans, both structural and nonstructural flood damage reduction alternatives were considered. In addition, other system needs associated with flood damage reduction were considered.

The Comprehensive Plan was developed as a collaborative effort involving the U.S. Army Corps of Engineers' District at Rock Island, St. Louis, and St. Paul as well as a number of Federal and state agencies and non-governmental organizations.

B. Description of the Study Area

The study area encompasses portions of five states—Minnesota, Wisconsin, Iowa, Illinois, and Missouri—extending more than 800 miles along the Mississippi River from Minneapolis-St. Paul downstream to southeast Missouri (below St. Louis), and along 200 miles of the Illinois River downstream from (but not including) the metropolitan Chicago area to the confluence with the Mississippi River.

The study area is the Upper Mississippi River Basin drainage area above Cairo, IL, at the confluence of the Mississippi and Ohio Rivers exclusive of the Missouri River Basin, and encompasses approximately 185,000 square miles (Figure 1). The total acreage of the river-floodplain system exceeds 2.6 million acres of aquatic, wetland, forest, urban, grassland, and agricultural habitats. The distribution of leveed floodplain as proportion of total floodplain area is approximately:

- 3 percent north of Lock and Dam 13 on the Mississippi River;
- 50 percent from Pool 14 through Pools 26 for the Mississippi River;
- 80 percent in the open river (Mississippi downstream of its confluence with the Missouri River; and
- 60 percent of the lower 160 miles of the Illinois River.

The upper boundary of the study area is in the vicinity of St. Paul, MN (River Mile 864.8). The downstream boundary is at Thebes, IL (River Mile 43.7), the upstream limit of the Mississippi River and Tributaries (MR&T) Project. The MR&T Project is a comprehensive flood control and navigation project on the Lower Mississippi River authorized by the Flood Control Act of 1928, providing systemic flood protection to the Gulf of Mexico.

The study area includes the major metropolitan areas of St. Louis, MO; Davenport, IA; LaCrosse, WI; and the Twin Cities of Minneapolis and St. Paul, MN. There are currently over 140 flood protection systems in place in the Mississippi and Illinois River floodplains protecting urban and agricultural areas. Most of the systems—approximately 100 total—are federally-constructed, locally-owned and operated (100 percent non-Federal), with the remaining systems having been constructed over the years by private interests. In total, these systems include over 2,200 miles of floodwalls and levees. In addition, there are numerous environmental areas, managed by Federal, state or local governments.

FIGURE 1. The Upper Mississippi River Basin

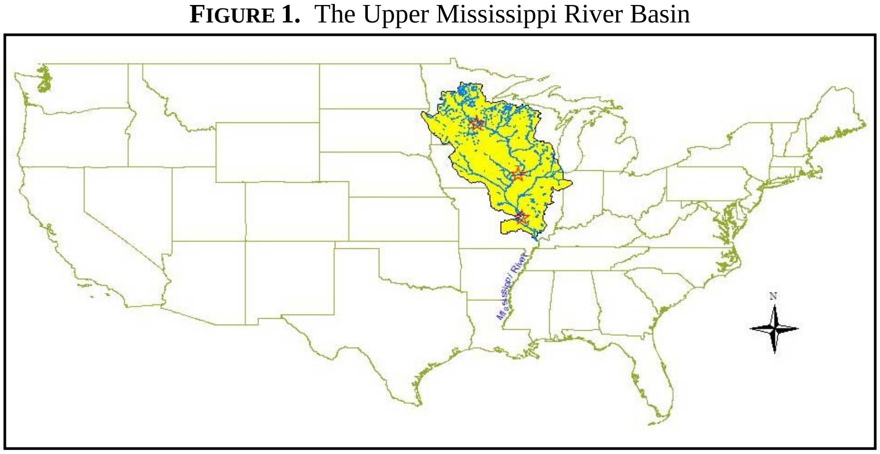

FIGURE 2. Study Area Indicating the Four Reaches and Corps offices

III. PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

A. Prior Studies and Reports

The following is a concise description of previous, related studies and reports (presented in chronological order).

Comprehensive Master Plan for the Upper Mississippi River System; U.S. Army Corps of Engineers, 1982.

Public Law 95-502 authorized the construction of a new dam and a 1,200-foot lock at Alton, Ill., and directed the Upper Mississippi River Basin Commission to prepare a Comprehensive Master Plan for the Management of the Upper Mississippi River System. The Upper Mississippi River Basin Commission was composed of the state and Federal agencies that had a legislated interest or mission affecting the Upper Mississippi River. The Corps of Engineers, with its many activities on the river, was a member of the Commission and was a lead agency in the study. The report recommended that Congress immediately authorize the engineering, design, and construction of a second chamber, 600 feet in length, to complement the new 1200-foot chamber at the Lock and Dam No. 26 replacement project. Non-structural and minor structural improvements were recommended at other locks in the system, in addition to monitoring traffic movements to gather data for future use in evaluating possible improvements to the navigation project. The Master Plan proposed a ten-year environmental program that would include habitat rehabilitation and enhancement projects. Also recommended were a long-term resources monitoring program with a computerized analysis and retrieval system, a program to develop federally-owned lands for recreation, and an assessment of regional economic benefits generated by people using the river for various recreational activities. The five affected states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) have since established the Upper Mississippi River Basin Association (UMRBA) to coordinate inter-agency water resources planning and to further the implementation of the recommendations of the Master Plan study.

The Great Flood of 1993 Post-Flood Report of the Upper Mississippi River and Lower Missouri River Basins; U.S. Army Corps of Engineers, 1994.

This post-flood report documents information for use by professionals within and outside the Corps of Engineers in connection with future planning programs associated with reservoir water-control management, floodplain management, and emergency management. The report summarizes the meteorology of the 1993 flood event, including antecedent conditions that led to the flooding conditions. The hydrology and hydraulic parameters of this flood are compared to previous events, and there are numerous tabulations of river stages, discharges, frequencies, and flood extent mapping, as well as descriptions of the effect that levees and reservoirs had on the flood. The Corps of Engineers' activities during the flood are documented, including reservoir operations, and emergency and recovery measures. A preliminary description and appraisal of flood damages is provided.

Science for Floodplain Management into the 21st Century: A Blueprint for Change; Scientific Assessment and Strategy Team, 1994.

The Scientific Assessment and Strategy Team (SAST) was established by a directive of the White House on November 24, 1993, to provide scientific advice and assistance to officials responsible for making decisions with respect to flood recovery in the Upper Mississippi River Basin. The SAST had responsibilities to the FMRC as well as responsibilities independent of the FMRC to obtain, organize, analyze, and distribute scientific data and information. An assessment was made of selected sub-systems within the river basin providing information on how they contribute to flooding, how they respond to flooding, and how they have been affected by changes in flood pulse.

Sharing the Challenge: Floodplain Management into the 21st Century (commonly referred to as the Galloway Report); Interagency Floodplain Management Review Committee, 1994.

The Interagency Floodplain Management Review Committee was established as part of the Administration's Flood Recovery Task Force. The mission of the review committee was to delineate the major causes and consequences of the 1993 flooding, evaluate the performance of existing floodplain management and related watershed management programs, and to make recommendations to the Administration's Floodplain Management Task Force on changes in current policies, programs, and activities of the Federal Government that would most effectively achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds. Major conclusions of this report include:

- Establish environmental quality and national economic development as co-equal objectives of planning
- Support collaborative efforts among federal agencies and across state, tribal, and local governments.
- Provide for coordination of the multiple federal programs to enhance the floodplain environment and provide natural storage
- To ensure that existing federally constructed water resources projects continue to meet their intended purposes and are reflective of current national social and environmental goals, require periodic review of completed projects.

Floodplain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries; U.S. Army Corps of Engineers, 1995.

This study was authorized by House Resolution 2423, dated 3 November 1993, which was signed into law as part of the Energy and Water Development Appropriations Act of 1994 (Public Law 103-136). The law provided the Corps of Engineers with appropriations to conduct studies in the reaches of the Upper Mississippi and Lower Missouri Rivers and their tributaries flooded in 1993. The assessment addressed eleven objectives: (1) description of the existing land and water resources and projections of future conditions; (2) identification of the desires of interested parties within the study area reflecting the diversity of opinions on alternative uses of floodplain resources; (3) description of how the land and water resources could be used to provide varying outputs; (4) description of the forces impacting on the use of the land and water resources; (5) development of a broad array of alternative land and water resource actions, including changes in policy; (6) evaluation and prioritization of alternative land and water resource actions; (7) preparation of the assessment report, including recommendations for further studies; (8) identification of critical facilities needing added flood protection; (9) examination of differences in Federal cost sharing for construction and maintenance of flood control projects on the Upper and Lower Mississippi Rivers; (10) evaluation of the cost effectiveness of alternative flood control projects; and (11) recommendation of improvements to the current flood control system.

Key findings of the Floodplain Management Assessment Report are as follows:

- Flood damages in urban floodplains with inadequate or not flood protection continue to be a major problem.
- No single alternative provides beneficial results throughout the system.
- It is essential to evaluate hydraulic impacts systemically.

• If all agricultural levees had been successfully raised and strengthened, urban flood protection would have been placed at much greater risk.
• Flood stage changes resulting from the removal of agricultural levees are highly dependent on subsequent use of the floodplain.

A Balanced Management for the Upper Mississippi, Illinois and Missouri Rivers; Delft Hydraulics, 1997.

In October 1996, the Upper Mississippi, Illinois and Missouri Rivers Association (UMIMRA) commissioned a team from Delft Hydraulics, based in the Netherlands   Delft provided an external look at current river system management. The report indicated Delft's view that the current approach to river management is not well balanced among the various river resources, and that a more ideal "integrated approach" is warranted. The report further suggested that a more active role could be played by governmental agencies, and that a means be developed for private concerns to be heard and incorporated. This would best be done in an open atmosphere where discussions could take place without pre-defined positions. The main conclusions of the report suggested that:

- more government leadership, either the Corps of Engineers or a Review Commission, was required in river management
- the US Army Corps of Engineers plays a key role in the river's management
- active participation of stakeholders in the planning process is needed
- improvements be made to the economic development and benefit/cost analysis
- interests of farmers should be taken into account
- governments should invest in expanding river navigation
- cost-effective levee improvements should be implemented
- ecological values of the system would best be served by integrated management of the river and river basin.

Upper Mississippi River System Flow Frequency Study; U.S. Army Corps of Engineers, 2004.

In October 1997, the U.S. Army Corps of Engineers, in partnership with state and Federal agencies, initiated a study to develop flow frequencies for the main-stem Upper Mississippi, Lower Missouri, and Illinois Rivers. The Upper Mississippi is that portion of the river above the mouth of the Ohio River and includes the Illinois River. The Lower Missouri is that portion of the river below Gavins Point Dam. Five Corps Districts —Omaha, Kansas City, St. Paul, Rock Island, and St. Louis— participated in this study effort. The Corps prepared existing flow frequency data for the upper and middle reaches of the Mississippi River in 1979. Existing flow frequency relationships for the Missouri River were developed in 1962. Flow frequencies were not developed for the tributaries.

The Corps and partnering state and Federal agencies selected and applied flow frequency analysis methods and analyzed the effects of reductions in flood runoff attributable to existing flood control reservoirs. The resulting flow-frequency relationships were used in conjunction with a one-dimensional, unsteady, flow model (UNET) to develop frequency profiles for the study area.

Final Integrated Feasibility Report and PEIS for the UMR-IWW System Navigation Feasibility Study; U.S. Army Corps of Engineers, 2004.

This study was initiated in April 1993 to address the potential economic losses to the nation from significant traffic delays at locks on the commercial navigation system between 2000 and 2050. In 2001, the study was restructured to address the ongoing cumulative effects of navigation, and the ecosystem restoration needs, with a goal of attaining an environmentally sustainable navigation system, in addition to insuring an efficient transportation system for the future. The study area extends from Minneapolis-St. Paul downstream to the confluence of the Ohio River and the Illinois Waterway from Grafton, IL, upstream through the Thomas J. O'Brien Lock in Chicago. It includes 37 locks (29 on the Upper Mississippi River and 8 on the Illinois Waterway) and approximately 1,200 miles of navigable waterway within portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

The principal navigation problem addressed by the study is the potential for significant traffic delays on the Upper Mississippi River-Illinois Waterway (UMR-IWW) Navigation System within the 50-year planning horizon. The principal environmental problems addressed by the study were changes to ecosystem structure and function that have occurred since initiation of the operation and maintenance of the existing 9-Foot Channel Navigation Project. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions while restoring, protecting, and enhancing the environment. The goal of the feasibility study was to outline an integrated plan to ensure the economic and environmental sustainability of the UMR-IWW Navigation System so it continues to be a nationally treasured ecological resource as well as an efficient national transportation system as designated by Congress in the 1986 Water Resources Development Act (Public Law 99-662). The Chief of Engineers has recommended implementing system-wide ecosystem restoration and navigation efficiency measures. Congress is considering authorization of these recommendations as evidenced by draft Water Resources Development Act language.

B. Existing Water Projects on the Upper Mississippi River

The following sections summarize the major water resource projects by the Federal government along the Upper Mississippi and Illinois Rivers.

1. The Swamp Land Act of 1850 and Levee Construction before 1900. Much of the Upper Mississippi River floodplain was included in Federal legislation known as the Swamp Land Act of 1850. Under its provisions, specified states (including Missouri, Iowa, and Illinois), were eligible to acquire selected areas of “swamp and overflow” lands. The states were expected to reclaim “said lands by means of levees and drains” to both lessen the destructive force from excessive flooding and eliminate malaria-breeding swamps. Proceeds from reclaimed land sales were to be used for further reclamation and for construction of roads to make the lands accessible. Although not successful in generating adequate funds for drainage and flood control, the plan provided for the vast transfer of lands from the Federal government to the states and from the states to counties and levee boards and later to private ownership. Thus, the primary significance of the swampland grants was that huge areas of land became available for settlement and agricultural use (Petterchak, 2000).

Some farmers began building levees on the upper and middle Mississippi River before the Civil War. Soon after the war, they organized into levee districts and began the first concerted effort to secure the river’s floodplains for agriculture. They extended and raised levees and began draining the lands behind them. Before the Corps became involved in levee construction, these farmers had defined many of the floodplains that would be taken from the river. Whereas channel constriction had altered the entire upper river, reclamation and levee building would transform the river most significantly below Rock Island, IL.

The Corps of Engineers began implementing flood control on the Upper Mississippi River under its navigation improvement authority. During the 1880s, individuals and organizations occupying the floodplain began pushing for Federal help. As early as 1884, the Sny Island Drainage District—enclosing over 110,000 acres—south of Quincy, IL, asked the Federal government to rebuild its 50-mile-long levee. The Corps reviewed the project and concluded that the levee did not help navigation and successfully recommended against government support. But the levee district persisted, and in the 1886, 1888, 1890, 1892 and 1896 Rivers and Harbors Acts, Congress authorized funding to preserve portions of the Sny Island levee in danger of eroding. The Corps used these funds to repair and riprap the levee and to build wing dams to direct the river's current away from it.

Pressure continued from other levee proponents, and in 1894, Congress instructed the Corps to survey the Mississippi River's west bank from Flint Creek, just north of Burlington, IA, to the Iowa River, and the river's east bank from Warsaw, IL to Quincy, IL. Congress directed the Corps to determine how the construction of these two levees could improve navigation. Based on Corps surveys, Congress, in 1895, authorized funding for both levees. In each case, the Corps was to improve navigation "by preventing the water from overflowing the natural and artificial banks along that part of the river, and deepening the channel ...". The Corps completed the nearly 50-mile Warsaw to Quincy Levee in 1896 and the 35-mile Flint Creek Levee in 1900.

2. Flood Control Acts of 1917 and 1928. Responding in part to requests from states located along the Mississippi River, Congress passed an official flood control act in 1917. As the country's first flood control act, it allowed the Corps to work on levees from the Head of Passes in Louisiana to Rock Island and on the Sacramento River, in California. This act, more so than the 1936 Flood Control Act, marks the formal beginning of the Corps involvement in flood control on the upper and middle Mississippi River. Through this act, the Federal government assumed an official role in securing the Mississippi River's floodplains for agriculture and gave the Corps a new mission for managing the middle and upper Mississippi River, a mission Congress strengthened in the 1928 Flood Control Act. Under these two acts, the Corps helped fortify levees in 11 levee and drainage districts that enclosed over 260,000 acres of floodplain.

3. 1930 Rivers and Harbors Act. Between 1925 and 1930, Midwestern business and navigation interests fought to restore commerce and to persuade Congress to authorize a new project for the river, one that would allow the river to truly compete with railroads. It would draw support from the largest and smallest businesses in the valley, from most of its cities, from the Midwest's principal farm organizations, and from the major political parties. Responding to this movement, Congress included the 9-foot channel project in the 1930 Rivers and Harbors Act.

To create a 9-foot channel, the Corps chose a system of locks and dams and quickly determined that the dams would have to be quite low. Numerous villages and cities rested just above ordinary high water. Railroads following the river on each bank were often just out of reach of high water. At larger river cities, industrial developments lined the river. Because of the small difference between the natural high water mark and the elevation of railroads, buildings, and other structures along the river and as well as of the small range of the annual flood stages, the Corps concluded that the dams would have to be designed not to increase flood stages. While they expected that contracting the river near the dams would increase the flood height at the dams by as much as 1 foot, they had calculated that this effect would dissipate within a few miles above the dam. Given the location of dams, the engineers expected no adverse effects from flooding by this effect.

In 1940, the Corps completed the 9-foot channel project. Twenty-six locks and dams now crossed the river between Minneapolis, MN and Alton, IL. The 9-foot channel project again reconfigured the upper Mississippi River's landscape, hydraulic character, and environment. The pools created by the dams permanently flooded thousands of acres that had been seasonally flooded before. Because the engineers took damage to cities, towns, and villages into consideration in planning the location of the darns, few of these entities would require special protection. The greatest flowage effects would occur to agricultural lands, floodplain forests, and brush lands.

4. Flood Control Acts of 1936 and 1938. In 1936, Congress passed the first national flood control act. Along with the 1938 Flood Control Act, this act broadened the Corps' role in flood control on the Mississippi River. These acts provided for flood control reservoirs, urban or local flood protection projects, and floodplain management. For the middle and upper river's main stem, however, the acts focused on agricultural levees. Under the 1936 Flood Control Act, Congress authorized 26 projects for the Mississippi River's main stem above the Ohio River. Of these, 25 called for raising and enlarging existing levees protecting agricultural lands. Only the East St. Louis and Vicinity project was authorized to protect an urban area. Congress extended its protection of the main stem's agricultural levees in the 1938 Flood Control Act. The five levee improvement projects authorized in this act were to protect existing levee and drainage districts in Illinois between Alton and the mouth of the Ohio River. Together with the agricultural levee improvements authorized under the 1936 act, these projects fortified most of the levee system on the Mississippi River in Missouri and Illinois. And as the Corps had reinforced the levee system above Alton under the acts preceding 1936, the Corps had helped secure most of the important agricultural levees between Rock Island and the Ohio River.

Congress extended the Corps' flood control work to the middle and upper river's tributaries in the 1936 act. Congress had authorized improvement of many of the Illinois River's agricultural levees in the 1928 act, but little work had been approved for other tributaries. In 1936, Congress authorized 15 projects for the Illinois River—14 for agricultural levee and drainage districts and one for a levee setback and floodway improvement. Demonstrating its willingness to consider non-levee projects, Congress authorized four flood control reservoirs for the main stem's tributaries in the 1936 act and another in the 1938 Act. In 1936, it provided for dams and reservoirs at Decorah, IA, on the Upper Iowa River, and for the Des Moines River approximately 60 miles below Des Moines (Red Rock project). For Illinois, Congress approved the Carlyle dam and reservoir on the Kaskaskia River, and for Minnesota, it approved the Lac qui Parle dam and reservoir on the upper Minnesota River. The Decorah, Carlyle, and Red Rock projects were specifically aimed at protecting urban populations, although they guarded agricultural lands as well. The Lac qui Parle project had the more general objective of safeguarding the Minnesota River valley downstream. In 1938, Congress authorized the Coralville dam and reservoir, on the Iowa River, to protect Iowa City and some 1,073 square miles downstream. With these projects, Congress had authorized four of the major reservoirs that would be built on the upper Mississippi River's tributaries above the mouth of the Missouri River.

5. Flood Control Acts 1944 to 1958. In the 1946 Flood Control Act, Congress authorized work for only two main stem agricultural levee districts—Prairie du Rocher and Sny Island. Also Congress approved the Illinois River Flood Control Project, an unusual project in that it called for reclaiming a levee district from agriculture.

Urban levees were the principal focus, however. In 1944, Congress enacted local projects for Sabula, Des Moines, and Elkport, IA, and Galena, IL. Only Sabula lay on the main stem. In the 1948 Flood

Control Act, Congress authorized no projects for the Mississippi River below the Twin Cities. It did approve a channel diversion project to protect Aitkin, MN on the Mississippi River north of Minneapolis, a project to defend South Beloit on the Rock River in Illinois and a project to protect agricultural bottomlands along the Henderson River. In Section 205 of the 1948 act, Congress gave the Secretary of the Army the power to approve flood protection works under $2 million (today this limit is $7 million). Although the Corps has built many projects under this authority, these projects have not been examined in this discussion. In the 1950 Flood Control Act, Congress again focused on urban flood protection, authorizing projects for Canton and Cape Girardeau, MO, on the Mississippi River, and another urban project for Beardstown, located on a small tributary of the Illinois River. In neither act did Congress authorize agricultural projects for the main stem, and only authorized the Henderson River agricultural project for the upper river's tributaries.

Congress returned to the Mississippi River's agricultural levees in the 1954 Flood Control Act. Up until 1936, Congress had concentrated on the agricultural levees between Rock Island and Alton. In the 1936, 1938, and 1946 Flood Control Acts, it had authorized the Corps to reinforce the levee system below Alton. With the 1954 act, Congress authorized the modernization of the reach between Rock Island and Alton. Under this act, Congress called for the modification or construction of 14 rural levee projects within the Rock Island District. Between Rock Island, IL and Hamburg, IL, this act called for improving 386 miles of levee "to protect agricultural land along both sides of [a] 200-mile stretch of the Mississippi River." The act also included the Upper Iowa River project near New Albin, IA, which entailed improving the outlet of the river at its confluence with the Mississippi River to protect agricultural lands. Through this act, as they had done under the others, farmers strengthened their hold on the upper Mississippi River's floodplains.

Urban projects received attention as well. The 1954 act included projects for four urban areas: Alton, IL; Hannibal, MO; and Sabula and Muscatine, IA. Although Muscatine and Hannibal lay on the Mississippi River, the projects at these cities were designed to protect the cities from flooding on tributary rivers. As in 1950, the 1954 act authorized no work on agricultural levees on the upper Mississippi River's tributaries, nor did it approve any urban levees for cities on tributaries off the Mississippi River.

With the most important agricultural levees on the upper and middle Mississippi River being secured, Congress concentrated on urban levees and broad flood protection on the Mississippi River tributaries in the 1958 Flood Control Act. In it, Congress approved four projects for Minnesota: the Winona and St. Paul-South St. Paul projects on the Mississippi River, the Mankato-North Mankato project on the Minnesota River, and the Rushford project on the Root River. Rather than a levee, Congress authorized a large earthen dam to protect the small town of Spring Valley, WI, on the Eau Galle River. The largest project under the 1958 Act was the Saylorville dam and reservoir on the Des Moines River, approximately 11 miles above the city of Des Moines. Congress authorized this reservoir to supplement the flood storage capacity of the Red Rock reservoir to reduce the flood levels downstream on the Des Moines River, especially at Des Moines, and to lower flood levels on the Mississippi River.

6. Flood Control Projects After 1960. Between 1960 and 1980, the Corps finished many of the agricultural projects authorized in the 1950s and early 1960s and began building many of the urban projects authorized during these years. In these two decades, Corps engineers completed 25 agricultural and nine urban flood protection projects for the upper and middle Mississippi River. After

1980, urban projects dominate. From 1980 to the Flood of 1993, the Corps dedicated only one agricultural levee and eight urban projects on the main stem.

The greatest change in the upper and middle Mississippi River Basin after 1940 came on tributary rivers. While work by local interests and the Corps on agricultural projects on the Illinois River had dramatically changed this tributary before 1940, few other tributaries had been greatly altered by reclamation and flood protection projects by this time. After 1940, however, and especially after 1960, the basin's tributary rivers would be changed in important ways.

Seven reservoirs finished between 1967 and 1987 serve a variety of purposes. The Red Rock reservoir, completed in 1969, and the Saylorville reservoir, completed in 1977, help protect Des Moines, IA, and agricultural lands below from floods on the Des Moines River. Along with the Coralville reservoir, completed in 1958, these projects also serve to reduce flood levels on the Mississippi River. In Illinois, the Corps completed the Carlyle dam in 1967 and the Shelbyville dam in 1970, both on the Kaskaskia River. While Carlyle helps defend both agricultural and urban areas, Shelbyville protects primarily agricultural lands. Rend Lake, a multiple - purpose project which has 109,000 acre-feet of storage for flood control, 160,000 acre-feet for joint purposes, and 25,000 acre-feet for conservation and sediment retention, was completed in 1972. This project is located on the Big Muddy River in southern Illinois. In Missouri, the Corps completed the Clarence Cannon Dam and Mark Twain Lake in 1987. This multiple-purpose dam provides hydroelectric power, flood protection and low flow augmentation storage and recreational use. Two dams that provide flood protection but were designed to promote wildlife concerns are the Devil's Kitchen Dam on Grassy Creek, a tributary of the Big Muddy River in Illinois, and the Big Stone Lake-Whetstone River Dam on the upper Minnesota River. The Devil's Kitchen project, completed in 1960, is one of three structures that store water for the Crab Orchard National Wildlife Refuge. The Big Stone Lake-Whetstone River Darn, finished in 1974, provides a conservation pool of 2,800 acres for wildlife purposes. Thus, since 1960, Congress and the Corps have expanded the upper and middle Mississippi River basin's urban flood protection infrastructure dramatically.

Between 1965 and 1966, the Bureau of the Budget brought together a team of specialists from various agencies to reassess the Government's flood management program. As one focus of their study, the team was to examine whether the nation was developing its floodplains wisely. In 1966, based on this report, President Lyndon Johnson issued Executive Order 11296, directing Federal agencies to evaluate the flood hazard potential before locating new buildings in the floodplain. In 1968, Congress followed with the National Flood Insurance Act, and in 1973, with the Flood Protection Disaster Act. Under the latter act, Congress required communities wanting Federal assistance for financing or constructing structures in the floodplain to initiate land use restrictions and required individuals to buy flood insurance.

Conflict over its cost and effect stalled the nation's flood protection program between 1970 and 1986. During this era, Congress passed no major bill for water resources projects. Environmental concerns, budget deficits, less support for water projects, and impasses over the Water Resources Council's Principles and Standards were the primary reasons. The Principles and Standards had required the Corps to evaluate both the national economic development and environmental quality objectives and to measure the beneficial and negative effects for all projects. It outlined a process and methods of evaluating alternative means solutions, and it made capital intensive projects harder to justify. And under Presidents Jimmy Carter and Ronald Reagan, the Office of Management and Budget viewed the civil works program as "a controllable, discretionary, government expense."

After a 14-year hiatus, Congress passed the Water Resources Development Act of 1986. In this act, nonstructural flood control was given greater status.

IV. PLAN FORMULATION

The Upper Mississippi River Comprehensive Plan followed the Corps of Engineers' six step planning process specified in Engineering Regulation (ER) 1105-2-100. The process is described below.

A. Planning Process

The process identifies and responds to problems and opportunities associated with the Federal objective and specified State and local concerns. The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statues, applicable executive orders, and other Federal planning requirements. The process provides a flexible, systematic, and rational framework to make determinations and decisions at each step so that the interested public and decision makers are fully aware of the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, and the significant implications of each alternative plan.

If a Federal and state interest is identified, the process culminates in the selection of a plan to be recommended to Congress for implementation. As part of identifying the selected plan, a number of alternative plans are developed and compared with the no action alternative, allowing for the ultimate identification of the national economic development (NED) Plan.

The NED Plan is the plan that maximizes the net economic development benefits, consistent with the Federal objective. In addition to considering the economic benefits, the environmental impacts of the alternatives, the socioeconomic impacts, and the cultural properties impacts of the alternatives are considered.

The steps used in the plan formulation process include:

1. **Identify Problems and Opportunities.** The specific problems and opportunities are identified, and the causes of the problems discussed and documented. Planning goals are set, objectives established, and constraints identified.

2. **Inventory and Forecast Resource Conditions.** This step characterizes and assesses conditions in the Upper Mississippi River System as they currently exist and forecasts the most probable without-project condition (or no action alternative) over the period of analysis. This assessment gives the basis by which to compare various alternative plans and their likely impacts. The without-project condition is what the river and its uses are anticipated to be like over the planning period without any action implemented as a result of this study.

3. **Formulate Alternative Plans.** Alternative plans are developed in a systematic manner to ensure that reasonable alternatives are evaluated.

4. **Evaluate Alternative Plans.** The evaluation of each alternative consists of measuring or estimating the economic benefits, costs, environmental impacts, and social effects of each plan, and determining the difference between the without- and with-project conditions.

5. **Compare Alternative Plans.** Alternative plans are compared, focusing on the differences among the plans identified in the evaluation phase and public comment. As part of the evaluations, the best plans are identified based upon those plans that provide the greatest economic benefits for the least cost.

6. Select Recommended Plan. A recommended plan is selected and justification for its selection is prepared. If no implementable alternative is identified, the recommended plan is the no action alternative.

B. Water Resources Development Act (WRDA) 1999, Section 459

In addition to the six step planning process, Section 459 of the Water Resources Development Act of 1999, lists three requirements specific to the Comprehensive Plan process:

(b) CONTENTS. - The plan under subsection (a) shall -
(1) contain recommendations on management plans and actions to be carried out by the responsible Federal and non-Federal entities;
(2) specifically address recommendations to authorize construction of a systemic flood control project for the upper Mississippi River; and
(3) include recommendations for Federal action where appropriate and recommendations for follow-on studies for problem areas for which data or current technology does not allow immediate solutions.

C. Environmental Requirements

1. Federal Laws and Executive Orders. Table 1 provides a summary of the environmental requirements applicable to all Corps studies. A more detailed description of these requirements, along with Corps Planning Guidance Documents, can be found in Chapter 1, *Environmental*, of the supplemental CD.

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Table 1. Environmental Requirements (Federal Law/Executive Orders)

Bald Eagle Protection Act (16 U.S.C. 668)
Clean Air Act (42 U.S.C.§§ 7401-7671g)
Clean Water Act (33 U.S.C. 1251 et seq.)
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §§ 9601-9675)
Endangered Species Act (16 U.S.C. 1531 et seq.)
Farmland Protection Policy Act (7 U.S.C. 4201 et seq.)
Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)
Food Security Act of 1985 (16 U.S.C. §§ 3801-3862)
National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4347)
National Historic Preservation Act (16 U.S.C. 470 et seq.)
Noise Control Act (42 U.S.C. §§ 4901-4918)
Resource, Conservation and Rehabilitation Act (RCRA)(42 U.S.C. 6901 et seq.)
Floodplain Management, E.O. 11988
Protection and Enhancement of the Cultural Environment, E.O. 11593
Protection and Enhancement of the Environmental Quality, E.O. 11514
Protection of Wetlands, E.O. 11990
Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, E.O.

2. Corps Policy - Environmental Operating Principles. In 2002, U.S. Army Corps of Engineers (USACE) published a doctrine referred to as the *Environmental Operating Principles and Implementation Guidance* (EOP). EOP describes ways in which the Corps' missions must be integrated with natural laws, values, and sound environmental practices. The EOP doctrine is intended to result in an organizational culture change over time, and embraces the following seven principles:

1. strive to achieve environmental sustainability
2. consider environmental consequences
3. seek a balance and synergy between human development activities and natural systems
4. accept corporate responsibility and accountability for environmental actions
5. assess and mitigate cumulative impacts to the environment
6. build and share and integrated scientific, economic, and social knowledge base
7. respect the views of individuals and groups in Corps activities

To the extent consistent with Section 459, the Corps has applied EOP during the Comprehensive Plan planning process.

D. Collaboration Team. In August 2002, a Collaboration Team (CT) was formed specifically for the Comprehensive Plan, consisting of representatives from Federal and State Government agencies and certain non-governmental organization representatives who have significant responsibilities for or interest in various aspects of floodplain management, particularly flood damage reduction, economic development, and natural resources. Interaction with the Collaboration Team (CT) provided a source of extensive public involvement. Additional information on the CT is found in *Appendix F. Public Involvement*.

The Collaboration Team has worked with the Corps' Product Development Team (PDT) throughout the duration of the study. The CT provided comment and input on identifying, validating, and prioritizing system-level problems, needs, and opportunities; measures and strategies (called philosophies); and alternative plans. The members of the CT help to facilitate project coordination and communication efforts, particularly with respect to their particular agencies, organizations, and publics.

The CT contributed ideas, comments and discussion to all facets of the Upper Mississippi River Comprehensive Plan process. For example, at the first CT meeting, discussion of problems, goals and objectives was initiated, Step 1 of the Corps' Planning Process.

While the emphasis of the Comprehensive Plan is on systemic planning, knowledge by the CT in both systemic and local context, insured that the problems were identified and understood by all. Using input and discussion from the CT Meeting held August 2002, the PDT established initial objectives. The PDT provided 'strawman' list of objectives which were provided to the CT, and then discussed and finalized, as presented in this report, at the next CT meeting in December 2002.

The inventory of the existing flood damage reduction systems on the Mississippi and Illinois Rivers, with over 150 systems spread over a thousand river miles, benefited from input by the Collaboration Team to help insure data and information quality in Step 2, inventory of existing conditions.

The first part of Plan Formulation, Step 3 in the Planning Process, is to develop strategies which when combined with measures, form alternative plans. The PDT brainstormed and developed a list of over 30 strategies, which the CT preferred to name Philosophies. CT insight and discussion resulted the

Philosophies presented in this report. The Corps PDT developed a list of all flood damage reduction and ecosystem restoration measures which may be applicable. The CT and PDT determined the more applicable and useful measures before the development of systemic alternative plans (these are indicated in **BOLD** in the following section). Alternative plans and new or reformulated plans created due to what had been learned, the final part of planning Step 3, resulted in the full array of systemic plans considered.

It was a CT request which resulted in the development and subsequent initial evaluation of the Emergency Action Scenarios, analyzing temporary emergency measures, such as flood fighting, to reduce flood damages.

Step 4 is to evaluate alternative plans. Due to a CT request, evaluation of the regional economic development (RED) benefits of several early alternative plans was accomplished in 2004 and included in the evaluation of plans.

E. Assessment of Problems and Opportunities

1. Existing Conditions. The Upper Mississippi River System and associated environments have a rich record of human history spanning over 12,000 years. The abundant and diverse ecological resources found along the Upper Mississippi River System have attracted and sustained human populations for thousands of years, providing food, water, and transportation. Today, the Upper Mississippi River System continues to provide a multitude of goods and services to many users including: serving as a vital transportation network, a vital riverine ecosystem, a commercial and recreational fishery, providing recreational and tourism opportunities, and serving as a source of industrial and municipal water supply.

The Upper Mississippi River System is a vital part of our national economy. The navigable portion of the system and the locks and dams that allow waterway traffic to move from one pool to another are integral parts of a regional, national, and international transportation network. The system is significant for certain key exports and the nation's balance of trade. For example, in 2000, the Upper Mississippi River System carried approximately 60 percent of the nation's corn and 45 percent of the nation's soybean exports.

The Mississippi River represents the largest riverine ecosystem in North America and the third largest in the world. The System's ecosystem consists of over 2.7 million acres of aquatic and floodplain areas consisting of bottomland forests, islands, backwaters, side channels, and wetlands; supporting more than 300 species of birds, 57 species of mammals, 45 species of amphibians and reptiles, 150 species of fish, and nearly 50 species of mussels. More than 40 percent of North America's migratory waterfowl and shorebirds depend on the food resources and other life requisites (shelter, nesting habitats, etc.) that the system provides.

Elevations within the Upper Mississippi River System drainage basin range from 300 feet above sea level (Cairo, IL) to 1,950 feet above sea level (Timms Hill, WI). The average river slope is 0.5 feet per mile. The predominant landform in the basin is flat to irregular plains that are composed of a thick layer of silt (from 3 to 300 feet thick).

The Upper Mississippi River System supports a wide range of recreational opportunities including boating, camping, hiking, hunting, and trapping. Annually, the system supports $1.2 billion in direct and secondary expenditures, and supports 12 million visitor-days of use by people who hunt, fish, boat, sightsee and otherwise visit the river and communities (USACE Technical Report EL-95-16, 1995).

Floodplain use varies from north to south on the Upper Mississippi River System. Above Clinton, IA, the relatively narrow floodplain is largely undeveloped with the exception of isolated urban communities that occupy a small (percentage-wise) portion of the floodplain. The remaining floodplain areas remain susceptible to seasonal flooding and generally consist of backwater complexes, floodplain forests, and marshlands. South of Clinton, IA, and particularly below Keokuk, IA, much of the floodplain has been converted to agricultural use. Levee and drainage districts (predominately established in the late 1800s and early 1900s) operate and maintain levee and drainage systems to protect the agricultural fields. The distribution of leveed floodplain (urban and agricultural) as a proportion of the total floodplain area is approximately:

The distribution of leveed floodplain as proportion of total floodplain area is approximately:

- 3 percent north of Lock and Dam 13 on the Mississippi River;
- 50 percent from Pool 14 through Mel Price on the Mississippi River;
- 80 percent in the open river (Mississippi downstream of its confluence with the Missouri River); and
- 60 percent of the lower 160 miles of the Illinois River (below Peoria Dam).

a. Nature of Flooding on the Upper Mississippi River System. There is no single cause of flooding on the Upper Mississippi River System. Either snowmelt, rain on snow, or rainfall can cause major flooding at various locations within the study area. The following events drove major floods in the Upper Mississippi River Basin:

- 1965 - A rainfall-snowmelt event occurring in late winter and early spring. The type of event expected for this region. This is the event of record on the Upper Mississippi from St. Paul to Clinton.

- 1993 - Major multiple season event, caused primarily by late spring and summer convective rainfall of similar pattern to typical summer events, but of greater persistence, depth, and duration. This was the event of record from Keokuk, IA to St. Louis on the Mississippi River.

The inspection of major historic floods implies the following important climatologic aspects of Upper Mississippi flooding:

Location	**Climatological Aspects**
Upper Mississippi, Northern Reach (St. Paul to Clinton)	Flood regime dominated by rain on snow events
Upper Mississippi Transition Region (Clinton to Keokuk)	Rainfall or rain on snow may cause a major flood event
Upper Mississippi Southern Reach (Keokuk to Thebes) & Illinois River	Rainfall events cause major floods of record

In recognition of the climatological differences that result in major floods in the different regions, and the differences in floodplain use (discussed above in Section IV.D.1), the study area, encompassing the entire upper Mississippi River and the Illinois Waterway, was divided into a series of four reaches (Figure 2). Table 2 provides a description of the reaches used in this study.

Table 2. Description of the Four Reaches

Reach	Description	Range of River Miles
1	Vicinity of St. Paul, MN to Lock and Dam 13 at Clinton, IA	863.9 to 522.5
2	Lock and Dam 13 at Clinton, IA to Lock and Dam 19 at Keokuk, IA	522.5 to 364.2
3	Lock and Dam 19 at Keokuk, IA to Thebes, IL	364.2 to 43.7
4	Illinois Waterway	291.0 to 19.4

The Great Flood of 1993 resulted in catastrophic damages throughout much of the Upper Mississippi River Basin. Forty seven deaths were attributed to the flood, and damages due to heavy rainfall and flooding exceeded $15 billion. Approximately one-half of the flood damages were related to agricultural losses. In-place flood damage reduction facilities such as levees and reservoirs, and flood plain management practices prevented additional damages. Corps of Engineers facilities prevented an estimated $19 billion in potential damages. The region has suffered losses due to significant flooding as summarized below.

Following is a summary of recent historical flood damages on the Upper Mississippi River System. Historically notable floods on the Upper Mississippi River prior to 1947, for which there are no reliable damage figures, include the floods of 1828, 1844, 1851, 1868, 1880, 1881, 1888, 1892, 1920, and 1922. The flood damages and descriptions discussed below were taken from U.S. Army Corps of Engineers' Post Flood Reports for the respective floods.

In 1947, three above-normal rainstorms, combined with other rainfall events, created flood conditions on the Mississippi River downstream of Keokuk, IA, (Reach 3) in June and July. Damages in rural areas (rural in 1947) were approximately $35 million and damages in urban areas exceeded $15 million. Twelve persons lost their lives during this flood and nearly 14,000 persons were displaced. Nearly 1 million acres were inundated.

The 1965 flood resulted in damages primarily in Reaches 1 and 2. Record snowfall and above normal rainfall contributed to record flood crests along the Mississippi River. Damages in urban areas were in excess of $40 million and damages to agricultural areas were nearly $18 million while transportation suffered approximately $150,000 in damage.

A severe flood in 1973 caused damages primarily in Reaches 2, 3 and 4. Above-normal rainfall in the spring of 1973 resulted in high levels of runoff, three flood crests, and new record flood stages. This was also a flood of long duration—in excess of four months. Damage in urban areas was nearly $43 million, agricultural areas was close to $20 million, while other damages such as impacts to transportation, flood fighting costs, etc. was over $12 million.

In February 1974, a backwater effect from high stages on the Ohio and Lower Mississippi Rivers caused flooding in study Reach 3. Additionally, heavy rains throughout Iowa and Illinois resulted in 2 more crests. Damages in urban areas in 1974 were under $1 million, while damages in rural areas exceeded $12 million.

Heavy rainfall caused three spring flood events the following year, 1995. No record flood stages were set and damages were largely in rural areas—approximately $8 million. The high stages inundated 238,000 acres.

In 1985 and 1986 floods caused by heavy rains resulted in damages along the Mississippi and Illinois Rivers. The 1986 flood caused nearly $29 millions in damage in the state of Illinois and approximately $14 million in Missouri.

The 1993 flood was a major, regional flood impacting all study reaches. From March until July, the general weather pattern above-normal precipitation as well as heavy snow cover, contributed to significant flooding. The precipitation amounts were some of the wettest on record for June, July, and August in the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. Record flood stages were set in Reach 2. Millions of acres were inundated. Damages from this flood event in urban areas were approximately $1.5 billion, while damages in rural areas were approximately $1.4 billion. Nearly $60 million was expended to repair flood damage reduction systems under the Public Law 84-99 program.

A significant flood occurred in 2001 in Reach 2. No consistent flood damage data was collected during this flood, but Federal program payouts by the Federal Emergency Management Agency exceeded $12 million, while the Small Business Administration paid out over $5 million.

b. Existing Damage Reduction Protection Systems. The Upper Mississippi and Illinois River mainstem floodplains have extensive existing flood control projects consisting of levees and floodwalls and large tributary reservoirs. They vary widely in age and level of protection provided. Most components of this system were federally constructed or improved, and were planned and built incrementally (rather than systemically) under various authorities (See Section III B, *Existing Water Projects on the Upper Mississippi River)*. There are separable areas of the floodplain which have non-Federal projects, not meeting USACE design and construction standards.

Table 3 provides a summary of the existing flood control systems on the Upper Mississippi River and Illinois Waterway.

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Fridley	MN	Mississippi	1	Non-Federal	Urban	863.9	
St. Paul	MN	Mississippi	2	Federal	Urban	838.5	510
South St. Paul	MN	Mississippi	2	Federal	Urban	833.3	590
Newport	MN	Mississippi	2	Non-Federal	Urban	831.5	
South St. Paul - Reach 2	MN	Mississippi	2	Non-Federal	Urban	831.3	
Inver Grove	MN	Mississippi	2	Non-Federal	Urban	830.5	
Lake City	MN	Mississippi	4	Non-Federal	Urban	773.3	
Cochrane	WI	Mississippi	5	Non-Federal	Urban	742.3	
Winona	MN	Mississippi	6	Federal	Urban	727.4	6,000
LaCrosse	WI	Mississippi	8	Non-Federal	Urban	699.0	
Genoa	WI	Mississippi	8	Non-Federal	Urban	679.5	
Lansing	IA	Mississippi	9	Non-Federal	Urban	662.7	
Marquette	IA	Mississippi	10	Non-Federal	Urban	634.7	
McGregor	IA	Mississippi	10	Non-Federal	Urban	633.4	
Clayton	IA	Mississippi	10	Non-Federal	Urban	624.6	
Glen Haven	WI	Mississippi	10	Non-Federal	Urban	618.3	
Guttenburg	MN	Mississippi	10	Federal	Urban	615.4	480
Dubuque	IA	Mississippi	12	Federal	Urban	580.6	1,100
East Dubuque	IL	Mississippi	12	Non-Federal	Urban	580.0	40
Pool 12 Overwintering	IL	Mississippi	12	Wildlife Area	Other	568.5	628
Pleasant Creek	IA	Mississippi	13	Wildlife Area	Other	550.8	2,530
Green Island	IL	Mississippi	13	Non-Federal	Ag	547.3	4,490
Sabula	IA	Mississippi	13	Federal	Urban	535.0	896
Spring Lake	IA	Mississippi	13	Wildlife Area	Other	534.3	3,300
Fulton	IL	Mississippi	14	Federal	Urban	519.8	6,800
Clinton	IA	Mississippi	14	Federal	Urban	517.3	1,940
Meredosia	IL	Mississippi	14	Federal	Ag	511.5	10,310
Princeton Refuge	IA	Mississippi	14	Wildlife Area	Other	505.2	1,129
East Moline	IL	Mississippi	15	Federal	Urban	489.3	920

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Bettendorf	IA	Mississippi	15	Federal	Urban	486.6	470
Rock Island	IL	Mississippi	16	Federal	Urban	481.2	1,000
Milan	IL	Mississippi	16	Federal	Urban	478.5	2,150
Andalusia	IL	Mississippi	16	Non-Federal	Urban	473.4	150
Andalusia	IL	Mississippi	16	Wildlife Area	Other	463.0	393
Muscatine/Madd Creek	IA	Mississippi	17	Federal	Urban	456.0	
Drury	IL	Mississippi	17	Federal	Ag	455.2	5,000
Muscatine-Louisa County	IA	Mississippi	17	Non-Federal	Ag	448.5	
Muscatine Island	IA	Mississippi	17	Federal	Urban	448.4	26,480
Big Timber	IA	Mississippi	17	Wildlife Area	Other	444.0	1,039
Bay Island	IL	Mississippi	17	Federal	Ag	442.6	25,169
Lake Odessa	IA	Mississippi	17	Wildlife Area	Other	437.5	6,800
Iowa River-Flint CR Upper	IA	Mississippi	18	Federal	Ag	427.9	17,400
Keithsburg	IL	Mississippi	18	Non-Federal	Urban	427.6	226
Iowa River-Flint CR Middle	IA	Mississippi	18	Federal	Ag	416.4	22,500
Oquawka	IL	Mississippi	18	Non-Federal	Urban	416.0	70
Henderson #3	IL	Mississippi	18	Non-Federal	Ag	413.2	2,250
Iowa River-Flint CR Lower	IA	Mississippi	19	Federal	Ag	408.1	2,910
Henderson #1	IL	Mississippi	19	Federal	Ag	407.3	7,300
Burlington Industrial	IA	Mississippi	19	Federal	Urban	406.5	223
Henderson #2	IL	Mississippi	19	Federal	Ag	402.4	7,400
Green Bay	IA	Mississippi	19	Federal	Ag	391.0	13,340
Niota	IL	Mississippi	19	Non-Federal	Urban	385.0	886
Keokuk	IA	Mississippi	20	Private	Urban	364.0	
Des Moines/Mississippi	IA	Mississippi	20	Federal	Ag	359.0	10,990
Mississippi & Fox Upper	IA	Mississippi	20	Non-Federal	Ag	357.8	3,000
Mississippi & Fox Lower	IA	Mississippi	20	Non-Federal	Ag	356.2	4,700
Hunt-Lima	IL	Mississippi	20	Federal	Ag	351.7	21,290
Gregory	IA	Mississippi	20	Federal	Ag	351.3	8,000

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Canton	MO	Mississippi	21	Federal	Urban	342.0	500
Indian Grave Upper	IL	Mississippi	21	Federal	Ag	338.8	12,680
Union Township	IL	Mississippi	21	Federal	Ag	333.3	4,240
Indian Grave Lower	IL	Mississippi	21	Federal	Ag	332.9	6,960
Fabius	MO	Mississippi	21	Federal	Ag	327.8	14,260
Marion County	MO	Mississippi	22	Federal	Ag	322.4	4,000
South Quincy	IL	Mississippi	22	Federal	Urban	321.7	5,520
Reiff, Nick	MO	Mississippi	22	Non-Federal	Ag	320.0	1,200
South River Industrial/American Cyanamid	MO	Mississippi	22	Federal	Urban	319.0	1,626
South River	MO	Mississippi	22	Federal	Ag	315.7	10,300
Bay Island	MO	Mississippi	21	Wildlife Area	Other	311.5	450
Hannibal	MO	Mississippi	22	Federal	Urban	309.5	37
Sny Island Reach I	IL	Mississippi	22	Federal	Ag	307.6	44,200
Sny Island Reach II	IL	Mississippi	24	Federal	Ag	292.5	17,280
Ted Shanks State CA	MO	Mississippi	24	Wildlife Area*	Other	289.6	
Sny Island Reach III	IL	Mississippi	24	Federal	Ag	282.3	43,100
Clarksville Refuge	MO	Mississippi	25	Wildlife Area	Other	275.0	346
Petus-Burns-Prewitt-Jeager	MO	Mississippi	25	Private	Ag	271.6	400
Clarksville Levees	MO	Mississippi	25	Private	Ag	269.0	2,340
Sny Island Reach IV	IL	Mississippi	25	Federal	Ag	268.8	9,800
Kissinger Levee District	MO	Mississippi	25	Non-Federal	Ag	266.4	2,570
MRA (Rip-Rap Landing)	IL	Mississippi	25	Wildlife Area	Other	265.5	125
Busch-Goose Pasture Farms	MO	Mississippi	25	Private	Ag	264.1	410
Cannon Wildlife Refuge	MO	Mississippi	25	Wildlife Area*	Other	262.2	3,480
Annada D & LD	MO	Mississippi	25	Private	Ag	262.2	3,320
Elsberry Drainage District	MO	Mississippi	25	Non-Federal	Ag	255.9	18,200
Elsberry Drainage District	MO	Mississippi	25	Non-Federal	Ag	255.9	23,500
Kings Lake Drainage District	MO	Mississippi	25	Non-Federal	Ag	249.0	3,300
Sandy Creek	MO	Mississippi	25	Non-Federal	Ag	245.7	944

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Foley Drainage District	MO	Mississippi	25	Non-Federal	Ag	245.0	1,214
Batchtown Wildlife Area	IL	Mississippi	25	Wildlife Area	Other	244.3	2,540
Cap Au Gris	MO	Mississippi	26	Non-Federal	Ag	241.2	4,150
Winfield D & LD	MO	Mississippi	26	Non-Federal	Ag	238.9	2,826
Brevator	MO	Mississippi	26	Non-Federal	Ag	238.1	1,800
Schramm	MO	Mississippi	26	Private	Ag	237.3	280
Old Monroe	MO	Mississippi	26	Private	Ag	236.8	900
Heitman	MO	Mississippi	26	Private	Ag	236.4	300
Marstan-Portuchek	MO	Mississippi	26	Private	Ag	236.1	755
Peruque Creek	MO	Mississippi	26	New Levee	Ag	231.4	3,800
St. Peters Drainage Assoc. No. 1 (Urban)	MO	Mississippi	26	Federal	Urban	230.0	700
St. Peters Drainage Assoc. No. 1 (Ag)	MO	Mississippi	26	Non-Federal	Ag	229.8	300
Consolidated North County	MO	Mississippi	26	Non-Federal	Ag	206.3	30,000
Wood River	IL	Mississippi	27	Federal	Urban	198.1	13,700
Columbia Bottoms Levee	MO	Mississippi	27	Wildlife Area	Other	194.2	
Chouteau Island	IL	Mississippi	27	Non-Federal	Ag	191.2	2,400
Chouteau, Nameoki and Venice	IL	Mississippi	27	Federal	Urban	189.9	4,800
Gabaret/Cabrolet Island	IL	Mississippi	27	Non-Federal	Ag	187.3	800
St. Louis Flood Protection Project	MO	Mississippi	Open River	Federal	Urban	181.7	3,160
Metro East Sanitary District	IL	Mississippi	Open River	Federal	Urban	179.4	74,000
Prairie Du Pont	IL	Mississippi	Open River	Federal	Urban	170.7	12,000
Columbia	IL	Mississippi	Open River	Federal	Ag	160.9	14,800
Harrisonville	IL	Mississippi	Open River	Federal	Ag	142.9	27,800
Harrisonville - A	IL	Mississippi	Open River	Federal	Ag	142.9	27,800
Harrisonville - B	IL	Mississippi	Open River	Federal	Ag	142.9	27,800
Stringtown	IL	Mississippi	Open River	Federal	Ag	139.5	2,800
Fort Chartres and Ivy Landing	IL	Mississippi	Open River	Federal	Ag	134.0	15,900
Prairie Du Rocher & Modoc	IL	Mississippi	Open River	Federal	Ag	124.5	16,000
Ste. Genevieve Urban Levee	MO	Mississippi	Open River	Federal	Urban	123.8	505

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Ste. Genevieve Levee District No. 2	MO	Mississippi	Open River	Private	Ag	119.5	7,000
Kaskaskia Island	MO	Mississippi	Open River	Federal	Ag	113.4	9,460
Bois Brule	MO	Mississippi	Open River	Federal	Ag	103.2	26,060
Degognia & Fountain Bluff	IL	Mississippi	Open River	Federal	Ag	91.8	36,200
Grand Tower	IL	Mississippi	Open River	Federal	Ag	78.9	14,800
Miller Pond	IL	Mississippi	Open River	Federal	Ag	70.7	4,300
Preston	IL	Mississippi	Open River	Federal	Ag	70.7	16,200
Clear Creek	IL	Mississippi	Open River	Federal	Ag	61.0	18,000
Cape Girardeau	MO	Mississippi	Open River	Federal	Urban	52.2	140
E. Cape Girardeau & Clear Creek	IL	Mississippi	Open River	Federal	Ag	51.5	9,400
N. Alexander County	IL	Mississippi	Open River	Federal	Ag	51.5	3,600
Hubble Creek	MO	Mississippi	Open River	New Levee	Ag	49.3	13,566
Hennepin	IL	Illinois	Peoria	Federal	Urban	204.9	2,600
Herman Levee	IL	Illinois	Peoria	Non-Federal	Ag	178.0	380
Komatsu	IL	Illinois	Peoria	Non-Federal	Urban	164.6	125
East Peoria Sanitary District	IL	Illinois	Peoria	Federal	Urban	162.4	
East Peoria	IL	Illinois	Peoria	Federal	Urban	161.2	950
Peoria Sanitary District	IL	Illinois	Peoria	Non-Federal	Urban	160.0	61
Keystone	IL	Illinois	LaGrange	Non-Federal	Urban	157.5	375
Pekin-LaMarsh	IL	Illinois	LaGrange	Federal	Ag	152.4	3,010
Banner Special	IL	Illinois	LaGrange	Federal	Urban	141.9	4,561
Banner Marsh	IL	Illinois	LaGrange	Wildlife Area	Other	141.0	5,524
Spring Lake	IL	Illinois	LaGrange	Federal	Ag	141.0	13,120
Rice Lake	IL	Illinois	LaGrange	Wildlife Area	Other	135.0	5,592
East Liverpool	IL	Illinois	LaGrange	Federal	Ag	130.1	2,885
Liverpool	IL	Illinois	LaGrange	Federal	Urban	127.2	2,885
Lake Chautauqua	IL	Illinois	LaGrange	Wildlife Area	Other	126.8	4,212
Thompson	IL	Illinois	LaGrange	Federal	Urban	123.4	5,498
Lacey, Langellier, W. Matanzas, Kerton Valley	IL	Illinois	LaGrange	Federal	Ag	115.6	10,406

Table 3. Summary of Existing Flood Control Systems

Location	State	River	Navigation Pool	Type of Construction	Urban or Ag	Mid-point RM	Approx. Acres Protected
Big Lake	IL	Illinois	LaGrange	Federal	Ag	105.7	3,401
Kelly Lake	IL	Illinois	LaGrange	Federal	Ag	101.7	1,045
Hager Slough	IL	Illinois	LaGrange	Non-Federal	Ag	92.0	3,698
Lost Creek	IL	Illinois	LaGrange	Federal	Ag	89.7	2,740
Sanitary Dist. of Beardstown	IL	Illinois	LaGrange	Federal	Urban	88.6	860
Coal Creek	IL	Illinois	LaGrange	Federal	Ag	88.5	6,794
Crane Creek	IL	Illinois	LaGrange	Federal	Ag	84.2	5,417
South Beardstown	IL	Illinois	LaGrange	Federal	Ag	84.2	10,516
Little Creek	IL	Illinois	Alton	Federal	Ag	76.7	1,800
McGee Creek	IL	Illinois	Alton	Federal	Ag	71.4	10,800
Meredosia and Willow Creek	IL	Illinois	Alton	Federal	Ag	69.4	16,946
Coon Run	IL	Illinois	Alton	Federal	Ag	68.9	4,600
Smith Lake	IL	Illinois	Alton	Private	Ag	67.2	1,500
Oakes	IL	Illinois	Alton	Private	Ag	66.3	525
Valley City	IL	Illinois	Alton	Federal	Ag	65.1	4,900
Mauvaise Terre	IL	Illinois	Alton	Federal	Ag	64.8	4,900
Robertson	IL	Illinois	Alton	Private	Ag	63.3	1,000
Scott County	IL	Illinois	Alton	Federal	Ag	59.3	10,500
Walnut Creek	IL	Illinois	Alton	Non-Federal	Ag	56.3	500
Big Swan	IL	Illinois	Alton	Federal	Ag	53.6	12,300
Hillview	IL	Illinois	Alton	Federal	Ag	46.6	12,900
Village of Pearl	IL	Illinois	Alton	Private	Urban	43.2	1,000
Hartwell	IL	Illinois	Alton	Federal	Ag	40.7	8,900
Keach	IL	Illinois	Alton	Federal	Ag	35.3	8,400
Schaefer-Farrow	IL	Illinois	Alton	Private	Ag	32.6	800
Bluffdale Farms	IL	Illinois	Alton	Non-Federal	Ag	32.3	1,000
Eldred-Spankey	IL	Illinois	Alton	Federal	Ag	28.1	11,300
Nutwood	IL	Illinois	Alton	Federal	Ag	19.4	11,300

Tables 4 and 5 display the variance in approximate level of start of damages of the existing flood damage reduction projects on the Upper Mississippi River and Illinois Waterway, respectively, as well as those unprotected areas that are in the study area.

Table 4. Mississippi River – Summary of Start of Damages for Existing Systems

	Number	< 50 yr	50 yr	50 – 100 yr	100 yr	100-200 yr	200 yr	200-500 yr	500 yr	> 500 yr
Urban	**42**	**10**	**2**	**0**	**3**	**2**	**1**	**3**	**2**	**19**
Federal	27	---	---	---	1	1	1	3	2	19
Non-Federal	14	10	2	---	2	---	---	---	---	---
Private	1	---	---	---	---	1	---	---	---	---
Agriculture	**59**	**23**	**6**	**3**	**5**	**10**	**11**	**2**	**0**	**1**
Federal	36	---	5	3	4	10	11	2	---	1
Non-Federal	14	12	1	---	1	---	---	---	---	---
Private	9	9	---	---	---	---	---	---	---	---
Other	**32**	**31**	**---**	**---**	**1**	**---**	**---**	**---**	**---**	**---**
Unprotected	**34**									

Table 5. Illinois Waterway – Summary of Start of Damages for Existing Systems

	Number	< 50 yr	50 yr	50 – 100 yr	100 yr	100-200 yr	200 yr	200-500 yr	500 yr	> 500 yr
Urban	**11**	**5**	**2**	**0**	**3**	**0**	**0**	**1**	**0**	**0**
Federal	7	3	2	---	1	---	---	1	---	---
Non-Federal	3	1	---	---	2	---	---	---	---	---
Private	1	1	---	---	---	---	---	---	---	---
Agriculture	**30**	**16**	**4**	**1**	**1**	**1**	**2**	**1**	**1**	**3**
Federal	23	10	3	1	1	1	2	1	1	3
Non-Federal	3	3	---	---	---	---	---	---	---	---
Private	4	3	1	---	---	---	---	---	---	---
Other	**6**	**6**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**
Unprotected	**3**									

The existing flood damage reduction projects built by the U.S. Army Corps of Engineers have prevented in excess of $83 billion in damage from Upper Mississippi River flooding during the past several decades.

c. Critical Infrastructure. Impacts to critical infrastructure resulted in tremendous economic losses during the 1993 flood. The trucking industry was forced to reroute much of its traffic to more lengthy routes due to closures of bridges and interstate highways. Bridge closures proved to be problematic for other businesses, as employees and customers often did not have normal bridge access across rivers in going to and from work, causing major disruption for many.

Rail traffic was also impacted, either by flooded rail lines, erosion of rail beds, or by constrained bridges. At one time during the flood, seven of eight rail lines across the State of Missouri were closed.

A Presidential Commission defined critical infrastructure on a national basis. *Critical infrastructure* are those deemed to be so vital that the incapacity or destruction of critical components within them would have a debilitating regional or national impact. Items included in a follow-on Executive Order (E.O. 3010) were:

- electrical power systems
- gas and oil
- transportation
- emergency services
- telecommunications
- water supply systems
- banking and finance
- continuity of government

In addition, information on hazardous materials production, storage, and waste facilities was deemed critical by the Water Resources Council in 1978. An analysis of available information on the Upper Mississippi and Illinois River system resulted in the following tables of critical infrastructure in the 500-year (approximately) floodplain within the boundaries of the three Corps of Engineers Districts.

Table 6. Critical Infrastructure at Risk of Inundation due to the 500-year Frequency Flood Event

Mississippi River

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
St. Paul District																							
Pool Above St. Anthony Falls		1		1																			**2**
POOL 1																							**0**
POOL 2		39	7	4												2				1	2		**55**
POOL 3		2	1		1																		**4**
POOL 4		3	2	2	1					1									2			1	**12**
POOL 5					2												1					1	**4**
POOL 5A																							**0**
POOL 6																							**0**
POOL 7																						1	**1**
POOL 8		35	4	8	1					3	1				1				1			3	**57**
POOL 9				1	2																		**3**
POOL 10		2		5						1						1							**9**
Rock Island District																							
Guttenberg		3	1																				**4**
Dubuque	1	30	6				1																**38**
East Dubuque						1																	**1**
Clinton		25	3	1		2					1	1					1	1		3			**38**
Fulton						3					1				1							1	**6**

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
Meredosia						2																	**2**
East Moline				2	1																		**3**
Bettendorf		15	4																				**19**
Rock Island Arsenal						1																	**1**
Rock Island		4	1	1											1			1			1		**9**
Andalusia						2											1						**3**
Muscatine-Madd Creek		4																					**4**
Muscatine Island		33	3		26		1	1			1				2	1	1		2		1	1	**73**
Iowa-Flint Creek No.4				1		1									1		1						**4**
Des Moines County No.7		1																					**1**
Keithsburg				1		2											1						**4**
Des Moines County No.8		2		0		0									1								**3**
Oquawka						1																	**1**
Green Bay		1	1																				**2**
Niota																	1						**1**
Des Moines-Mississippi															2		1						**3**
Hunt-Lima						3									3	1							**7**
Indian Grave Upper		2													3				1				**6**
Indian Grave Lower															1								**1**
Canton		1		3													1			1			**6**
Fabius River		3	1	1												1							**6**
Marion County						2																	**2**
Sny Reach I		1		1		4									1		1		1				**9**
Unprotected	1	50	11	26	34	42	6	2		2					1		6		6	4			**191**
St. Louis District																							

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
Bois Brule				2											3	1							**6**
Brevator				1																			**1**
Chouteau Island										1													**1**
Clear Creek						9									3								**12**
East Cape Girardeau	1			1						2	1				2	1							**8**
Miller Pond				1																			**1**
North Alexander		1															1		1				**3**
Preston		4		1											3	1	1						**10**
Big Five	1	5		3		9				2	1				8	2	2		1				**34**
Columbia Bottoms											1												**1**
Columbia				1											1	1							**3**
Consolidated N. County		1									2				2		1			1			**7**
Degonia & Fountain Bluff		2		1		1					1				1	1	2		1				**10**
Grand Tower				1		2									1					1			**5**
Degonia & Grand Tower		2		2		3					1				2	1	2		1	1			**15**
Elsberry		0		1												1							**2**
Foley																	1						**1**
Fort Chartres & Ivy Landing		1															1						**2**
Harrisonville		7		1		6									3								**17**
Harrisonville, Stringtown		8		1		6									3		1						**19**
Kaskaskia Island															1								**1**
King's Lake					1																		**1**
Old Monroe		1									1												**2**
Pettus-Burns-Prewitt-Jaeger				1																			**1**

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
Prairie Du Rocher		3		2		2									2		1						**10**
Saint Peters		2		2		7										1							**12**
Sandy Creek				1																			**1**
Sny Island NO. 3		3																	1				**4**
Sny Island NO. 4						3									1								**4**
St Genevieve NO.2				1																			**1**
Winfield L&DD				1		2																	**3**
Unprotected		16	1	36	12	38	3	2						1	7	4	5		3	3	0	1	**132**
GRAND TOTALS:	**4**	**313**	**46**	**119**	**81**	**154**	**11**	**5**	**0**	**12**	**12**	**1**	**0**	**1**	**61**	**20**	**34**	**2**	**21**	**15**	**4**	**9**	**925**

Illinois River

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
Rock Island District																							
Ottawa High School															1								**1**
East Peoria Sanitary		2						1															**3**
East Peoria		1	1			1									1				1	1			**6**
Pekin-LaMarsh			2				1																**3**
Liverpool																	1						**1**
Lacy															3								**3**
Big Lake															1								**1**
Hager Slough				1											2								**3**
Coal Creek															1								**1**
Beardstown Sanitary/Lost Cr.						5				3	1	0	1	2	7		1		2	1		1	**24**
Crane Creek						10									1								**11**
Unprotected		28	9	41	26	31	4	5			1			1	7	2	3		3	1	1	4	**167**
St. Louis District																							
Bluffdale Farms						2																	**2**
Eldred															1								**1**
Farrow						2																	**2**
Hartwell															2	2							**4**
Keach															1	1							**2**
Nutwood				1		3																	**4**
Unprotected			2	6	11	14	1	1									1						**36**

Levee District	Superfund	Hazardous Waste Handlers	Petrochemical Storage	NPDES	Water Intakes	Water Wells	Power Plants	Power Substations	Television Towers	Radio Towers	Cellular Phone Towers	Pager Towers	Hospitals	Nursing Homes	Schools	Airports	Post Offices	Prisons	Fire Stations	Police Stations	Military	Landfills	**Total**
Big Swan						2									3								**5**
Hillview						3									2								**5**
Indian Creek NO. 2						2									2								**4**
Mauvaise Terre		2		1		3									2				2	1	0		**11**
Mcgee Creek				1							1				1								**3**
Meredosia Lake															3	1							**4**
Mud Creek															1	1							**2**
New Pankeys Pond															1								**1**
Scott County						4									2								**6**
Valley City						2									1								**3**
Willow Creek			1	2	1	5	1	1							2		1		1	1		1	**17**
Unprotected			1	1		5									3								**10**
GRAND TOTALS	**0**	**33**	**16**	**54**	**38**	**94**	**7**	**8**	**0**	**3**	**3**	**0**	**1**	**3**	**51**	**7**	**7**	**0**	**9**	**5**	**1**	**6**	**346**

d. Existing Economic Conditions. The study area encompasses portions of five states—Minnesota, Wisconsin, Iowa, Illinois, and Missouri—extending nearly 800 miles along the Mississippi River from Minneapolis-St. Paul downstream to southeast Missouri (below St. Louis), and along 200 miles of the Illinois River downstream from (but not including) the metropolitan Chicago area to the confluence with the Mississippi River. The year 2000 population of the study area exceeds 9.7 million. This figure includes those living in counties adjacent to the Mississippi and Illinois Rivers, plus one county removed from these adjacent counties. The area includes major metropolitan cities and manufacturing centers, medium and small towns, and large concentrations of agricultural activity.

The study area (in its entirety) exhibits the following profile characteristics:

- Population growth is lower than the national growth trend over the last decade.
- The area's population is more rural than the nation as a whole` and is less racially diverse.
- High school graduation rates are higher than the national average.
- Personal income per capita is similar to the national average.
- Unemployment rates are lower than the national average.

These characteristics vary widely among regional sub-areas within the study area.

The Tennessee Valley Authority (TVA) compiled an *Existing Economic Conditions* report dated March 2004 in support of the Comprehensive Plan.

e. Existing Ecosystem Conditions

(1) Land Cover. There is a diversity of land cover types in the study area. An analysis of land cover was compiled through the Upper Mississippi River System Environmental Management Program. A summary of this compilation can be found in Table 7.

The Upper Mississippi River System floodplain area encompasses over 2,700,000 acres. Agriculture is the dominant land cover class, followed by water habitat, floodplain forests and other various classes of vegetation. Land cover classes are unevenly distributed throughout the river system, and the absolute floodplain area of river reaches and pools may also differ greatly. The largest differences occur in the amount and distribution of agricultural land and the proportion of open water in the floodplain. Agriculture dominates the floodplain south of Rock Island, IL (Pool 14), and open water occupies a greater proportion of the floodplain between Minneapolis (Pool 1) and Clinton, IA (Pool 13). Wetland classes are generally more abundant between Minneapolis and Clinton.

Geomorphic areas, or aquatic and terrestrial features within river reaches, are parts of the river system that have similar geologic origins, formed by similar river processes or manmade structures. The geomorphic area data (Appendix E, *Cultural Resources*) is limited to UMR Pools 4 through 26, a reach of the Middle Mississippi River (RM 31-75), and the Illinois River La Grange Pool. From Lake Pepin, MN to St. Louis, MO the data shows that approximately 40 percent of the total floodplain area (including both aquatic and floodplain areas) is leveed, but levees are concentrated south of Rock Island, IL (Figure 1). The presence of levees closely approximates the amount and location of agriculture in the floodplain. The distribution of leveed floodplain as a proportion of total floodplain area is approximately:

- 3 percent north of Pool 13;
- 50 percent from Pool 14 through Pools 26;
- 80 percent in the open river; and
- 60 percent of the lower 160 miles of the Illinois River.

Table 7. Land Cover Class Distribution

Upper Mississippi River System (including the Illinois River) in Acres

LEVEED AREAS							
Study Reach	**Aquatic**	**Non-Forest**	**Forest**	**Agriculture**	**Developed**	**Other**	**Total**
Mississippi River							
Pools 1-13	1,597	5,804	1,930	1,551	6,919	0	17,802
Pools 14-19	2,860	11,786	10,026	128,025	14,845	0	167,542
Pools 20-Open River	11,669	51,619	42,161	502,806	59,729	0	667,985
Illinois River	4,196	15,879	11,257	220,792	7,468	0	259,592
TOTAL	**20,323**	**85,088**	**65,374**	**853,174**	**88,961**	**0**	**1,112,921**

UNLEVEED AREAS							
Study Reach	**Aquatic**	**Non-Forest**	**Forest**	**Agriculture**	**Developed**	**Other**	**Total**
Mississippi River							
Pools 1-13	163,597	115,951	104,155	47,242	42690	88	473,724
Pools 14-19	75,476	22,650	55,642	95,581	27,566	0	276,915
Pools 20-Open River	135,400	54,738	139,987	215,341	17,787	0	563,253
Illinois River	72,556	41,621	84,178	84,000	19,354	0	301,709
TOTAL	**447,029**	**234,961**	**383,962**	**442,164**	**107,397**	**88**	**1,615,601**

ALL AREAS							
Study Reach	**Aquatic**	**Non-Forest**	**Forest**	**Agriculture**	**Developed**	**Other**	**Total**
Mississippi River							
Pools 1-13	165,194	121,755	106,086	48,793	49,609	88	491,526
Pools 14-19	78,336	34,437	65,668	223,605	42,411	0	444,457
Pools 20-Open River	147,069	106,358	182,148	718,147	77,516	0	1,231,238
Illinois River	76,752	57,500	95,435	304,792	26,822	0	561,301
TOTAL	**467,352**	**320,050**	**449,337**	**1,295,337**	**196,358**	**88**	**2,728,522**

Contiguous floodplain susceptible to seasonal flooding constitutes approximately 23 percent of the floodplain area system-wide. Islands are approximately 8 percent of the floodplain area, bringing the total terrestrial area to approximately 70 percent of the floodplain from Minneapolis to St. Louis.

(2) Threatened and Endangered Species. The list of species in Table 8 was developed as a part of the Upper Mississippi River – Illinois Waterway System Navigation study. This list is representative of the federally-listed species within the study area, except for the extreme southern extent of the study area, which is downstream of the area considered by the Navigation Study. Chapter 1, *Environmental*, of the supplemental CD contains additional detail on federally-listed species.

Table 8. Species within the Upper Mississippi River System Floodplain Listed as Threatened or Endangered under the Federal Endangered Species Act (ESA)

Common Name	**Scientific Name**	**Federal Status**
Decurrent false aster	*Boltonia decurrens*	Threatened
Higgins' eye pearly mussel	*Lampsilis higginsii*	Endangered
Pink mucket pearly mussel	*Lampsilis abrupta*	Endangered (Extirpated)
Winged mapleleaf	*Quadrula fragosa*	Endangered
pocketbook mussel	*Potamilus capax*	Endangered (Extirpated)
Scaleshell mussel	*Leptodea leptodon*	Endangered (Extirpated)
Pallid sturgeon	*Scaphirhynchus albus*	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Threatened
Interior least tern	*Sterna antillarum*	Endangered
Indiana bat	*Myotis sodalist*	Endangered

States along the Upper Mississippi River System have a number of species identified that fall within their own state classification of endangered or threatened (Table 9). Analysis completed for the Upper Mississippi River – Illinois System Navigation Study identified State listed species that potentially occur within the floodplains of the Mississippi and Illinois Rivers. Additional detail on state-listed species is contained in Appendix A, *Environmental Planning and Analysis*.

Table 9. Number of Species Listed Threatened and Endangered in Each State

Listed Species	**Wisconsin**	**Minnesota**	**Iowa**	**Illinois**	**Missouri**
fish	21	21	15	31	52
mussels	18	30	14	27	24
invertebrates	24	49	15	25	62
mammals	2	15	7	8	11
birds	26	28	7	34	29
reptiles/amphibians	10	14	19	22	28
plants	128	276	147	331	374

2. Future Without Project Conditions

a. Introduction. While existing conditions establish a starting point for the planning process, a base condition—against which all actions will be measured—must be set out for the entire 50-year planning time frame. Forecasting what will happen within the floodplain and the extent of flooding in the future, without any action towards a systemic flood damage reduction system, is essential to being able to determine the extent of problems, opportunities, and the costs, benefits and impacts of alternative plans of improvement. The most likely future set of baseline conditions is designated the Future Without Project Conditions.

Given the lengthy period of analysis, it is usually impossible to predict with accuracy what will happen in a complex ecosystem where man and nature are so actively engaged. Given the broad geographic expanse of this planning effort and the associated level of funding available, certain simplifying assumptions were necessary. As discussed in the various categories of this section, given the uncertainties associated with making those predictions, the appropriate assumption is that existing conditions will continue into the future.

b. Climate and Its Potential Effects on Floods. Potential climate change, its direction and its extent, is currently the subject of much scientific data gathering and analysis. The fact that some global warming is occurring has become increasingly accepted within the scientific community. Exactly how global warming would affect different regions of this country is still the subject of much analysis and debate. The results of General Circulation Models used to project future climate are ambiguous. Although flood magnitudes and frequencies may change as a result of global warming, the evidence is not strong enough to project even the direction of change for the Upper Mississippi and Missouri River basins (reference Flow Frequency Study).

For the purposes of this study, it is assumed that whatever climate changes occur within the 50-year planning timeframe will have little effect on the types of vegetation, cropping patterns or flood frequencies as currently determined.

c. Watershed Land Use and Development. Within the 714,000 square mile watershed of the Upper Mississippi River (529,000 square miles of this are within the Missouri River basin), it is assumed that development will continue to occur in the uplands, especially around existing urban areas and along transportation corridors. This would involve a certain amount of conversion from crop, pasture, and forest land to urban commercial and residential uses. For small watersheds, undoubtedly urban development increases runoff and, if not mitigated, could increase flood peaks. However, it is assumed that increased runoff from much of the new development would be mitigated through the construction of on-site detention basins. Overall, future development in isolated areas of the watershed where on-site detention is not developed could alter the timing of the runoff from such areas in ways that would affect each flood event differently. However, for large floods on the Upper Mississippi River, this effect is assumed to be minor given the size of these developed areas versus that of the entire watershed.

d. Floodplain Land Use and Development

(1) Environmental. Environmental Chapter 1 provides a qualitative summary of past, present and future (without project) conditions for each of the river's significant floodplain environmental resources. Much of the background information for that write-up was derived from the UMRS-EMP Long-Term Resource Monitoring Program's Trends Analysis Report (1998).

Consistent with the Navigation Study, the Comprehensive Plan has assumed that the baseline environmental project condition (over the next 50 years) will be similar to that of the existing resource condition. Many river managers assert that, without strong and active intervention by governmental agencies and environmental Non-Governmental Organizations (NGOs), the river will continue to degrade somewhat over time. However, ongoing ecosystem restoration efforts by the states, the USFWS, the USFS, the NRCS, the Corps, and others will continue into the future even without the opportunities presented by a systemic flood reduction plan. These ecosystem restoration programs are discussed further in the Environmental Appendix, page A-22.

(2) Commercial Development. There are several forces which are expected to induce future commercial development in the floodplain: the natural attraction of easily developed land; the need to be near a reliable source of water (either directly from the river or from alluvial aquifers); and the need to be located adjacent to water transportation. On the other hand, there is at least one strong force which discourages future commercial development: the National Flood Insurance Program which not only mandates actuarial rates (i.e. unsubsidized rates) for new construction, but also requires local governments to enact and enforce strict zoning with respect to development within the base (1 percent chance) floodplain.

The net effect of these competing forces upon future floodplain development is difficult to predict. In larger urban areas where land is scarce and local/state regulations, or their absence, make levee building feasible, it is possible that a small number of new levees, primarily for the purposes of commercial and industrial development, would be constructed. However, it is expected that, even in the very limited cases of new levee building, construction would be forced back out of the floodway and that resulting protected areas would be small compared to the river's floodplain, thus producing little to no effect on major flooding events

(3) Residential Development. Residential development is subject to some of the same forces that influence commercial development. Actuarial flood insurance rates on new home construction tend to discourage development within the base (1 percent chance or 100-year) floodplain. Moreover, following the past few major floods, there have been substantial state and FEMA funds available to buy out severely damaged home owners. In at least one instance, this has extended to the buy out of virtually an entire town, Valmeyer, IL. Some new homebuilding can be expected in farming areas, but even in this case, it is anticipated that nearly every new home would have its first floor elevated above the base flood, in compliance with local regulations. Also, as average farm size continues to grow, it would be expected that the number of floodplain farm houses would decrease. The net effect over the 50-year planning time frame is projected to be a slight decrease in residences within the floodplain, but given the difficulties in quantifying this for a broad study of this nature, no change has been assumed for the purposes of quantifying flood damages and benefits.

(4) Transportation Development within Floodplain. Inasmuch as highway usage shows no signs of lessening in the near future, it seems reasonable to project a continued upward trend, at least to some degree, throughout the 50-year planning time frame. This is reinforced by a population which continues to grow in the five-state basin area. From 1980 to 2000 the five-state area's population increased 10.3 percent, from 28,072,000 to 31,281,000. Given an upward trend in traffic, at least some road building would appear to be necessary within the planning period. This can be significant since most state transportation agencies have standards which call for elevating major highways across floodplains at higher than natural ground level and sometimes higher than the base flood elevation. In these cases, highways can, in effect, act as dams in obstructing overbank flow in times of flooding. Bridges can also cause a swell effect on floodwaters when designed without sufficient allowances for high flows. However, it is anticipated that such development would occur along existing roadway corridors and would be an expansion of existing crossings rather than entirely new crossings. Moreover, new bridges must meet state and Federal requirements concerning impacts to flood levels. Therefore, although the next 50 years will see increased highway construction, and, to a lesser extent, railway crossings, it is not projected that significant impacts to flood heights will occur.

(5) Critical Infrastructure Development within Floodplain. In 2000, the population in the Comprehensive Plan study area was over 9.7 million, an increase of 8.2 percent from 1990, significantly lower than the national growth rate of 13.2 percent during the same period. With 24.3 percent of its population living in rural areas, the region is more rural compared to the rest of the nation, as defined by the U.S. Census Bureau. All critical infrastructure within the study area is outlined in Tables C-2a and C-2b in Appendix C, *Economic Analysis*. Infrastructure growth will tend to mirror population growth and thus will also be below the national average. Based on historical area population growth rates it is anticipated that future development of critical infrastructure will mirror current development and stay below the national average. Future development will be also restricted by floodplain regulations.

(6) Agricultural Use of the Floodplain. For the purposes of this study, agricultural usage of the floodplain, in terms of acreage, is expected to continue into the future at approximately current levels. If anything, worldwide competition and its effects on grain prices may slightly lessen the amount of acreage in grain production over time. In recent years there has also been a tendency for governmental agencies and NGOs to selectively buy floodplain land either for the purposes of ecosystem restoration or forest development where soil type and hydrologic conditions make it conducive to those uses. However, with the passage of the Energy Policy Act of 2005, both of these factors may be somewhat offset by laws and policies which strongly support ethanol production. While the possibility exists that land usage may tend toward slightly less agricultural floodplain usage in the future, no change in overall agricultural usage has been projected for this study due to the global economic uncertainties associated with making such projections for a 50-year time frame. Agricultural productivity per acre is expected to increase throughout the planning time frame given anticipated advances in seed development, fertilization, and more efficient agricultural practices. Cropping patterns are projected to remain much as patterns that exist today. These latter two assumptions, of course, assume no significant climate change affecting rainfall, growing season or other natural factors affecting grain production.

Upper Mississippi River and Illinois Waterway Navigation Study Sparks Companies report *Economic Scenarios and Resulting Demand for Barge Transportation Final Report* dated April 1, 2002 presents five traffic forecast scenarios based on key drivers which include crop area. This report shows U.S. crop area remaining constant over the next 50 years for the Central, Favorable, and Most Favorable Scenarios; and declining for Least Favorable and Hypoxia Scenarios.

e. Flood Protective Works

(1) Existing Levees/Floodwalls. The existing Upper Mississippi River and Illinois Waterway flood control projects was not intended or authorized to eliminate all flood damage potential within the study area. There is a known and accepted risk of flood events which would exceed the design levels of the many existing projects. Estimates of damages which would occur under these low probability-high impact scenarios are included in U.S. Army Corps of Engineers "damage curves" and annual damage calculations. The intersection of design-exceeding floods with their associated damages is referred to as *residual annual damages*. These are the annual probability-based damages which could occur with an existing project. Significant damages and impacts would likely occur with catastrophic design-exceeding flood events. The Great Flood of 1993 provides insight into these impacts. These would be the realities of such a significant event:

- Infrastructure would be directly and severely impacted. Roads, railroads, and bridges are impassible, hindering emergency health and safety services, commerce, and community mobility.
- Utilities would be impaired. Water supplies could be lost (i.e., Des Moines, 1993). Communications systems and power plants operations could be affected or shutdown.
- People would be displaced and property damaged. Lives could be lost or seriously disrupted. Property damage could be in the billions of dollars.
- Restoration and recovery for infrastructure, utilities, people and businesses would take weeks, months, or years.

During the 1993 Flood, no major urban flood protection project was overtopped along the Mississippi and Illinois Rivers. This is obviously fortunate, but this scenario could occur in the future. For example, if a design-exceeding flood occurred at St. Louis and East St. Louis, the human cost and city/regional impact could be enormous. Flood damage reduction projects provide huge benefits, but also impart a false sense of security. What might occur with the low-probability design-exceeding flood must be considered within the planning and community response process.

In the existing "system" of levees and floodwalls, as appurtenant structures such as gravity drains, closure structures, pump stations and relief wells age beyond their original projected life (usually 50 years or less), it is anticipated that these structures will deteriorate and could fail to perform as intended during a flooding situation. In the worst cases, failures of these components and appurtenances could result in failure of an entire levee system resulting in inundation of tens of thousands of acres, even at flood levels significantly below the crown of the levees. This study does not attempt to project if and where these failures will occur, but this phenomena has likely evidenced itself in the St. Louis area during the past few major floods. Some future pressure for raising or strengthening levees is also foreseen, especially in urban areas or in levee systems which protect municipalities. However, except in cases where projects are currently underway by the Corps, e.g. Muscatine, IA, and East Peoria, IL, this study does not attempt to project levee raises or strengthening, given the uncertainties in predicting exactly where they will occur. A third effect, as discussed above, could involve the buying out of entire levee districts and converting their use to one of habitat restoration. Two such examples would be the Little Creek Levee District, also known as Spunky Bottoms, and the Emiquon Levee District in the Illinois River floodplain. In summary, while all of these changes, which already evidence themselves in the present, are likely to continue to occur to varying degrees in the future, the computation of flood damages is based on a continuation of the existing system into the future.

(2) New Levees/Floodwalls. Given the degree to which the upper Mississippi and Illinois River valleys have already been leveed plus the fact that some states such as Illinois have statutes and policies in place which make the construction of new levees difficult, no additional agricultural levees have been projected for the 50-year planning time frame, other than those currently in planning by the Corps. However, as developable land becomes scarcer, it is considerably more likely that pressure will be felt in urban areas to construct a certain amount of new levees. Even so, given the uncertainties associated with predicting just where such levee building will occur, no additional urban levees have been assumed for purposes of damage quantification in this study.

(3) Upland Reservoirs. Reservoirs form major components of the flood damage reduction system on the Upper Mississippi River, but few of any size exist within the Illinois River basin. No new reservoirs are projected in the future for either river basin however, given the scarcity of relatively unencumbered sites and the high costs of construction.

f. Institutional

(1) Federal Programs

(a) Department of Agriculture. For the purposes of setting the future without condition of this study, it was assumed that the various programs of the Department of Agriculture would continue in their present form and at their present funding levels. These programs include the Emergency Watershed Protection Program (EWP), Emergency Wetlands Reserve Program (EWRP), Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), the Cooperative River Basin Program and the Watershed Protection Program (both authorized by PL 83-566), the Sodbuster and the Swampbuster Provisions of the Food Security Act of 1985, and the Forestry Incentive Program. The future without condition also assumes price and income support programs similar to their current form. It also assumes that the U.S. Forest Service will continue to acquire in-holdings within designated U.S. Forest Service boundaries as they become available from willing sellers. This includes some land that lies within leveed floodplains.

(b) U.S. Fish and Wildlife Service. It is assumed that the U.S. Fish and Wildlife Service will continue to maintain and operate refuge lands within the floodplains of the Mississippi and the Illinois Rivers, including certain lands that it manages for the Corps. There may also be collaborative efforts with state agencies and non-governmental organizations, as discussed in on the following page.

(c) Federal Emergency Management Agency. The future without condition assumes that the National Flood Insurance Program (NFIP) and the Hazard Mitigation Grant Program (Section 404, Stafford Act) will continue in their current forms. The National Flood Insurance Program requires that all structures located lower than the base flood, 1 percent chance annual (100-year) flood event, purchase flood insurance if the owner receives a loan from a federally insured bank or other financial institution. The Hazard Mitigation Grant Program, using a small portion of the insurance premiums, provides funding for mitigation projects, such as buyout of structures which are frequently inundated.

Their collective effect will be to discourage future floodplain construction and to gradually remove existing flood prone structures from the floodplain.

(d) U.S. Army Corps of Engineers. The future without condition assumes that the current programs of the Army Corps of Engineers will continue in the same form as they currently exist.

This means a continuation of the P.L. 84-99 program to provide assistance to non-Federal entities during times of flooding and to assist in the rehabilitation of flood protective works for damages caused by floods when economic feasibility is demonstrated and other conditions are met. Federal assistance should continue to both federally-constructed levee systems and to those systems constructed by local interests who adhere to minimum Federal design standards and maintenance criteria.

It is assumed that ecosystem restoration programs such as the Section 1135 (WRDA 1986) and Section 206 (WRDA 1996) Continuing Authorities and the Upper Mississippi River Environmental Management Program (WRDA 1986 as amended) will continue at roughly their current funding levels.

It is assumed that over the 50-year planning time frame, a limited number of new levees in urban areas will be constructed. However, due to the difficulty in determining the exact sites where construction will occur, no attempt has been made in either the hydraulic or economic analyses to model these effects.

It is assumed that over the 50-year planning time frame, federally-constructed projects, as they near the end of their projected life, will be examined to determine whether reconstruction of certain deteriorated components is feasible and in the Federal interest.

(2) State Programs. It is assumed that the five basin states will continue to participate in floodplain ecosystem restoration projects, either collectively without Federal agency assistance or in partnership with the Corps of Engineers and the U.S. Fish and Wildlife Service and certain Non-Governmental Organizations. It is assumed that those states which have programs to oversee the permitting of levees, e.g. Illinois, will continue to exercise those programs similar to their current form.

(3) Non-Governmental Organizations (NGOs). It is assumed that in the future without project condition, environmental NGOs, such as the Nature Conservancy, the American Land Conservancy and the Audubon Society, will continue to work to acquire and restore certain floodplain properties to recapture their natural values and floodplain functions. One such effort is the Middle Mississippi River Partnership which involves a collaboration of Federal and state agencies as well as NGOs in an effort to restore and enhance sustainable natural resources on public and private lands within the middle Mississippi River corridor. It is assumed that NGOs such as the Upper Mississippi, Illinois and Missouri Rivers Association which focus on the commercial activities of the floodplain (agricultural, industrial, transportation, etc) will continue to work to see that these values are also served in future development plans.

3. Problems and Opportunities. The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G)(WRC, 1983) has been utilized to guide the development of the Comprehensive Plan. The Federal objective in the planning process (as defined by P&G) is to contribute to national economic development, consistent with protecting the nation's environment.

In accordance with Sec. 459 of the Water Resources Development Act (WRDA) of 1999, the Federal objective for the Comprehensive Plan is flood damage reduction. While addressing this primary objective, certain other objectives are to be evaluated to the extent that they relate to flood damage reduction. These secondary objectives include navigation project maintenance; bank caving and erosion; watershed nutrients and sediments management; habitat management; recreation needs; and other related purposes.

The Upper Mississippi River Comprehensive Plan effort was developed in a collaborative environment as described below. This is an extension of the collaborative working relationship among Federal, state, and local agencies and other non-Federal organizations/interest groups that has been in place in the Upper Mississippi River System for a number of years. The UMRS collaboration has resulted in development and agreement with the following Guiding Principle.

Guiding Principle for the Upper Mississippi River System

"The balance of economic, ecological and social conditions so as to meet the current, projected and future needs of the Upper Mississippi River System without compromising the ability of future generations to meet their needs."

The problem and opportunities sections, Step 1 of the six step planning process, that follow, have been broadly written to capture the immediate study opportunities for flood damage reduction and to provide a framework for discussing potential future follow-on study recommendations that are more encompassing in nature.

a. The Problem

(1) Flood Damage. Despite more than 100 years of private and Federal investment in local flood protection systems, significant damages continue to occur during major flood events. The Flood of 1993 provided a vivid demonstration of the vulnerabilities of the existing flood control systems on the Upper Mississippi River System. Assessments of the economic damages caused by the Flood of 1993 range from $15 to 20 billion, including more than $2.9 billion in damages along the Mississippi River and its floodplain. The social disruption was beyond measure, with more than 50,000 homes damaged or destroyed and approximately 54,000 persons evacuated from flooded areas (NOAA, 1994). While the size and impact of the Flood of 1993 was unprecedented in recent history, floods of equal or greater magnitude are anticipated to occur in the future, and the region may again be exposed to the destructive potential of the Mississippi River.

The flood damage reduction facilities (Federal and non-Federal) of the Upper Mississippi River System were not constructed in accordance with any overall systemic plan. These facilities have varying structural integrity, and provide varying levels of flood protection for similar land uses. Not since 1981 (with the termination of the Upper Mississippi River Basin Commission) has there been an overall planning authority for Upper Mississippi River System resources management (McGuiness, 2000). System-wide, coordinated, and integrated management of the Upper Mississippi River System is not currently the mission of any one agency. Today, separate government programs address a host of floodplain concerns.

The Flood of 1993 awakened renewed interest in developing a systemic approach to flood damage reduction on the Upper Mississippi River System. In authorizing this study, Congress recognized the need for a planning effort that develops an implementable floodplain management plan for which there is a Federal interest. That plan needs to address the immediate problem of reducing future flood damages, but also needs to evaluate the potential for a future, more-resources inclusive, integrated river resources management program.

(2) Ecosystem Resources. Since the early 1800s, the Upper Mississippi River ecosystem has been drastically affected by the loss of wetlands and other habitats. This was due to water pollution, land use changes (i.e. urban development, agriculture, forestry, and mining), navigation improvements (i.e. locks and dams, dikes, revetments, and dredging), and flood damage reduction improvements (levees, floodwalls, and reservoirs). Likewise, the Illinois River ecosystem has suffered a series of ecologically adverse events, including Lake Michigan water diversion, floodplain drainage, water pollution, commercial navigation, and accelerated sedimentation.

More recently, pollution controls and environmental restoration projects have helped improve conditions on the Upper Mississippi River System for some species. However, the disruption of the natural ecosystem has caused a loss in the abundance of certain other populations of native species and has resulted in an increased number of species being listed as state threatened. The nature of Upper Mississippi River System habitat degradation is more fully characterized below.

(a) Floodplain Connectivity. Seasonal flooding is an ecologically important process in large river floodplain ecosystems because such flooding connects the river with its floodplain. In the Upper Mississippi River-Illinois Waterway, many low elevation floodplain areas are no longer subject to seasonal flooding because they are permanently flooded from impoundment by navigation dams. Comparing pre-dam and post-dam conditions, total open water area has decreased or remained stable in Pools 4 and 10 through 26, the Open River, and the Illinois River, but it increased in Pools 5 through 9. Decreases in water area are attributable to several geomorphic processes including loss of contiguous backwaters; filling of isolated backwaters; loss of secondary channels; filling between wing dams; and delta formation. Increases in water area are apparent where dam impacts inundated significant amounts of low elevation floodplain in lower pool areas.

In addition, constructing levees reduces aquatic habitat connectivity with floodplain habitats. Aquatic-terrestrial connectivity is important for many physical, chemical, and biological functions. Floodwater flow moves sediment and nutrients over the floodplain to shape it and to enrich the soils and rejuvenate marshes, prairies, and forests. Chemical transformations in floodplain habitats consume and transform nutrients to balance input and outputs and nutrient discharge to coastal areas (Gulf of Mexico). Biological responses to flooding can be diverse and prolific; microbial and invertebrate production thrives on inundated floodplain vegetation, fish feed on the invertebrates and spawn in flooded land, stranded fish feed a variety of predators and scavengers, and shorebirds are drawn to exposed mudflats surrounding backwater lakes. Reduced connectivity to floodplain habitats impacts the functions described above, and also impacts connected habitats and receiving waters by concentrating sediments and nutrients in smaller areas or shunting them downstream.

(b) Water Pollution. The water quality of the Upper Mississippi River System has improved in response to a mandated treatment of domestic sewage (USACE, 1998). However, the river still receives a mixture of contaminants from agricultural, industrial, municipal, and residential sources. For example, heavy metals accumulated in riverbed sediments could be a long-term problem for aquatic life, especially in sites downstream of metropolitan areas.

Watershed nutrients is a water pollution problem specifically called out in the Section 459 legislation, and for that reason, it is the central water quality concern addressed in this report. The nutrients topic is fully addressed in Environmental Chapter 6.

Several factors have contributed to the increase in the Upper Mississippi River System nutrients loading. First, the expansion of agriculture prior to the 1980s resulted in a loss of 26 million acres of wetlands (along with its natural capacity for denitrification). Second, there has been a substantial increase in the application of nitrogen fertilizer to crop fields, and third, the use of drainage tiles has accelerated the drainage of nitrogen fertilizer containing groundwater from the system.

Nutrient loading has the potential to degrade water quality and aquatic life along the river system per se. Most Upper Mississippi River System states have significant river miles impaired by high nutrient concentrations. Impaired waters are those not fully supporting one or more resource uses, including swimming, fish consumption, aquatic life, and/or drinking water.

In addition to basic compliance with Federal environmental laws dealing with water quality, the Comprehensive Plan study provides an opportunity to explore flood damage reduction compatible methods (such as wetlands restoration), for nitrogen load reduction by denitrification and nitrogen retention.

(c) Sedimentation. Sedimentation is a major socio-economic problem in the Upper Mississippi River System. It has caused portions of the floodplain to fill, thereby decreasing channel conveyance and increasing flooding. It has also caused maintenance problems in reservoirs; blockage of inflow/outflow pipes for water supply facilities and power plants; blockage of the entrances to harbors and marinas; the filling of drainage ditches; increased cost of water treatment; and aesthetic and structural damages (including erosion at bridges).

Sediment can also be a major physical or chemical pollutant. High levels of turbidity can limit the penetration of sunlight into the water column, thereby limiting the growth of plants. Gravel beds covered with fine sediment could also impact fish spawning. Metals tend to be highly attracted to ionic exchange sites that are associated with fine clay particles. Iron and manganese coatings commonly found on clay also attract these pollutants. Many of the persistent, bio-accumulating and toxic organic contaminants are strongly associated with sediment.

For years, Federal and state agencies have been reporting that decreasing budgets have greatly reduced the amount of sediment monitoring being conducted in the basin. The USGS "sediment program" has not changed significantly in magnitude since the late 1990s. Funding has usually been directed at ongoing sediment problems for only short-term analysis. It has been 20 years since major sediment monitoring of the Upper Mississippi River System tributaries was performed. If funding is not re-established, there will be a large historical data gap that will be statistically difficult to overcome.

The 1993 flood showed the value of installing flood-prevention measures and land-treatment practices on watershed agricultural lands. NRCS projects prevented many millions of dollars in damages during this flood event, with lower crop losses in areas with upland watershed treatment.

b. Goals and Opportunities. The overall goal of the Comprehensive Plan is to develop a systemic, comprehensive flood damage reduction plan for the Upper Mississippi and Illinois Rivers, sufficiently comprehensive to address flood damage reduction needs and supportive of evolving long-term economic and environmental sustainability goals.

Specific objectives are to:

- minimize the threat to health and safety resulting from flooding by using structural and non-structural flood damage reduction measures;
- reduce damages and costs associated with flooding;
- identify opportunities to support environmental sustainability/restoration goals of the Upper Mississippi River and Illinois River floodplain as part of any systemic flood damage reduction plan;
- seek opportunities to address, in concert with flood damage reduction measures, other floodplain specific problems, needs and opportunities to include:
    - continued maintenance of the navigation project and related commercial infrastructure;
    - reduction of nutrient input and sedimentation into the rivers;
    - improved habitat management;
    - bank caving and erosion reduction;
    - improved recreation opportunities; and
- identify and recommend appropriate follow-on studies.

An additional objective expressed by some stakeholders is to develop a systemic flood damage reduction plan to be able to pass a very large flood, thereby avoiding a disaster similar to the 1993 flood.

On a system as large as the Upper Mississippi River System, the number of potential flood damage reduction alternatives and permutations is significant. In the same vein, the Floodplain Management Assessment (USACE, 1995) and Galloway Report provide an extensive representation of flood damage reduction related opportunities; categorically, these opportunities include various modifications to levees, reservoirs, flood insurance programs, flood fighting, buyouts, flood response/recovery, and crop insurance. However, the scope and funding of the Comprehensive Plan study precludes the Corps' ability to address, in detail, all of the measures identified in those reports. The Comprehensive Plan study does provide a limited opportunity to begin the development of a conceptual, analytical, and collaborative framework for increasing our understanding of the processes impacting upon floodplain communities.

c. Planning Constraints. Following identification of problems and opportunities which result in the development of goals and objectives, Step 1 concludes with planning constraints.

The study-specific constraints identified for the Comprehensive Plan include:

- As per the Water Resources Development Act of 1999, Section 459, flood damage reduction is the emphasis (study authorization places primary emphasis on flood damage reduction, and secondary emphasis on other project purposes).

- Make maximum use of existing data (Reference Water Resources Development Act of 1999, Section 459).

- Environmental measures are linked to flood damage reduction (for inclusion, environmental measures need to be related to flood damage reduction).

- Need for future site-specific studies (due to funding limitations, project development process will be tiered). Any site-specific studies would follow the traditional cost sharing requirements of feasibility phase studies, 50 percent federal and 50 percent non-federal cost.

- Due to funding availability, certain current or future floodplain activities, issues, conditions, and alternative futures that are components of a comprehensive plan related to environmental quality will be minimally addressed during the course of this study.

- Limit alternative plans to those that increase the hydraulic profile at any location to no more than 1.0 feet, associated with national (FEMA) criteria, for the base flood (the one percent chance annual flood event).

- Conduct the analysis in a timely manner within budget which translates for example, into no analysis of induced rise for existing unprotected areas.

F. Formulation of Alternative Plans

Plan formulation—the development of alternative plans to address the objectives and opportunities identified—is Step 3 of the Corps' six step planning process. Plan formulation is composed of several main parts leading to the final development of the array alternative plans considered.

The third step typically includes three major components:
1. identification of measures and strategies;
2. combining measures and strategies (termed *philosophies* by the Collaboration Team) to develop alternative plans; and
3. based upon an initial evaluation of the alternatives, reformulation and development of additional alternatives based upon what is learned

1. Identification of Potential Measures

a. Flood Damage Reduction Measures. Using past experience, brainstorming, and public and Collaboration Team input, the following list of possible flood damage reduction measures was developed. **Bold-faced type** indicates measures generally preferred during the discussions. ***(PW)*** indicates a measure that was identified by the public at the November 2002 Public Workshops or in response to the workshop notice requesting input. Appendix F Public Involvement describes the results of the Public Workshops in detail.

1. Flow Diversions
   a. Diversion Channels
   b. Timed use of off-channel (behind levee) storage ***(PW)***

2. Upland Detention
   a. Flood Control Reservoirs ***(PW)***
      1) New
      2) Modified regulation of existing
   B. Dry Detention Basins
   c. Watershed Small Ponds and Detentions ***(PW)***
   d. Wetlands restoration

e. Grasslands restoration

3. Channel Modifications
   a. Channel Geometry-increased Channel Capacity (using underwater weirs) ***(PW)***
   b. Reduced Energy Loss
      1) Vegetation management
      2) Channel Straightening
      3) Modifying/reducing constrictions - bridges, levees (*PW*)
   c. Overbank conveyance-increase ***(PW)***
      1) Levee set-backs (*PW*)
      2) Re-alignment of levees/structures
      3) Remove Levee (*PW)*

4. Levees and Floodwalls
   a. Raising levees/structures (*PW*)
   b. Controlled overtopping of levees/structures (*PW*)
   c. Low Profile Berms to protect environmentally sensitive areas

5. Reduction in Existing-Condition Damage Susceptibility
   a. Flood proofing
   b. Relocation/Acquisition/Buy-outs *(PW)*
   c. Improved Flood-Warning/Preparedness

6. Reduction in Future-Condition Damage Susceptibility
   a. Land use/Construction regulation (floodplain management) ***(PW)***
   b. Easement - Conservation and flowage (*PW*)

b. Ecosystem Restoration Measures. Flood damage reduction is the primary purpose of the Comprehensive Plan (Section 459 of the Water Resources Development Act of 1999). Therefore, opportunities for ecosystem restoration are limited to those that could be implemented in conjunction with flood damage reduction alternative plans. Also considered was the type of habitat management strategy that might be applied at a given floodplain site, as this could ultimately impact the number of manageable habitat acres. Up to four different options for floodplain ecosystem management were evaluated against each of the flood damage reduction alternative plans. The options are described in Table 10.

Table 10. Description of Ecosystem Restoration Options

Option	Description
1 No Action	No additional habitat management of Upper Mississippi River System floodplain.

2	Conservation Easements Acquired in Conjunction with Plan Flowage Easements	A payment for residual property rights on flood damage reduction flowage easement lands would be offered to landowners (on a voluntary basis) as conservation easements for future fish and wildlife management purposes. This option could encourage enhanced Federal funding to support the management of existing state and Federal conservation programs (e.g. CREP, WRP, EMP programs, etc.). Lands under these conservation easements could be enhanced using a wide variety of available habitat improvement methods.
3	Buyouts	Lands included as flood damage reduction buyouts would have to meet two criteria: (1) the cost of levee improvements for a given Drainage and Levee District would have to exceed the value of the land protected, and (2) levee areas must be less than 10% urbanized. The same site development measures described for Option 2 would be applied here as well. Similar to Option 2, the affected lands would be actively managed for fish and wildlife purposes. This option addresses a more literal interpretation of the WRDA '99 language that states "flood damage reduction and floodplain management by means of…habitat management…"
4	Conservation Easements on Lands adjacent to Levees Construction	This measure is similar to Option 2. However, since no flowage easements would be involved, obtaining conservation interests landward of the levees would be tantamount to the cost of a fee simple acquisition.

Lands included as flood damage reduction buyouts would have to meet two general screening criteria: (1) the cost of levee improvements for a given Drainage and Levee District would have to exceed the value of the lands protected (i.e. it would be cheaper to protect the site from flood damages by acquiring its land--rather than by investing in a structural solution), and (2) levee areas must be less than 10% urbanized (i.e. the area should be suitable for ecological restoration by not being significantly threatened by urban development either now or during the next 50 years. The same site development measures described for Option 2 would be applied for buyouts as well. Similar to Option 2, the affected lands would be actively managed for fish and wildlife purposes. This option addresses a more literal interpretation of the WRDA '99 language that states "flood damage reduction and floodplain management by means of...habitat management.

2. Plan Formulation Philosophies and Design Criteria

a. Philosophies. Alternatives should be formulated to achieve flood damage reduction, termed by the Corps as national economic development benefits, and also achieve gains in National Ecosystem Restoration (NER) and sustainability benefits as possible. The fist part of Plan Formulation, Step 3 in the Planning Process, is to develop strategies which when combined with measures, form alternative plans. The PDT brainstormed and developed a list of over 30 strategies, which the CT preferred to name Philosophies. CT insight and discussion over several months and at several meetings resulted in the Philosophies presented in the report. Developing the philosophies ends the first part of planning step three.

Prior to developing specific alternatives, the following plan formulation philosophies, in no preference order, were developed to guide the formulation of systemic alternative plans:

- Use Non-structural techniques. Apply permanent buyouts, relocation and other appropriate non-structural measures to reduce flood damages.

- Uniform level of protection for the entire system and by reach. The Comprehensive Plan is to consider systemic plans which provide uniform levels of protection everywhere along the Mississippi and Illinois Rivers.
- Uniform level of protection by land use (urban, critical infrastructure and non-urban). Plans should be consistent by major land use for the Upper Mississippi River system.
- Minimize loss of life.
- Minimize impacts to adjacent properties. As discussed in Constraints and Design Criteria following, the maximum induced impact allowed for alternative plans is a one foot rise in water surface elevations.
- Emergency Action Plan (Flood Routing Plan). As requested by the Collaboration Team, analyze temporary emergency raises to the existing flood damage reduction systems during a major flood event to determine the impacts of emergency measures, from both benefit and induced rise standpoints.
- Flexibility (to meet a wide range future conditions).
- Achieve flood damage reduction with maximum gains in NER/sustainability. Gains in national environmental restoration are always considered per the Environmental Operating Procedures and other Corps planning policies.

After considering and evaluating initial alternative plans, the list of philosophies was expanded by adding the following philosophies. The changes specifically identify that alternative plans be systemic in breadth, consider critical infrastructure, and add the potential of reconstruction of existing systems.

1. The alternative should cover a range of scope from a very high level of flood protection to lesser levels. The 0.2 percent chance annual (500-year) protection was the highest level of protection considered with other alternative plans having systemic, uniform level of protection progressively less.
2. The alternatives should specifically address critical infrastructure, including transportation access (bridges/approaches) across the Mississippi and Illinois Rivers.
3. A reconstruction option should be considered to evaluate the condition of the existing flood protection systems and propose rehabilitating them, as justified, to their original performance, which may have become degraded over time due to the age of the systems.

b. Design Criteria. Four design criteria were established collaboratively to be applied uniformly and consistently in the development of alternative plans for the entire study area.

The following four design criteria were used to formulate the alternative plans, except as noted in the detailed description of individual plans.

(1) The existing level of protection. In areas where the existing level of protection exceeds that of the proposed alternative plan, the existing flood protection system would remain unchanged.

(2) Increase of one foot for the 1 percent chance annual (100-year) flood. Floodplain development is managed by local, state, and Federal laws and statutes. Floodways for state or local communities in the Federal Insurance Program are developed using an allowable induced rise in the water surface profile of one foot for the one percent chance annual (100-year) flood. This minimum criterion is set by FEMA for floodways and can be modified by state and local ordinances to develop even more stringent guidelines. For example, the State of Illinois has imposed a maximum allowable stage increase of 0.1 foot for floodways with allowable compensation to all landowners that exceed the allowable impact. This management tool for floodplains was used to develop one of the Comprehensive Plan criterions that could be accepted by local, state and Federal Floodplain Managers. The criterion set for all plans (except as noted) in this study is not to exceed the one-foot rise in water surface profile for the one percent chance annual (100-yr) flood.

(3) Minimize water surface profile rise at Thebes, IL. Thebes, IL, is the downstream limit of the Comprehensive Plan and the upstream limit of the existing Mississippi River & Tributaries Project. The MR&T levee systems protect thousands of square miles of floodplain from a Project Design Flood. Induced water surface profile raises from the Upper Mississippi River System passed below Thebes would necessitate costly mitigation measures to restore the existing levels of protection to the MR&T Project. Therefore, every attempt was made to limit the hydraulic impact of the various alternatives at Thebes, IL. The limitations of this criterion were explored as part of Alternative G, described below.

(4) The ratio of total average annual damages prevented per acre. When determining which areas to include in an alternative that cannot be applied systemically to every existing drainage and levee district due to induced water surface profile rises, the districts with the highest ratio of average annual damages to acres protected were included first. For example, if in a given reach an alternative plan could only afford to improve the level of protection of one levee district due to induced hydraulic impacts that exceed the previous criteria, the levee district with the higher ratio of total average annual damages per acre would be selected for improvement, and the others would remain at their current height.

3. Description of Alternative Plans. The following is a description of the alternative systemic plans considered for the Upper Mississippi River Comprehensive Plan, the second part of planning Step 3, formulation alternative plans. The ***Plan Summary*** designates by land use type the level of protection for the land use type for the particular plan.

No Action Alternative

Description. The No Action plan represents the future condition without any Corps project as a result of the Comprehensive Plan. Refer to Section 2, *Future Without Project Conditions.* All other alternative plans, Plans A through M, are compared to this, the No Action plan, to determine the benefits and costs of each plan. If no action is taken, significant flooding could occur on the system.

Plan Summary

- Urban - no change to the existing level of protection which varies by location
- Agricultural – no change to the existing level of protection which varies by location
- Unprotected towns – no change to the existing level of protection which varies by location
- Other existing unprotected areas – no protection
- No mitigation required

Discussion. The No Action plan represents the future conditions without any project as a result of this study. In general, the landscape will remain generally as it exists. Significant changes will occur only in relatively localized areas.

Alternative A. Confined – 0.2 percent chance annual (500-year) Urban and Agricultural Protection

Description. This alternative plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual level of protection. The 0.2 percent chance annual (500-year) level of protection applies to urban, agriculture and unprotected communities. Briefly, as used in this report, confined means the flows are confined between the levees in the river channel and overbank area or between the levee on one bank and the bluff on the opposite river bank. Flood waters are not allowed to overtop any levee. It is assumed for analysis purposes, that levees would be raised as needed to keep the flood waters out of the levee areas, confined to the river. Design criteria 2 and 3 above do not apply to Plan A.

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – 0.2 percent chance annual (500-year)
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. This alternative plan applies a uniform, high level of protection to existing protected areas and unprotected urban areas regardless of its impacts on flood profiles. Uniformly raising all areas in this manner will potentially result in significant increases in flood heights in some portions of the system, greater than 7 feet. This plan is considered unacceptable due to the induced rise in flood heights. This alternative plan represents the upper bound (regarding increases in the line of protection) on structural plans for flood damage reduction considered in this study.

The remainder of the alternative plans are considered unconfined from a hydrologic standpoint. Within the context of the Comprehensive Plan, unconfined means allowing no more than a one foot water surface profile rise. The river is no longer confined between the levees or levee and bluff. With a one foot rise, the analysis lets river flows overtop leveed areas to insure no more than the one foot water surface profile rise. The analysis to determine how to achieve the one foot limit is very analysis intensive requiring much trial analysis to not exceed the one foot rise criteria.

The four alternative plan design criteria, discussed above, apply to the following plans except as noted below.

Alternatives B through E represent consistent levels of protection across major land use types (urban and agricultural). In order to meet the 1.0 foot allowable maximum rise standard, as well as to minimize impacts to the Lower Mississippi River, some agricultural levee districts will, by necessity, need to be excluded from improvement. The selection of levee districts that can be included in the plans followed the procedures discussed in Section 2.b, *Design Criteria* using national economic development (NED) criteria.

Alternatives B through E would result in preventing an additional increment of potential future flood damages. The NED analysis indicates that all plans have benefit to cost ratios (BCRs) less than 1.0. If the plans were implemented, substantial regional economic benefits would result.

Alternative B. 0.2 percent chance annual (500-year) Urban and Agricultural Protection

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level of protection. 0.2 percent chance annual (500-year) level of protection applies to urban, agriculture and unprotected communities.

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – 0.2 percent chance annual (500-year)
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. This alternative plan applies a uniform, high level of protection to existing protected areas and unprotected urban areas.

Alternative C. 0.2 percent chance annual (500-year) Urban / 200-yr Agricultural Protection

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level for urban areas and the 200-yr level for agricultural areas. Unprotected urban areas would also be protected to the 0.2 percent chance annual (500-year) level. The hydraulic impacts of this alternative on flood profiles and the Lower Mississippi River would be minimized through creation of additional storage areas and/or the exclusion of some agricultural districts from the plan.

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – 0.5 percent chance annual (200-yr) protection
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Alternative D. 0.2 percent chance annual (500-year) Urban / 1 Percent chance annual (100-yr) Agricultural Protection

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level for urban areas and approximately the 100-yr level for agricultural areas (the level of protection would be left intentionally insufficient to obtain FEMA certification). Unprotected urban areas would be protected to the 0.2 percent chance annual (500-year) level. The hydraulic impacts of this alternative on flood profiles and the Lower Mississippi River would be minimized through creation of additional storage areas and/or the exclusion of some agricultural districts from the plan.

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – approximately 100-yr protection
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. This floodplain management plan was intentionally developed such that for existing protected areas which require a raise in protection height, the new height would be less than required to obtain Federal Emergency Management Agency (FEMA) certification as providing protection for the base, or 1 percent chance annual, flood event. This plan would minimize new floodplain development in concert with current Federal policies of not inducing floodplain development while raising the level of protection for many of the agricultural levee districts.

Alternative E. 0.2 percent chance annual (500-year) Urban / 2 Percent chance annual (50-yr) Agricultural Protection

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level for urban areas and the 50-yr level for agricultural areas. Unprotected urban areas would be protected to the 0.2 percent chance annual (500-year) level. The hydraulic impacts of this alternative on flood profiles and the Mississippi River and Tributaries (MR&T) Project, would be minimized through creation of additional storage areas and/or the exclusion of some agricultural districts from the plan.

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – 50-yr protection
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. As with alternative plan D, this floodplain management plan was intentionally developed such that for existing protected areas which require a raise in protection height, the new height would be less than required to obtain Federal Emergency Management Agency (FEMA) certification as providing protection for the base, or 1 percent chance annual, flood event.

Alternative F. 0.2 percent chance annual (500-year) Urban and Highway Approach Protection

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level for urban areas, and the use of ring levees to protect smaller urban centers within predominantly agricultural levee districts. In addition, the highway approaches to major river bridge crossings would be raised to an elevation above the 0.2 percent chance annual (500-year) flood event. The hydraulic impacts of this alternative on the Lower Mississippi River would be minimized through creation of additional storage areas and/or the exclusion of some agricultural districts from the plan.

Plan Summary

- Urban - 0.2 percent chance annual (500-year)
- Do not raise Agricultural protection
- Inside Agricultural – protect communities (ring levee encompassing only existing development)
- Inside Agricultural – bridge approaches only protected if needed for emergency access.
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. This alternative provides a high level of protection to urban areas and primary east-west (Mississippi River) and north-south (Illinois Waterway) bridge crossings. In general, this alternative is likely to produce smaller hydraulic impacts than plans which include agricultural levee district raises due to the isolated nature (and existing high level of protection) of urban areas on the system. However, the raising of bridge approaches across the floodplain has the potential to increase flood heights locally. This may necessitate the inclusion of bridge-like openings in the raised approach to provide additional flood conveyance.

Alternative G. 0.2 percent chance annual (500-year) Urban and Agricultural Protection w/ no Minimization of Impacts to Lower Mississippi River Valley

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level of protection. 0.2 percent chance annual (500-year) level of protection applies to urban, agriculture and unprotected communities.

Plan Summary

- The third criteria to minimize impacts on the MR&T Project does not apply to this plan
- Urban - 0.2 percent chance annual (500-year)
- Agricultural – 0.2 percent chance annual (500-year)
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Other existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. This alternative tests the sensitivity of Alternative B with regards to meeting the criteria for no, or minimal, impacts to water surface profiles at the downstream limit of the study to avoid impacts to the MR&T Project. Removal of this criterion may allow for additional agricultural districts to be included in the plan; however, the plan would still need to meet 1.0 foot maximum rise standard. In order to meet this standard, some agricultural levee districts would, by necessity, need to be excluded from the plan. The selection of levee districts that can be included in the plan followed the fourth criteria as above. In addition, the MR&T Project would have to be raised to mitigate for any induced rise from the Upper Mississippi River.

Alternative H. 0.2 percent chance annual (500-year) Urban and Agricultural Protection w/ Selective Buyouts

Description. This plan involves protecting areas with existing levees/floodwalls to the 0.2 percent chance annual (500-year) level of protection. 0.2 percent chance annual (500-year) level of protection applies to urban, agriculture and unprotected communities. The hydraulic impacts of this alternative on the Lower Mississippi River would be minimized through creation of additional storage areas and/or the exclusion of some agricultural districts from the plan. This plan is identical to Plan B, with the exception of areas where the cost of the levee improvement exceeds the value of the land to be protected.

Areas that meet these criteria would be purchased in fee title and actively managed for ecosystem benefit. For the analysis at this time, it is assumed that the levees would remain in place at their current height, and the water levels within the interior of the drainage district would be actively managed for wildlife purposes and flood storage, if needed.

Plan Summary

- Urban - 0.2 percent chance annual (500-year)
- Agricultural areas – 0.2 percent chance annual (500-year), cost effective comparison of the levee improvement cost versus value of land cost
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. For agricultural areas with existing protection, a comparison of the cost to implement the raise (construction cost estimate) to the cost to purchase the area in fee was made using an average fee cost of $6,000 per acre. The more cost effective option would then be chosen if this plan were to be implemented. As initially formulated, for agricultural districts it was either raise the level of protection to 0.2 percent chance annual or fee purchase. If this alternative plan were evaluated further, additional assessments would be done to determine whether real estate easements are required for the areas where lines of protection are not increased, and to evaluate associated ecosystem benefits.

Alternative I. Relocation of Urban Resources Outside of the 100-Year Floodplain

Description. Plan I involves relocating all flood impacted urban properties out of the 100-year floodplain through voluntary incentive programs or through condemnation. Urban areas with at least 1.0 percent chance annual (100-year) protection would not be impacted.

Plan Summary

- Urban areas – buyout all structures below 100-yr flood level
- Do not raise agricultural protection
- Inside agricultural – buyout communities
- Bridge approaches – no protection for approaches -
- Unprotected towns – buyout
- Existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Alternative J. Floodplain Management

Description. This alternative involves a change in floodplain management policies to restrict urban development in the 0.2 percent chance annual (500-year) floodplain, and the removal of existing flood protection systems in agricultural areas to increase floodplain connectivity. Permanent evacuation of flood prone developed areas involves the acquisition of lands by purchase, the removal of improvements, and the relocation of the population from such areas. Lands acquired in this manner could be used for recreation, ecosystem restoration, or for unprotected agriculture at the higher elevations.

Plan Summary

- Urban – 0.2 percent chance annual (500-year) protection
- Agricultural Levees – removed/no protection and buyout developed areas in agricultural levee districts
- Unprotected towns – no protection/buyout
- Unprotected agricultural– no protection
- Mitigation of all impacts due to plan implementation

Discussion. Economic resources in the floodplain will always be at risk. Traditional structural approaches to floodwater management have provided significant protection from flooding. However, there can be disadvantages to using structural approaches, including: increased risk of catastrophic flooding if structures fail or the flood damage reduction system capacity is exceeded; damage to natural resources and natural floodplain function; and increased economic damages if catastrophic flooding occurs. A second approach is to evacuate floodplains and move residents and their public and private investments to less risky areas. (Interagency Floodplain Management Review Committee, 1994).

Objectives of this alternative are to:

1. reduce the vulnerability of the nation to loss of life and property and the disruption of societal and economic resources caused by flooding;
2. sustain, restore, or enhance the natural resources, ecosystems, and other functions of the floodplain; and
3. prevent repetitive losses from flooding.

This plan evaluated the impacts of removing all agricultural levees along the Mississippi and Illinois Rivers. Existing urban levees/floodwalls are assumed to remain intact. Agricultural levee removal could result in a mixture of floodplain development. To capture this uncertainty, two bounds, or conditions, of floodplain developments were evaluated in this plan. The lower bound is that the floodplain would turn totally into an agricultural regime. The upper bound would be that the floodplain would revert back to natural ecological succession in the floodplain. If agricultural levees would be removed, then the impact to water levels on the flood plains could be within the bound created.

Alternative K. Protection of Regional Critical Infrastructure

Description. This alternative involves providing 0.2 percent chance annual (500-year) protection to regional critical infrastructure—as defined by the Presidential Commission on Critical Infrastructure—using structural (levees, road raising) and/or non-structural methods (flood proofing, relocation, etc.).

Plan Summary

- Urban - 0.2 percent chance annual (500-year) protection
- Agricultural – 0.2 percent chance annual (500-year) (structural or non-structural) if levee protects regional critical infrastructure – no raise otherwise
- Unprotected towns – 0.2 percent chance annual (500-year) protection (levee encompassing only existing development)
- Existing unprotected areas – no protection
- Mitigation of all impacts due to plan implementation

Discussion. The analysis across the system did not indicate a sufficient concentration of critical infrastructure in any reach or sub-reach to merit further evaluation of this alternative, with the exception of a single transportation (bridge) measure

Alternative L. Protection of All Bridge Approaches

Description. This alternative involves structurally raising all bridge approaches and floodplain highways to the 0.2 percent chance annual (500-year) level, plus freeboard or, if less expensive, the raising of existing levees to protect the bridge approaches. When raising of the bridge approach, or highway, with a solid embankment would induce a rise in the 0.2 percent chance annual (500-year) flood level, openings would be provided to minimize the induced rise.

Plan Summary

- Bridge approaches raised/protected to 0.2 percent chance annual (500-year) level
- Mitigation of all impacts due to plan implementation

Discussion. This alternative plan would consider all river crossings over the Mississippi and Illinois Rivers in the study area.

Table 11 displays a summary of the alternative plan features.

Table 11. Summary Description of Alternative Plans

Plan	No Action	Plan A	Plan B	Plan C	Plan D	Plan E	Plan F
Old Name		C1	U1	U2	U3	U4	UE1 or U5
Plan Description	NO ACTION	Confined 500-yr	500-yr	200-yr Ag levee protection	~100-yr Ag levee protection	50-yr min Ag levee protection	Local protection for towns & bridge approaches @ 500-yr
H&H Condition	No Change	Confined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
Urban Systems	No Change	500-year	500-year	500-year	500-year	500-year	500-year
Agricultural Districts	No Change	500-year	500-year	200-year	100-year	50-year	Protect towns & bridge approaches only, not Ag lands
Unprotected towns	No Change	500-yr ring levee with no new development'	500-yr ring levee with no new development'	500-yr ring levee with no new development'	500-yr ring levee with no new development'	500-yr ring levee with no new development'	500-yr ring levee with no new development'
Other Existing Unprotected	No Change	No protection	No protection	No protection	No protection	No protection	No protection
Note/other information							No analysis of bridge approach, 2 examples of ring around town (Hull, Eldred)

Plan	Plan G	Plan H	Plan I	Plan J	Plan K	Plan L
Old Name	U7	U10		U9	U8	U11
Plan Description	Allow up to 1' rise at Thebes, 500-yr Ag	500-year cost effective buyout	Buyout development in 100-yr floodplain	No development in 500-yr floodplain, buyout development in Ag areas, remove Ag levees	500-yr for Ag with regional critical infrastructure	Local protection for bridge approaches @ 500-yr
H&H Condition	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
Urban Systems	500-year	500-year	500-year	500-year	500-year	500-year
Agricultural Districts	500-year	500-year except purchase when more cost effective than levee raise	Buyout towns	Remove/breach existing levees - reconnect areas to river - buyout towns/structures	500-year IF contains regional critical infrastructure	500-year for levees with bridge approaches
Unprotected towns	500-yr ring levee with no new development'	500-yr ring levee with no new development'	Buyout towns	Buyout towns	500-yr ring levee with no new development'	500-yr ring levee with no new development'
Other Existing Unprotected	No protection	No protection	No protection	No protection	No protection	No protection
Note/other information	MR&T criteria DOES NOT APPLY Need estimate to mitigate on MR&T					Protecting all approaches not viable. One bridge approach on Upper Miss at Quincy may warrant further study (Fabius)

4. Alternative Plan Evaluation. The Flood Control Act of 1936 established the policy that flood control on navigable waters or their tributaries is in the interest of the general public welfare, and is therefore a proper activity of the Federal Government. It provided that the Federal Government, cooperating with state and local entities, may improve streams or participate in improvements "for flood control purposes, if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected." The 1936 Act, as amended, and, more recently the Water Resources Development Act of 1986 and other acts, specify the details of Federal participation.

Planning step four, evaluation of alternative plans, is accomplished using four accounts established in the Corps' Principles and Guidelines to facilitate the evaluation and display of effects of alternative plans (ER 1105-2-100):

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services.
- The Environmental Quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans.
- The regional economic development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment).
- The Other Social Effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation, and others.

Analysis of the NED and EQ accounts is required. Evaluation of RED or OSE accounts is discretionary. For the Upper Mississippi River Comprehensive Plan, RED benefits were computed by the Tennessee Valley Authority (TVA, 2004) for Alternatives A, B, and D. The TVA estimated that every dollar spent on comprehensive flood control at the 500-year (for urban areas) and 100-year (agricultural areas), which includes Plans A, B and D, would generate as much as $5.00 in increased gross regional product. Gross Regional Product is defined as an estimate of each state's or region's share of the nation's gross domestic product, which is the total value of the goods and services produced by labor and property in the United States. Also, employment is projected to increase by more than 20,000 jobs annually in the five-state Upper Mississippi Valley Region resulting from upgraded levee protection provided by implementation of either Plan A, B, or D. More complete results of the TVA analysis of RED benefits are summarized in Appendix C, *Economic Analysis*.

The evaluation processes used to determine the hydraulic impacts, potential flood damage reduction benefits, and implementation costs of the alternative plans is briefly described below. Detailed discussion of methods and assumptions can be found within the individual technical appendices. In the evaluation of induced flooding impacts, three main areas are considered for potential induced water surface profile impacts: 1) existing flood protection systems; 2) unprotected communities/towns, and; 3) other unprotected areas.

Generally, for the existing flood protection systems and unprotected communities along the Mississippi and Illinois Rivers, any induced flooding impacts by a rise in the water surface profile are mitigated by raising the height of the protection systems, either the existing system or the new levee around a community. Due to a lack of data and information, there is no accounting of the impact of induced flooding on currently unprotected areas.

Alternative plans were evaluated to varying levels of detail. With limited available data, funding and time, only about half of the plans formulated could be evaluated. For example, alternative plan C lies between plans B and D and was not specifically evaluated as the evaluation of plan C could be inferred from plans B and D. Plan I is buyout within the existing 1 percent chance annual floodplain. However data is not readily available identifying the floodplain and structures and other property within that floodplain so it was not evaluated. Plan J, buyout of the 0.2 percent chance annual (500-year) floodplain was accomplished by assuming that this floodplain was essentially bluff to bluff and then sampling a few levee districts for structures to obtain cost of the buyout. Plan K addressing critical infrastructure was considered by first estimating how much critical infrastructure lies within the protected levee areas, about one third of all critical infrastructure, meaning about two thirds is located in the unprotected floodplain, so no further was accomplished.

For some alternatives, representative test areas were evaluated to assess the overall applicability for system-wide application. Other alternatives were screened based upon hydraulic modeling results which showed little to no effect of the alternative. In some instances, alternatives were screened based upon the results of evaluations on similar, bounding alternatives which showed them to be unacceptable.

a Hydraulic Evaluation. The hydraulic analyses of alternative plans formulated utilize the existing numerical hydraulic (UNET) models developed for the Flow Frequency Study (FFS) along with a new, stochastically-generated, 1,000 years of tributary inflows. The hydraulic models were reassembled to begin and end at more hydraulically significant break points, the four study reaches, than the jurisdictional Corps District boundaries. Each model simulation, using the full 1,000 years of tributary inflow record produces a series of 1,000 annual peak stages at each model cross section location. These computed peak stages are used to form a non-analytical stage frequency curve at each location. Comparing the computed stage frequency from each alternative simulation with that of an existing condition simulation provides the stage impacts for each alternative. These stage impacts are then applied to the published frequency water surface elevations from the Flow Frequency Study to produce a final frequency water surface elevation to be used in computing economic flood damages and construction costs for each alternative.

b. Economic Evaluation

(1) General Methodology. This study area was evaluated using traditional expected value (damage and flood probability analysis). Risk and uncertainty analysis was not undertaken for this reconnaissance level of detail. Current stage frequency profiles were used to provide elevations for floods with varying probability. The river stage associated with the 0.2 percent chance annual (500-year) flood elevation) was recorded for each evaluation location.

Average annual damages (AAD) are defined as the monetary value of national economic development (NED) flood loss that can be expected in any given year based on the magnitude and probability of loss from all possible flood events. AAD is the calculated area under the Damage/Frequency curve (Figure3). This is estimated by the function:

$$AAD = \sum_{1}^{n} \left((P_{x-1} - P_x) * \left(\frac{D_{x-1} + D_x}{2} \right) \right)$$

where:

AAD	=	Average (Expected) Annual Damage
X	=	Flood event
P	=	Probability (%) of flood event
D	=	Flood event damage
n	=	Probability/Damage points

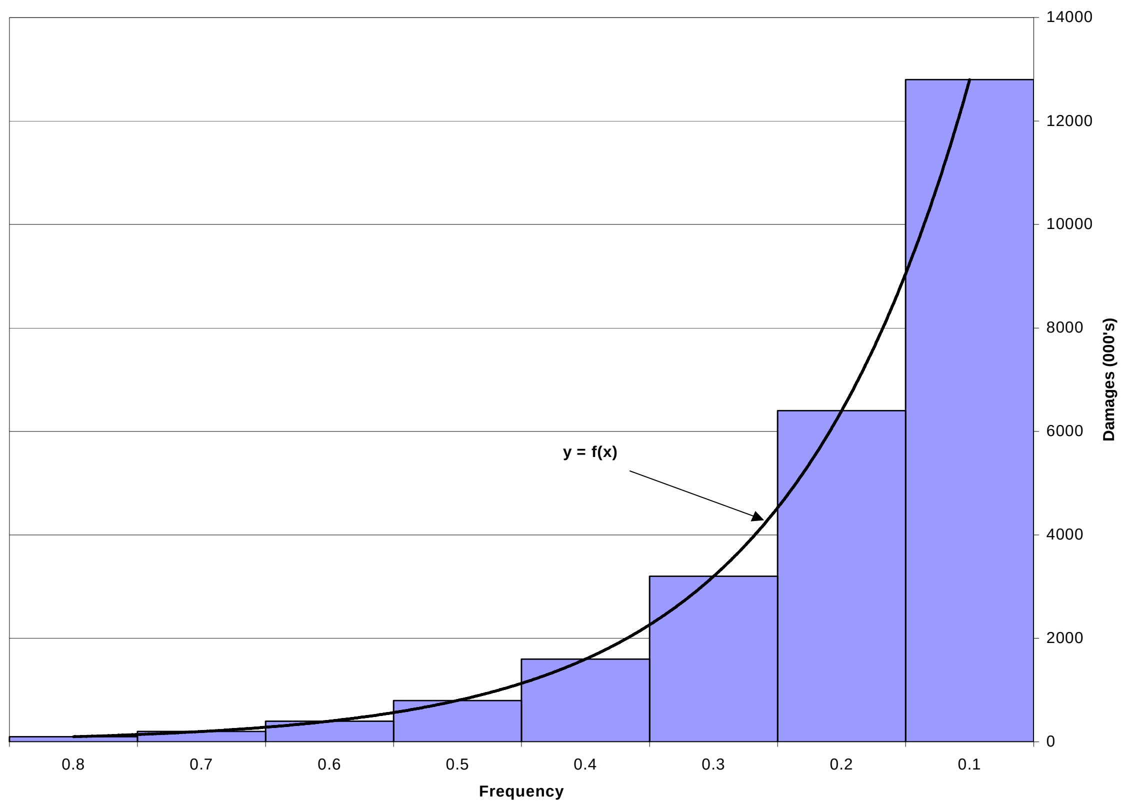

FIGURE 3. Sample Damage Curve

Average annual benefits (AAB) are defined as the difference in AAD between the without project (existing condition) and with project condition.

Construction costs detailed in this report are in 2005 price levels. Interest during construction (IDC) and annualized costs are computed using a 5-3/8 percent rate as mandated for (FY05) Federal water resource projects. IDC is an opportunity cost (alternate use of Federal funds) which is added to project costs. Annualized costs are computed identical to a loan amortization, over an analysis period, at the project interest rate. A three-year construction span and a 50-year period have been used for the IDC and annualizing calculation, respectively.

These water surface profiles were used evaluate both the without project and with project conditions. For the with project conditions, several different alternatives were analyzed.

Several assumptions were made to develop data to uniformly analyze each flood protection project. Again, because of the broadness of the study, the level of detail that each flood protection project was analyzed had to be simplified from a typical feasibility or reconnaissance study analysis. Therefore, each flood protection project would have a single midpoint elevation and a single or beginning damage elevation to simplify the analysis of the average annual damages for each flood protection project. Furthermore, a start of damages elevation was calculated for each flood protection project. This elevation is presented in terms of approximate flood frequency.

Flood damage information (i.e., structure and content values; depth-damage estimates) for existing projects in the study area was gathered from a variety of sources. Much information was provided by previously completed USACE project studies (Basin, Reconnaissance, Feasibility, etc) or available summaries from those studies. This type of data varies widely in age (i.e., anywhere from 30 to 50 years old) and in land use reporting (changes in usage may be unknown). The dollar denominated values for flood damage data has been adjusted to current price levels using Engineering News-Record (ENR) cost factors.

For cost estimation, civil engineering studies focused primarily on developing generic quantities associated with levee construction and levee modifications. Using a spreadsheet format, formulas were developed to compute quantities for the more significant levee quantities to include levee degradation, new levee materials, berm materials, additional levee right-of-way, acreage of seeding, acreage of clearing and stripping, crushed stone, asphalt cement concrete, and other needed items. Each Corps of Engineers District developed a spreadsheet for their respective levee and floodwall systems in order to calculate and document quantities.

In general, national economic development (NED) analysis assumes that all resources are fully employed. As a consequence, regional economic development (RED) effects can occur only when resources are transferred from one or more regions of the country to the project region. Therefore, RED effects should not be included in NED Benefit/Cost computations for project justification. Some reasons information provided by RED effects may have a bearing on project decision making are:

- RED effects are often of prime interest to local sponsors and can play an important role in securing their support for Corps water resources projects;
- RED effects can form the basis for allocating project cost sharing requirements;
- Presenting RED effects leads to more informed decision-making.

Using the NED rule only insures that a project will generate the largest possible economic pie. Applying NED describes benefits accrued on a national basis. RED describes changes in distribution of income and employment. Regional effects for Comprehensive Plan alternatives are presented in the Economics Appendix for each of the five Midwestern States bordering the Upper Mississippi and Illinois Rivers.

(2) Social Impacts. The following description summarizes potential social impacts of the various plans. Please refer to appendix C, *Economic Analysis*, for relative impacts point assignments matrix and discussion.

Noise: Any systemic noise impacts would be short-term and likely minor during construction. No appreciable long-term effects are anticipated.

Aesthetics: Alternative A would lead to moderate negative impacts, relative to existing conditions, since existing levees would be considerably higher to cover 500-year protection with associated rise in 500-year flood elevations. There may be minor adverse impacts to communities for structural alternatives, relative to existing conditions, as these would mostly occur with existing levees. The main exception is for Plan H where the impacts of some levee raises are off-set by benefit of more substantial levee removal (and greater aesthetic value). Note that aesthetic impacts could be greater on a site-specific basis, particularly with communities that do not have flood protection under existing conditions but would be afforded such protection under the proposed alternatives. Minor beneficial impacts for Plan I as removal of flood-prone properties could improve aesthetic value. Moderate beneficial for Plan J as removal of some levees may improves aesthetic views of the river. No impact for Plan K or L. These are focused on critical infrastructure which are usually more limited and wouldn't result in substantial to aesthetic value, relative to existing conditions.

Recreational Opportunities: No change for most alternatives, relative to existing conditions. There could be some recreation created through levee removal and/or creation of storage areas for Plan H and Plan J.

Public Health and Safety: Alternative A may have only minor beneficial effects because substantial rises in flood heights could be dangerous, even if levees and floodwalls are raised accordingly. The dangers of increased flood heights eliminate some of the benefits of increased protection. For other alternatives, it is assumed that moderate beneficial effects relative to existing conditions as the increases in flood heights would be considerably less than Alternative A.

Transportation: It is assumed that major benefits to transportation would accrue for Plans A, B and G as 500-year agricultural protection would protect roads and travel within leveed areas. A moderate benefit is assumed for Plans C, F and H as the impacts would be slightly less. There would be a minor benefit to transportation for Plan D. Under Plan K, transportation benefits would be major, as this targets critical transportation areas impacted by flooding. Plan L implementation would improve transportation around bridges, which becomes important during flood conditions. For all other plans, the effects are assumed to be negligible relative to existing conditions.

Community Cohesion: Minor community cohesion benefits would accrue for structural alternatives, relative to existing conditions, except for Plan H, where beneficial impacts would be likely offset by "negative" buyouts. It is likely that community cohesion would be negatively impacted under Plan I due to the potential for breaking apart or moving all or part of a community. Plans J, K and L would not greatly affect community cohesion.

Community Growth and Development: Plan A has substantial positive impacts for increased growth, relative to existing conditions. The new levee structures would not limit floodplain development with new 500-year protection. Some minor, positive impacts would occur for other structural alternatives, with existing levees being raised which could promote growth, but ring levees with no new development could negatively impact growth in these areas. Relative to existing conditions, this is likely only a minor beneficial impact. It is assumed that there would be negative impact from non-structural plans, as these plans would relocate properties out of the floodplain and/or discourage future growth within the floodplain. Neither critical infrastructure alternative would have an effect, relative to existing conditions.

Business and Home Relocation: The actions discussed here could have a range of impacts for home/business relocation. Improved levees under Alternatives A, B, C, D, and E would improve conditions to where business and homes would be less likely to be moved. Conversely, some negative impacts would be observed at Plans H, I and J as these would include levee and home buyouts.

Existing/Potential Land Use: Plan A and Plan G would provide the greatest opportunity for existing and future land use as these plans provide the greatest protection. Alternatives B, C and D provide for moderate beneficial impacts, though less than Alternative A. Alternatives C, D, E and F would provide only small additional opportunities for land use, relative to existing conditions. Plan H provides small improved changes for land use, but also negative impacts through levee buyouts. Alternatives I and J would include more extensive levee removal or removal of properties from the floodplain, a "negative" impact for existing and potential land use. Plan J would have the greater impact as it involves removal of agricultural levees and would affect the most acreage of land removed (or limited) from potential future agricultural use. However, Plans I and J would provide the greatest potential for restoration, and thus would see a different form of potential future value (a potential environmental benefit).

Controversy: Plan A would be extremely controversial for not only the project area but also downstream in the lower river area. Plans I and J would be controversial because of impacts to landowners. Most structural plans, i.e., Alternatives A, B, C, D, E, F, and G, would have varying levels of controversy due to cost, perceived economic benefits, changes in flood elevations and levee buyout actions. Plans K and L would not be as controversial, as fewer landowners would be impacted.

c. Hydraulic and Economic Evaluation Results. The following section provides summary outputs, by reach, of the alternative evaluation results. Detailed listing of modeling results and cost estimates can be found in appendices B, C, and D.

Alternative A. Confined - 0.2 percent chance annual (500-year) Urban and Agricultural Protection. Flood storage available from all the levee areas was eliminated from the river in the UNET model. The levees would be considered raised as high as needed to insure no overtopping. The hydraulic model could only recognize the non-leveed floodplain.

The water surface differences that this plan caused is shown in Appendix B, *Hydrology and Hydraulics,* Table B-10 at the main gages. The profile increases were dramatic for reaches 3 and 4. The maximum increase for Reach 3 on the Mississippi River is 2.7 feet for the 100-year flood between river miles (RMs) 86 and 101; 4.6 feet for the 200-year flood between RMs 91 and 93; and 7.9 feet for the 0.2 percent chance annual (500-year) flood between RMs 89 and 93. The maximum increase on the Illinois River in Reach 4 is 1.33 feet between RMs 48 and 49; 1.97 feet between RMs 49 and 54; and 3.11 feet between RMs 43 and 56. The stage increases below the Meredosia Gage on the Illinois River is partially due to the backwater effects from the Mississippi River. The plan produced no measurable increases in water surface elevations within reaches 1 and 2.

For each leveed area, the flood damage reduction benefits were computed, , as the net reduction in average annual damages. Construction and real estate costs, by leveed area, were computed and annualized for comparison to benefits. The annualized benefits and costs, by reach, are summarized in

Table 12. A complete tabulation of benefits and costs, by leveed area, are presented in Appendix D, *Engineering and Cost Estimates.*

Table 12. Evaluation of Plan A - 500-yr Urban, 500-yr Ag

Reach	Annualized Benefits ($)	Annualized Costs ($)	Benefit-to-cost Ratio
1	3,564,000	41,836,000	0.09
2	1,826,000	24,981,000	0.07
3	10,394,000	389,694,000	0.03
4	3,385,000	115,027,000	0.03
Total	**19,169,000**	**571,538,000**	**0.03**

Construction First Cost $8.74 million

The BCR for this alternative is significantly below 1.0. The remaining, residual damages associated with this alternative are shown in Appendix C, *Economic Analysis.*

Alternatives B, C, D, and E. 0.2 percent chance annual (500-year) Urban and Variable Agricultural Protection. For each of these alternatives, hydraulic modeling was used to identify which agricultural districts could be included in the alternative to meet the design criteria of allowing up to 1.0 foot of rise in the hydraulic profile, and minimal rise at the lower end of the study area. Only agricultural districts in Reach 4 had to be removed from the alternative to meet the criteria. In addition, two designated storage areas were added to help meet the criteria of no significant impact to the Lower Mississippi River. These storage areas would be preserved for use as storage during peak flood periods to reduce stages.

Alternative C was not evaluated. Due to limited budget and time and the fact that C is bounded by Alternative Plans B and D and the costs and benefits for C could be inferred, it was deemed more important to put effort on other plans.

Similar to Alternative A, the flood damage reduction benefits were computed, for each individual leveed area, as the net reduction in average annual damages. Construction and real estate costs, by leveed area, were computed for each alternative and annualized for comparison to benefits. The annualized benefits and costs, by reach, are summarized in Table 13. A complete tabulation of benefits and costs, by leveed area, are presented in Appendix D, *Engineering and Cost Estimates*.

Table 13. Evaluation of Plans B, D and E

Alternative Plan	Protection Level	Reach	Annualized Benefits ($)	Annualized Costs ($)	Benefit-to-cost Ratio
B Construction First Cost $5,006,758,000	500-yr Urban 500-yr Ag	1	3,564,000	42,174,000	0.09
		2	1,836,000	29,270,000	0.06
		3	4,785,000	146,012,000	0.03
		4	3,276,000	109,781,000	0.03
		Total	**13,461,000**	**327,237,000**	**0.04**
C		[1]	[1]	[1]	[1]

	500-yr Urban 200-yr Ag				
D Construction First Cost $3,758,685,000	500-yr Urban 100-yr Ag	1	3,562,000	41,798,000	0.09
		2	1,700,000	20,904,000	0.08
		3	4,936,000	115,589,000	0.06
		4	2,091,000	67,373,000	0.03
		Total	**12,289,000**	**245,664,000**	**0.05**
E Construction First Cost $2,905,510,000	500-yr Urban 50-yr Ag	1	3,532,000	41,716,000	0.08
		2	1,601,000	16,045,000	0.10
		3	4,233,000	65,655,000	0.06
		4	1,888,000	66,484,000	0.03
		Total	**11,254,000**	**189,900,000**	**0.06**

[1] Based upon the preliminary results from Alternatives B, D, and E; detailed benefit and cost analysis of this alternative was not pursued.

As shown above, alternatives B, C, D, and E have BCRs significantly below unity. The remaining, residual damages associated with these alternatives are shown in Appendix C, *Economic Analysis.*

Alternative F. 0.2 percent chance annual (500-year) Urban and Highway Approach Protection. The analysis and evaluation of Alternative F was not accomplished. The evaluation would require a very detailed, site specific analysis beyond the resource availability of the current Comprehensive Plan. To determine a construction cost estimate, each bridge approach would have to be analyzed to determine the impacts of the approach raise and then the determination of the flow openings required to mitigate this induced rise, a very time and effort intense analysis for each site. In a similar site specific analysis, an estimate to provide local protection for each community within the agricultural levee districts would be required. Major construction costs would include levee cost, interior drainage and providing emergency access.

Alternative G. 0.2 percent chance annual (500-year) Urban and Agricultural Protection w/ no Minimization of Impacts to Lower Mississippi River Valley. Alternative G is a modification of Alternative B. Modifications were made the districts downstream of St. Louis in an attempt to maximize the area protected while continuing the first criteria of a maximum induced rise of no greater than one foot. Levee setbacks, levee degradations, and bridge modifications were all tested in developing this alternative.

As previously stated, only agricultural districts within Reach 4 were eliminated from Alternative B due to impacts to the Lower Mississippi River. Removing this criteria may allow additional leveed areas to be included. First, the Jefferson Barracks Bridge, carrying I-255 across the Mississippi River, was modified to have a larger flow area in the overbank on the Illinois side. Removing a portion of the embankment and raising it as a roadway on piers achieved this. The Columbia District was left at its existing elevations. The levee protecting a 10,000-acre segment at the northern end of the Harrisonville District was degraded to the 10 percent chance annual (10-year) flood elevation. The remainder of the Harrisonville District was raised to the 0.2 percent chance annual (500-year) level of protection. Additionally, Kaskaskia Island, Bois Brule, and Prairie Du Rocher districts were all raised to the 0.2 percent chance annual (500-year) level of protection.

The total construction cost would be about $5.9 billion.

Alternative H. 0.2 percent chance annual (500-year) Urban and Agricultural Protection w/ Selective Buyouts. The Alternative H is an outgrowth of alternatives A, B, C, D, and E, all of which display a very low BCR. Examination of results of the five alternatives indicated that Alternative H—buying marginal districts—may be more cost effective than providing a high level of protection. In addition, if buying districts was actually implemented, ecosystem restoration benefit opportunities would be bountiful in the districts purchased.

It should be noted that this analysis of Alternative H, which is presented in more detail in Appendix C, *Economic Analysis,* does not return a BCR of greater then 1.0; it does not have positive net national economic benefits.

An example of how Alternative H may impact a plan with a high level of protection is shown in Table 14. Assuming that a real estate cost of $6,000 per acre which includes the land cost and all assistance and associated costs and fees, for approximately one half of the levee districts it may be more cost effective to purchase rather than protect to the 0.2 percent flood event level (500-year).

Table 14. Evaluation of Plan H -Comparison of Cost of Protection/Acre vs. Buyout/Acre
(Using $6,000/acre cost to buy, including all fees)

Reach	Cost Effective	More Cost Effective to Purchase	Not Cost Effective	Even	Not Applicable
1	0	5	1	0	30
2	0	3	13	0	7
3	9	9	16	1	46
4	6	18	11	3	8
Total	**15**	**35**	**41**	**4**	**91**

It should be noted that this plan as initially formulated assumed that existing levees would remain in place. However, a detailed design analysis would be required to determine the best course of action if this plan were to be implemented. A comparison of benefits, both positive and adverse, and other impacts would have to be performed to determine whether to use all or some of the leveed areas for flood storage, and what level of protection is desirable, if any, for ecosystem restoration purposes, for instance. The timing of the flood event, which is uncontrollable, could have a significant impact on this analysis.

Alternative I. Relocation of Urban Resources Outside of the 100-Year Floodplain. The analysis and evaluation of Alternative I was not accomplished, as insufficient data exist. The data needed to evaluate this plan is the identification of the floodplain and an inventory of structures in the 1 percent chance (100-year) floodplain. In many rural areas, the floodplain has not mapped and available in a readily useable format and an inventory of structures is not available.

Alternative J. Floodplain Management. Alternative Plan J, buyout of the floodplain, bluff to bluff, is evaluated below. It is assumed the existing levees would be partially degraded to allow the river to recapture, reuse the floodplain. If this plan were implemented the existing water surface profile would be modified. To give a sense to this change in water surface profile, two resulting alternative land use types for the Overbank area were analyzed. The area to continue to be farmed, agricultural use, or be allowed to revert to natural conditions, most often forest or prairie. The following results of this analysis were obtained.

Table 15 displays the changes to water surface elevations for each Reach for the maximum, average and minimum change for the Reach. The two alternatives are *agricultural growth* and *natural growth*. The values represent the changes in water surface profile and discharges for the 1 percent chance annual (100-year) flood, the 0.5 percent chance annual (200-year) flood and 0.2 percent chance annual (500-year) flood event. Reach 1 was not studied for this plan because the levees are all urban levees in the system.

To capture this uncertainty, a bound of floodplain developments was created in this plan. The lower bound would be that the floodplain would turn totally into an agricultural regime. The upper bound would be that the floodplain would revert back to natural ecological succession in the floodplain.

Table 15. Plan J, Water Surface Change - Maximum, Average & Minimum Water Surface Change

100-Year	**Agricultural Growth**			**Natural Growth**		
Reach	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**
2	0.10	-1.50	-6.10	0.00	-1.10	-4.10
3	1.30	-4.40	-8.30	0.10	-2.70	-5.30
4	0.13	-2.83	-5.93	0.07	-2.18	-4.73

200-Year	**Agricultural Growth**			**Natural Growth**		
Reach	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**
2	0.10	-1.70	-6.40	0.00	-1.10	-4.40
3	2.60	-4.10	-8.10	0.90	-2.10	-5.10
4	0.17	-2.88	-6.09	0.08	-2.18	-4.77

500-Year	**Agricultural Growth**			**Natural Growth**		
Reach	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**
2	0.10	-1.70	-6.80	0.00	-1.20	-4.40
3	4.80	-3.10	-8.40	2.30	-0.50	-5.00
4	0.22	-2.74	-6.32	0.12	-2.01	-4.58

The Upper Mississippi River and Illinois Waterway currently have many flood damage reduction projects which provide high levels of protection to urban and agricultural areas. These projects were planned and constructed incrementally rather than systemically. Based upon annual estimates of damages prevented by federally-constructed projects, the majority of flood conditions (and flood damages) are protected against. From the perspective of average annual damages (flood frequency versus flood damage for the range of possible floods), greater than 99 percent of expected annual damage has been reduced by existing projects on the Mississippi River. Greater than 97 percent of expected annual damage has been reduced on the Illinois Waterway. Therefore, this study is pursuing alternatives which would reduce the remaining (less than) 1 percent of expected annual damages for the Mississippi River areas and the remaining (less than) 3 percent of annual damages for the Illinois Waterway areas. These are the residual annual damages of the existing “system” of flood control projects.

The cost estimate for Alternative J includes the land purchase cost, the buyout cost for small communities and other structures such as farmsteads located in agricultural areas and the cost to either degrade or open the existing levees to eliminate the existing flood protection. Another major cost classified as relocations is not included in the Plan J cost estimate. Relocations could include the cost to relocate transportation systems and other vital systems such a water and wastewater treatment facilities.

The total cost of Plan J would be about $3.2 billion.

Alternative K. Protection of Regional Critical Infrastructure. Using GIS with critical infrastructure point data combined with the water surface profiles and levee districts, it was determined that almost 65 percent of critical infrastructure located in the Mississippi and Illinois River floodplain is located in unprotected areas.

No further analysis was accomplished due to the following factors:

- the critical infrastructure is largely located outside of existing lines of protection
- the infrastructure is not concentrated in locations to provide additional protection
- the additional footprint needed to increase the line of protection would cover the infrastructure

The exception is transportation, specifically bridge crossings. Evaluating bridge crossing is the purpose of Alternative L

Alternative L. Protection of Critical Bridge Approaches. During the 1993 flood, approach roads leading to several Mississippi River bridges were flooded, impassable, and out of use for up to 90 days. These impacted approach roads generally run through floodplain levee districts. As the analysis below indicates, significant detour impacts ensue from the loss of use of these approach roads. Cross-river traffic and within-reach traffic are at risk. There is extensive personal, commercial, and public vehicle traffic directly affected by closure of these bridges.

Without reliable protection, it is assumed that the approach roads would be flooded (based on approach road low elevations) and traffic impeded with the same frequency as that with which structural flood damages would occur. Existing levee failure would force motorists to use detour routes, incurring additional costs for vehicle operation and opportunity cost of time.

Considering the potential benefits based upon traffic volume for the system, while the benefits can be significant, raising/protecting all the bridge approaches for the system is not feasible.

Benefits for protection of one bridge approach—the Quincy Bridge, which crosses the Fabius Drainage and Levee District north of St. Louis on the Mississippi River—are significant. This site-specific, not systemic analysis, results in the possibility of a feasible project for this one bridge location. Multiple bridge approach protection projects in the area would increase the project costs significantly while increasing the overall benefits only slightly in total and spreading the benefits over a number of projects, making all potential projects not justified.

Tables C-12 and C-13 in Appendix C, *Economic Analysis*, relate the stage/frequency/costs relationships for the Quincy Bridge detour cost impacts and the cost of protecting the bridge approach. More reliable protection for the Quincy bridge would also result in detour cost savings to the traffic from bridge outages at Keokuk, Hannibal and Louisiana, IA. Greater protection of the bridge approach through the Fabius Drainage and Levee District by means of levee improvements is far less costly (approximately one-fourth the cost) than a lengthy road raise project). This project appears to warrant further study (positive BCR indicated in Table C-13, *Economic Analysis* Appendix) as a non-systemic project, given the beneficial effects of the potential regional detour cost savings which would accrue.

Discussion. During the 1993 flood even, several Mississippi River bridges were unusable due to flooded approach roads. These closures impeded regional transportation and created detours up to approximately 200 miles. Generally, bridge closures were required where access roads were inundated by floodwaters overtopping agricultural levees. Table C-10 of Appendix C, *Economic Analysis*, lists the bridges most susceptible to closure due to rare flood events. Depending upon bridge location and traffic patterns, protection of specific bridges can reduce detour costs region-wide (i.e., Quincy, IL bridge with Fabius Drainage and Levee District access road. See Appendix C, *Economic Analysis*). This plan is, therefore, systemic in addressing the reduction of detour costs throughout the study area. (Although all bridges on the Illinois Waterway and Mississippi River were considered, only protection of the Quincy bridge may exhibit Federal interest).

d. Environmental Evaluation

(1) General Methodology. Alternative plans were evaluated from an ecosystem and environmental opportunities aspect in five major categories. The five categories—mitigation, secondary development, ecosystem restoration, nutrients and sediments—were evaluated in terms of acres. The evaluation approach is discussed in sections *a* through *e*, with the detailed evaluation analysis and results presented in Appendix A, *Environmental Planning and Analysis*.

(a) Mitigation. Early in the planning process, a decision was made to defer the development of a full-fledged Incremental Cost Analysis (ICA) until future site-specific feasibility studies have been performed. Accordingly, at this conceptual level of planning, the variability with respect to mitigation is primarily that inherent in the overall impact differences associated with the various alternative plans.

To obtain a gross indication of the magnitude of habitat mitigation required under each systemic alternative, the environmental team determined the net change in levee/floodwall footprint and affected habitat acres for each plan using engineering design data and GIS. The total impacted acreage of open water, non-forested, and forested habitat for each plan was then multiplied against a generic mitigation cost per restored floodplain acre.

(b) Secondary Development. By far, the most significant potential impact of the flood damage reduction systemic plans relates to induced secondary development. This is especially true in areas with minimal existing flood protection. Adverse effects of increased development include: water pollution from storm runoff, increased urban flooding from increased permeable surfaces, increased damages from floods overtopping levees, and a demand for even more structural measures. In recognition of this problem, Executive Order 11988 discourages Federal actions that act as an inducement to future floodplain development unless there is no reasonable alternative. While the Corps does not require compensatory mitigation for unavoidable secondary development effects, the minimization of such effects is an important planning priority.

The approach to the assessment of secondary development was to document the amount of alternative plan lands that would be at or above a 100-year level of protection with a project plan in place (i.e. likely to be within the regulated floodplain) and available for potential development. In addition (as supplemental information), Environmental Chapter 5 looks at the proximity of those lands relative to two potential specific development catalysts—existing river highway bridge crossings and existing major urban areas.

(c) Ecosystem Restoration Opportunities. Similar to the mitigation discussion, the environmental team determined that the use of an incremental cost analysis (ICA) was inappropriate for a general assessment of habitat restoration opportunities. As an alternative approach, ecosystem opportunities were identified for each management option and alternative plan in terms of potential ecosystem restoration management acres, percent ecosystem restoration sustainability achieved, and ecosystem restoration related construction costs.

The identification of potential ecosystem restoration locations for the various alternative plans and options were based on an affirmative response to a mix of questions relating to:

- whether a given Drainage and Levee District site (with a flood damage reduction project in place) would have less or more than a 100-year level of protection;
- whether or not the site requires flowage easement;
- whether or not the site has a significant degree of existing urbanization; and
- whether or not the riverside levee would be raised in elevation.

Next, the drainage and levee district ecosystem restoration location acres were totaled for each alternative plan and option. These acreages were than multiplied against an estimate of the percentage of those acres that might be manageable under each option to give a rough estimate of the total potential ecosystem restoration managed acres. Finally, these managed acres were then multiplied against a dollar cost per restored acre value derived from data developed in the navigation study.

The environmental team did not make an estimate of operations and maintenance (O&M) costs. While such an O&M determination is required for reach-specific feasibility analyses, it was felt that insufficient information exists for a meaningful quantification at the programmatic level. In addition, it was recognized that the annual O&M costs for an ecosystem restoration project is typically minor when compared to the annualized construction costs. For example, the estimated annual O&M costs for the Swan Lake Environmental Management Program Project were less than 10 percent of the annualized construction costs for that project.

(d) Nutrients Reduction. The Wetlands Initiative estimated that 38 percent of the lands within the 1percent chance annual (100-year) flood zone represent existing or drained wetlands. The nutrients analysis multiplied that percentage by the number of acres of potential ecosystem restoration managed lands (within levees) under each alternative plan to approximate the potential number of acres of wetland nutrients reduction opportunities.

(e) Sediments Reduction. The method used in this analysis was to determine the number of tributary feeders entering each of the floodplain Drainage and Levee Districts identified as Ecosystem Restoration opportunities for each alternative plan in subsection c. above. These values provide an indicator for the magnitude for sediments reduction opportunities available for addressing the sedimentation problem.

Resource-specific impact quantifications were performed for each of the five evaluation categories. Table 16 shows the relationship between each study plan and the impact factors evaluated. In all cases, the stated impacts assumed fully implemented alternative plans independent of economic considerations.

Table 16. Plans Quantified for Specific Types of Environmental Impact

Plan	Mitigation	Secondary Development	Ecosystem Restoration Opportunities	Nutrients Reduction	Sediments Reduction
No Action	Y	Y	Y	Y	Y
A	N	N	N	N	N
B	Y	Y	Y	Y	Y
C	N	N	N	N	N
D	Y	Y	Y	Y	Y
E	Y	Y	Y	Y	Y
F	Y	N	N	N	N
G	N	N	N	N	N
H	Y	Y	Y	Y	Y
I	N	Y	Y	Y	N
J	N	Y	Y	Y	Y
K	N	N	N	N	N
L	N	N	N	N	N

(2) Plans Quantified for Environmental Impacts. Plans B, D, E, H, I, and J were quantified for environmental impacts. The Comprehensive Plan alternative plans summary of evaluation (Table 17), displays the environmental impact findings at the systemic level. For a discussion and display of the results of the analysis by river reach, see Appendix A, *Environmental Planning and Analysis*.

As would be expected, the acreages and costs for mitigation fell out proportional to the amount of structural features implemented. Systemically, the mitigation acres and costs from highest to lowest were as noted in Table 17:

Plan B (2,721 acres at $15.2 million)
Plan D (1,755 acres at $9.8 million)
Plan E (1,345 acres at $7.5 million)
Plan H (1,240 acres at $6.9 million
Plans I and J (no mitigation acres or costs)

As would be expected, the potential for secondary development in the floodplain increases as the amount of structural flood protection increases. Systemically, the plans can be ranked from lowest to highest potential for secondary development as follows:

Plan J (-334,328 acres)
Plan I (-8,776 acres)
Plan D (1,048 acres)
No Action Plan (0 acres)
Plan E (4,987 acres)

Plan H (+215,775 acres)
Plan B (320,037 acres)

It should be noted that the Plan D effects could be more severe than the development acreages suggest. Plan D raises levees to an elevation, close to, but just shy of the regulated 100-year floodplain. This condition could encourage development with neither insurance nor building elevations being required, even as the possibility of a catastrophic flood increases.

Obviously, plans yielding a higher number of potentially manageable acres for ecosystem restoration would be preferred from an environmental standpoint. The plans with the highest number of management acres also tended to carry a higher ecosystem restoration measures implementation cost. Systemically, the plans ranked from highest to lowest potential for environmental opportunities, were as follows:

Plan J (807,943 potential acres at a cost of $261 million)
Plans B and H (175,002 acres at $455 million)
Plan E (133,889 acres at $348 million)
Plan D (131,995 acres at $672 million)
Plan I (9,791 acres)
No Action Plan (no acres or costs)

Since the nutrients reduction opportunities were calculated as a fixed proportion of the ER management acres—the relative ranking of the various plans was nearly the same. The plans are ranked from highest to lowest potential for nutrients reduction opportunities as follows:

Plan J (307,018 wetland acres)
Plans B and H (66,501 acres)
Plan D (50,158 acres)
Plan E (50,612 acres)
Plan I (3,721 acres)
No Action Plan (0 acres).

The plans ranked from highest to lowest potential for sediments reduction opportunities (as reflected by the number of tributary feeders present) were as follows:

Plan J (286 tributary feeders)
Plan D (206 feeders)
Plan H (141 feeders)
Plan E 135 feeders)
Plan B (124 feeders)

Of the plans quantified, Plan J performed the best from an environmental opportunities perspective. This plan required the least amount of mitigation, had the least potential for secondary development, had the highest potential for ecosystem restoration manageable acres, the highest potential for wetlands development, and the highest potential for applying sediment reduction features.

(3) Plans Not Quantified for Environmental Impacts. For various reasons, Plans A, C, F, G, K and L were not directly quantified for environmental impacts. However, to an extent, the potential magnitude of impacts from these plans can be deduced.

Plan A (Confined, 0.2 percent chance annual (500-year) protection), the most structural of the flood damage reduction plans, would likely have adverse environmental effects surpassing those of Plan B (Unconfined, 0.2 percent chance annual (500-year) protection). It would thus be the least desirable plan from an environmental standpoint.

Plan C (with 200-year agricultural protection) would likely be intermediate in its environmental effects between Plans B (including 0.2 percent chance annual (500-year) agricultural protection) and Plan D (including 100-year agricultural protection), but closer to Plan D effects than Plan B effects.

Plan F with no additional agricultural protection and its urban containment approach is judged to have environmental effects very similar to the No Action Plan (with no net effects).

Plan G would have effects similar to Plan B, but slightly more adverse due to its higher allowable flood stage rise and reduced requirements for real estate acquisitions.

Plans K and L, from a systemic perspective, would entail only minor changes in the environment, with effects not vastly different from those of the No Action Plan.

Table 17 presents a summary of the evaluation of the alternative plans.

Table 17. Summary Evaluation of Alternative Plans

Plan	No Action	Plan A	Plan B	Plan C	Plan D	Plan E	Plan F
Plan Description		Confined 500-yr	500-yr	200-yr Ag levee protection	~100-yr Ag levee protection	50-yr min Ag levee protection	Local protection for towns & bridge approaches @ 500-yr
ALTERNATIVE EVALUATION BY ACCOUNT							
NED		Yes	Yes	Yes	Yes	Yes	
H&H		Yes	Yes	Yes	Yes	Yes	
Econ (Ann Ben)		$19,169,000	$13,461,000	Yes	$12,289,000	$11,254,000	
Cost (1st cost)		$8,744,582,000	$5,006,758,000		$3,758,685,000	$2,905,510,000	
Annualized Cost		$571,538,000	$327,237,000		$245,664,000	$189,900,000	
BCR		0.03	0.04		0.05	0.06	
EQ							
Mitigation (Acres)			2,721		1,755	1,345	
Mitigation ($)			$15,200,000		$9,800,000	$7,500,000	
Secondary Devel (Potential New Acres)			320,037		1,048	4,987	
ER Opportunities (Potential ER Managed Ac)			175,002		131,995	133,889	
ER Opportunities (% Sustainability Achieved)			5700%		4300%	4300%	
ER Opportunities (First Costs, $)			$455,000,000		$672,000,000	$348,000,000	
Nutrients (Potential Wetlands Acres)			66,501		50,158	50,612	
Sediments (Potential # Tributary Feeders)			124		206	135	
RED		$30,381,000,000	$27,091,000,000		$22,029,000,000		
OSE							

Plan	Plan G	Plan H	Plan I	Plan J	Plan K	Plan L
Plan Description	Allow up to 1' rise at Thebes, 500-yr Ag	500-year cost effective buyout	Buyout development in 100-yr floodplain	No development in 500-yr floodplain, buyout development in Ag areas, remove Ag levees	500-yr for Ag with regional critical infrastructure	Local protection for bridge approaches @ 500-yr
<u>ALTERNATIVE EVALUATION BY ACCOUNT</u>						
NED	Yes	Yes		Yes		
H&H	Yes	Yes	No	Yes		
Econ (Ann Ben)		Yes	Not systemic	**In-progress**		Yes
Cost (1st cost)	$5,950,389,000			$3,187,480,000		
Annualized Cost	$381,949,305		Not systemic			
BCR	**In-progress**		Not systemic	**In-progress**		
EQ						
Mitigation (Acres)		1,240	No	No		
Mitigation ($)		$6,900,000	No	No		
Secondary Devel (Potential New Acres)		215,775	-8,776	-334,328		
ER Opportunities (Potential ER Managed Ac)		175,002	9,791	807,943		
ER Opportunities (% Sustainability Achieved)		5700%	300%	26100%		
ER Opportunities (First Costs, $)		$455,000,000	$25,000,000	$261,000,000		
Nutrients (Potential Wetlands Acres)		66,501	3,721	307,018		
Sediments (Potential # Tributary Feeders)		141	No	286		
RED						
OSE						

5. Other Flood Damage Reduction Concepts Evaluated

a. Emergency Action Plan (EAP) / Emergency Action Scenarios (EAS). Members of the Collaboration Team expressed their desire for an evaluation of an Emergency Action Plan (EAP), on the Upper Mississippi River System, to be included as part of the Upper Mississippi River Comprehensive Plan. In position paper dated May 14, 2003, the Upper Mississippi River Basin Association (UMRBA) expresses their opinions concerning the development of an Emergency Action Plan. In their position paper, they state:

"In particular, the UMRCP plan formulation process should develop and evaluate at least one alternative that reflects a system wide operational strategy for conveying floodwaters during major flood events. Such an alternative would presumably include such actions as strategic controlled levee overtopping, temporary levee raises, and minor structural modifications to accommodate the operational strategy. It would also include interstate and interagency agreements regarding flood fighting, which would address questions associated with when and where flood fighting should be focused."

In response to this request, the inclusion of an Emergency Action Plan as one of the alternatives to be evaluated in the Comprehensive Plan was considered. The initial discussions of this alternative are documented in the team meeting minutes of Sep 2003, which describes the proposed Emergency Action Plan as:

> *"Emergency Action Plan. The purpose of this plan is to evaluate whether there is a more effective flood-fighting alternative that maximizes NED considerations while minimizing impacts to profiles. All urban and agricultural levee systems… with maximum emergency flood-fighting levee raises assumed to be 3 feet."*

The evaluation of a series of Emergency Action Scenarios (EAS) was conducted to develop a better understanding of the hydraulic and economic impacts of emergency actions such as flood fighting. Last, a proposed methodology for development of an Emergency Action Plan is discussed below.

(1) Emergency Action Scenarios.
Description. An important first step in development of an Emergency Action Plan was to develop a better understanding of the hydraulic and economic impacts of emergency operations, flood fighting, on the Upper Mississippi River System. A series of four Emergency Action Scenarios were conducted to represent successively higher levels of systemic flood fighting. The primary hydraulic impacts of concern are potential increases in the computed frequency stages (i.e., 100-yr and 0.2 percent chance annual (0.2 percent chance annual (500-year)) flood levels) resulting from temporary increases in levee heights during a flood. The primary economic concern is the reduction in flood damages resulting from the flood fighting (presented here as the "average annual benefits" of flood fighting; which are computed as the reduction in "annual average damages").

The Emergency Action Scenarios represent systemic flood fighting efforts (simulated as increases to levee crest elevations) conducted during a flood event. Each successive scenario offers a higher level of emergency protection to the modeled levee districts. Discussions among the Comprehensive Plan technical workgroup members established that, based on knowledge of previous emergency operations, the maximum raise of a levee that can be achieved system-wide, on a safe and consistent basis, is 3 feet. Some communities do have the capability to increase their level of protection by more than 3 feet if given sufficient forewarning of impending high water. However, because of the system-wide nature of the study, all analyses were limited to a raise of 3 feet. The 3-foot rise represents all emergency actions, including sandbagging, flash boarding, pushing material on top of a levee and all other temporary measures used to raise an existing level of protection.

Levees were divided into three categories for the Emergency Action Scenarios: Urban/Industrial, Agricultural and Conservation. The Urban/Industrial levees received emergency response in each of the Emergency Action Scenarios while the Agricultural levees receive increasing levels of protection in each of the successive scenarios. The Conservation levees are not raised in any of the Emergency Action Scenarios. These levees are commonly used for wildlife refuges or other conservation purposes and, by design, are typically not raised during flood events. For the purposes of the Emergency Action Scenarios, Federal, non-Federal, and private levees were treated equally. Areas currently unprotected were not included in the scenarios. Finally, all levee raises were uniform within each of the three levee categories.

The four Emergency Action Scenarios established by the Comprehensive Plan were:

EAS1 - Raise only the Urban and Industrial levees by 2 feet. Agricultural levees and Conservation levees are left at existing elevations.

EAS2 - Raise Urban and Industrial levees by 2 feet. Raise Agricultural levees by 1 foot. Conservation levees left at existing elevations.

EAS3 - Raise Urban, Industrial and Agricultural levees by 2 feet. Conservation levees left at existing elevations.

EAS4 - Raise Urban, Industrial and Agricultural levees by 3 feet. Conservation levees left at existing elevations.

Discussion. The results of each Emergency Action Scenarios are summarized below for the four river reaches used in this study. The maximum computed stage increases for the 0.01 (100-yr) and 0.002 exceedence probability (0.2 percent chance annual (0.2 percent chance annual (500-year) events are shown in the Table 18. The information in the table shows that:

- there is no induced rise in frequency stage in Reaches 1 and 2 for any of the scenarios. This implies that induced damages are not a concern when determining emergency response priorities within these reaches.
- there is no induced rise in frequency stage anywhere along the length of the Mississippi River or Illinois River (Reaches 1-4) caused by increasing the level of protection of only urban and industrial areas.
- induced damages could be a concern for systemic agricultural levee raises in Reaches 3 and 4.

Table 18. Evaluation of Emergency Action Scenarios – Induced Rise (measured in feet)

Maximum Induced Stage Frequency Increase at 1% Chance Annual Event

Reach	EAS1 Max. Rise	EAS2 Max. Rise	EAS3 Max. Rise	EAS4 Max. Rise
1	0	0	0	0
2	0	0	0	0
3	0	0.4	0.7	1.1
4	0	0.3	0.6	0.8

Maximum Induced Stage Frequency Increase at 0.2% Chance Annual Event

Reach	EAS1 Max. Rise	EAS2 Max. Rise	EAS3 Max. Rise	EAS4 Max. Rise
1	0	0	0	0
2	0	0	0	0.1
3	0	1.1	1.9	2.9
4	0.1	0.6	1.3	1.8

The benefit in emergency operations is in preventing damages. Table 19 presents the remaining annual average damages for each Emergency Action Scenarios, along with the existing condition damages, and the resulting benefits of flood fighting for each reach. The residual damages do not include induced damages, or the cost of the emergency response. The economic analysis for all Emergency Action Scenarios assumes that damages begin at the top of the flood fighting protection, unlike the existing condition, where the economic damages are assumed to begin at half the freeboard range.

Table 19. Evaluation of Emergency Action Scenarios – Average Annual Damages

Average Annual Damages and Benefits for Alternative EAS1 (000's)

Reach	Existing Damages (AAD)	EAS1 Residual Damages (AAD)	EAS1 Benefits (AAB)
1	$3,629	$1,866	$1,763
2	$630	$187	$443
3	$9,210	$9,070	$140
4	$2,718	$2,220	$498
Total	$16,187	$13,343	$2,844

Average Annual Damages and Benefits for Alternative EAS2 (000's)

Reach	Existing Damages (AAD)	EAS2 Residual Damages (AAD)	EAS2 Benefits (AAB)
1	$3,629	$,1834	$1,795
2	$630	$33	$597
3	$9,210	$3,826	$5,384
4	$2,718	$1,115	$1,603
Total	$16,187	$6,808	$9,379

Average Annual Damages and Benefits for Alternative EAS3 (000's)

Reach	Existing Damages (AAD)	EAS3 Residual Damages (AAD)	EAS3 Benefits (AAB)
1	$3,629	$1,833	$1,796
2	$630	$22	$608
3	$9,210	$2,933	$6,277
4	$2,718	$902	$1,816
Total	$16,187	$5,690	$10,497

Average Annual Damages and Benefits for Alternative EAS4 (000's)

Reach	Existing Damages (AAD)	EAS4 Residual Damages (AAD)	EAS4 Benefits (AAB)
1	$3,629	$1,285	$2,344
2	$630	$3	$627
3	$9,210	$2,023	$7,187
4	$2,718	$748	$1,70
Total	$16,187	$4,059	$12,128

(2) Methodology for an Emergency Action Plan. The following methodology may serve as a first step in the development of an overall scheme to minimize flood damages during emergency conditions.

In developing an Emergency Action Plan for the Upper Mississippi River System, it is important to recognize that there is a logical order of what would be protected first, and to the greatest degree. This ordering favors areas with the highest value property and/or critical services (infrastructure). Ultimately an Emergency Action Plan should reflect this logic. One expression of this ordering might be (from highest to lowest):

- Urban Areas and Critical Infrastructure
- High Damage Agricultural Areas
- Low Damage Agricultural Areas
- Currently Unprotected Low-lying Areas

From the Emergency Action Scenarios that have been analyzed a better understanding has been developed as to where in the system flood fighting efforts result in hydraulic impacts that affect the level of protection of adjacent areas. Therefore, flood fighting could be restricted in those reaches where it creates negative impacts to higher priority areas. Additionally, where there are opportunities, storage areas immediately upstream of major urban areas should be identified for potential use as a "safety valve" to provide storage during major flood events (such as the areas identified immediately upstream of St. Louis in conjunction with Alternative B).

Four reasonable scenarios for Emergency Action Plan could be constructed as:

(1) flood fight to 3 feet in all urban areas;

(2) flood fight to 3 feet in agricultural areas with significant critical infrastructure or unusually high damage potential;

(3) in reaches where flood fighting along the remaining agricultural levees does not have a significant hydraulic effect (based on the EAS runs), flood fight up to 3 feet and less in areas where there is an impact on hydraulic profiles, and
(4) identify areas immediately upstream of major urban areas that could potentially be used to provide storage during major flood events.

To further develop this as an alternative requires that three important questions be answered:
(1) What is considered as significant critical infrastructure?
(2) What is considered as significantly high damage potential in agricultural areas?
(3) How great of a hydraulic impact (water surface rise) is considered significant?

In order to effectively compare an Emergency Action Plan with other alternatives or Emergency Action Plan scenarios, quantification of the costs of flood fighting would be considered, as well as the induced damages resulting from the hydraulic impacts of flood fighting.

b. Existing Flood Damage Reduction Reconstruction.

Description. Reconstruction involves the rehabilitation of existing Federal flood control projects that are no longer performing as intended due to long term degradation of project features which have exceeded their expected service life. Reconstruction would serve to insure that the project continues to deliver the full flood damage reduction benefits intended by Congress at the time of authorization, but would not expand or change the authorized scope, function, or purpose of the project. The alternative would not involve work typically associated with the routine operation and maintenance of a flood control project or corrective work required due to improper maintenance on the part of the non-Federal sponsor. A Federal project would be eligible for inclusion in this alternative only if the non-Federal sponsor has adequately operated and maintained the project to Corps standards; and there are no outstanding maintenance deficiencies.

Project features that may be considered as part of a reconstruction alternative include: concrete foundations, gravity drains, gated structures, closing structures, pumps and motors, relief wells and other under seepage control features, and electrical equipment.

Currently no existing authority has been identified that would allow for reconstruction of projects that have been turned over for maintenance by local sponsors. Therefore this alternative would require new Congressional authorization.

Discussion. Reconstruction would be defined by elimination. Reconstruction elements would not include design or construction deficiencies. Design or construction deficiencies would continue to be addressed according to ER 1165-2-119. Further, reconstruction would only address the impediments preventing a project from performing as authorized after all maintenance has been accomplished by the non-Federal sponsor and any deficiencies resulting from a lack of maintenance have been addressed. Reconstruction would consist of addressing the major project deficiencies caused by a long-term degradation of the foundation, construction materials, and the engineering systems beyond their expected service lives and the resulting inability of the project to perform its authorized project functions. In addressing reconstruction needs, the latest design standards and efficiency improvements can be incorporated into the project as long as the scope, function, and purpose of the project are not changed.

Since reconstruction projects would not entail a change in levee elevation, no secondary development or induced flooding effects would be expected.

The following proposed wording is included in the U.S. House of Representatives working version of the Water Resources Development Act of 2005 which shows an interest in reconstructing existing flood damage reduction systems to insure their adequacy in future years.

"RECONSTRUCTION OF ILLINOIS FLOOD PROTECTION PROJECTS.

(a) IN GENERAL.—The Secretary may participate in the reconstruction of an eligible flood control project if the Secretary determines that such reconstruction is not required as a result of improper operation and maintenance of the project by the non-Federal interest.

(b) COST SHARING.—The non-Federal share of the costs for the reconstruction of a flood control project authorized by this section shall be the same non-Federal share that was applicable to construction of the project. The non-Federal interest shall be responsible for operation and maintenance and repair of a project for which reconstruction is undertaken under this section.

(c) RECONSTRUCTION DEFINED.—In this section, the term ''reconstruction'', as used with respect to a project, means addressing major project deficiencies caused by long-term degradation of the foundation, construction materials, or engineering systems or components of the project, the results of which render the project at

risk of not performing in compliance with its authorized project purposes. In addressing such deficiencies, the Secretary may incorporate current design standards and efficiency improvements, including the replacement of obsolete mechanical and electrical components at pumping stations, if such incorporation does not significantly change the scope, function, and purpose of the project as authorized.

(d) ELIGIBLE PROJECTS.—The following flood control projects are eligible for reconstruction under this section:

(1) Clear Creek Drainage and Levee District, Illinois.

(2) Fort Chartres and Ivy Landing Drainage District, Illinois.

(3) Wood River Drainage and Levee District, Illinois.

(4) Cairo, Illinois Mainline Levee, Cairo, Illinois.

(5) Goose Pond Pump Station, Cairo, Illinois.

(6) Cottonwood Slough Pump Station, Alexander County, Illinois.

(7) 10th and 28th Street Pump Stations, Cairo, Illinois.

(8) Flood control levee projects in Brookport, Shawneetown, Old Shawneetown, Golconda, Rosiclare, Harrisburg, and Reevesville, Illinois.

(e) JUSTIFICATION.—The reconstruction of a project authorized by this section shall not be considered a separable element of the project.

(f) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated—

(1) $15,000,000 to carry out the projects described in paragraphs (1) through (7) of subsection (d); and

(2) $15,000,000 to carry out the projects described in subsection (d)(8).

Such sums shall remain available until expended."

V. COORDINATION AND PUBLIC VIEWS

A. Coordination. Coordination with various other Federal, state, local and non-governmental agencies and groups occurred through the Collaboration Team created in 2002. The coordination occurred through team meetings, teleconference calls, and electronic transmission of documents.

The current Upper Mississippi River Comprehensive Plan Collaboration Team is presented below.

Federal Representatives

- Ken Hinterlong, Federal Emergency Management Agency (FEMA), Region V, Chicago, IL
- Richard Leonard, FEMAFederal Emergency Management Agency, Region VII, Kansas City, MO
- DaveEllis, U.S. Fish and Wildlife Service (USFWS), Annada, MO
- Jon Duyvejonck, (USFWS)U.S. Fish and Wildlife Service, Rock Island Field Office, Rock Island, IL
- Dick Steinbach, USFWSU.S. Fish and Wildlife Service, Quincy, Illinois
- Jon Kauffeld, USFWSU.S. Fish and Wildlife Service, Region 3, Fort Snelling, MN
- Tim Yager, USFWSU.S. Fish and Wildlife Service, Region 3, Fort Snelling, MN
- Bill Franz, U.S. Environmental Protection Agency, (USEPA)Region 5, Chicago, IL
- Larry Shepard, USEPAU.S. Environmental Protection Agency, Region 7, Kansas City, MO
- Bob Goodwin, U.S. Department of Transportation, Maritime Administration

State Representatives

- Gary Clark, Illinois Department of Natural Resources (DNR)
- Arlen Juhl, Illinois Department of Natural Resources
- Paul Osman, Illinois State Floodplain Management, Illinois Department of Natural Resources
- Bill Cappuccio, Iowa Department of Natural Resources
- Tim Schlagenhaft, State of Minnesota
- Randy Scrivner, Missouri State Emergency Management Agency
- Mike Wells, Missouri Department of Natural Resources
- Charlie DuCharme, Missouri Department of Natural Resources
- Gretchen Benjamin, Wisconsin Department of Natural Resources

Non-Governmental Organization Representatives

- Kim Robinson, Upper Mississippi, Illinois, and Missouri Rivers Association
- Mike Klingner, Upper Mississippi, Illinois, and Missouri Rivers Association
- Dave McMurray, Upper Mississippi, Illinois, and Missouri Rivers Association
- Holly Stoerker, Upper Mississippi River Basin Association
- Mark Beorkrem, Mississippi River Basin Association
- Jennifer Frazier, American Land Conservancy
- Michael Reuter, The Nature Conservancy
- Owen Dutt, American Heritage Rivers

B. Public Views

1. Correspondence. Correspondence from other Federal agencies, and state and local agencies, organizations and individual persons will be summarized after the June 2006 public meetings and based upon all correspondence received.

Five letters were received in March indicating support for Alternative Plan G.

2. UMIMRA Preferred Plan. The major stakeholder for flood damage reduction in the Upper Mississippi River System, the Upper Mississippi, Illinois and Missouri River Association (UMIMRA), has indicated a strong preference for Alternative Plan G. Alternative Plan G would provide a systemic high level of flood protection, 0.2 % chance annual (500-year) protection, for most areas with existing floodwalls and levees.

Alternative Plan G, if implemented, would satisfy the WRDA authorization to "develop a plan in the interest of the systemic flood damage reduction…" This plan would address the planning objectives to 1) minimize the threat to health and safety resulting from flooding, and 2) reduce damages and costs associated with flooding.

To meet the criteria of no more than a one foot rise in water surface profile for the 1 percent chance (100-year) annual flood, nine (9) drainage and levee districts in the area south, downstream, of St. Louis, would not be allowed to raise their flood protection level. Some of the floodplains of these nine districts may offer an opportunity to address environmental sustainability and restoration goals of the UMRS.

If implemented, it would also address other objectives including nutrient input and sedimentation, bank caving and erosion reduction, and may offer the opportunity for improved recreation.

Considering the evaluation of Alternative Plan G by the four evaluation accounts would result in the following:

- NED – Construction cost of about $6 billion with a benefit-to-cost ratio of about 0.05.
- EQ – Plan G would allow unrestricted development in the protected areas. Existing environmental areas would be protected within the drainage and levee districts.
- RED – Very significant regional economic development benefits of over 27B due to the jobs created, construction, prevention of loss to bridges, flood fighting, social disruption of the population and the areas surrounding it could be expected.
- OSE – There are several categories considered in Other Social Effects. Aesthetics would be negatively impacted by Plan G, public health and safety would be improved, transportation systems would be protected within the leveed areas, community cohesion would improve, significant community growth and development would be allowed to occur as desired, relocations of businesses and homes would be minimized or not required, but there may be controversy with implementation of Plan G.

VI. CONCLUSIONS

A. General Overview

Two significant events occurred during the period of preparation of the draft report in 2005. First, severe hurricanes hit the southern United States. The hurricane experience last year in addition to the lessons of the flood of 1993 resulted in a reexamination of approaches to floodplain management and flood mitigation, changing some perspectives and opening opportunities. Secondly, during the development of the report, the Corps of Engineers issued several engineering circulars, emphasizing collaborative approaches to planning and reaffirming the assessment of plans from a basis of four accounts.

Historically, many entities have influenced floodplain development. But when a significant natural disaster occurs, significant federal resources are invested to recover from the disaster, along with considerable resources from state, local and private entities. Collaboratively laying out a process to guide where floodplain development may occur while minimizing residual risks for those targeted areas will, in the end, lower the recovery funds required from all sources.

This planning effort has not resulted in the selection of a systemic plan which can be recommended for implementation by the Army Corps of Engineers at this time. However, this effort has identified the need for a partnership of federal, state and local interests to periodically come together and review the need for changes in floodplain usage and to examine options to address those needs. The Corps can bring hydraulic, hydrologic, economic, environmental and engineering expertise to such a collaborative partnership.

B. Conclusions

- The study successfully developed a set of tools capable of analyzing the hydraulic, economic, and environmental effects of systemic flood damage reduction alternatives.
- The existing flood damage reduction systems currently prevent 95-97% of the potential (average annual) flood damages on the system.
- The hydrologic body of knowledge of the Upper Mississippi and Illinois Rivers has dramatically increased as a direct result of the previous Flow Frequency Study and the Comprehensive Plan. The systemic modeling is a useable product for the future, if maintained for the Corps and other Federal, state, and local agencies. It allows the determination of system-wide hydrologic impacts to actual and proposed changes. This modeling has the potential to substantially change the way this river system is managed.
- Specific findings of the hydraulic analysis of alternatives include:
    - The levees above Lock and Dam 19 at Keokuk, Iowa (study reaches 1 and 2) can be raised without causing more than a one-foot increase in 100-yr flood profile. Likewise, the levees on the Illinois River (reach 4) can be raised without causing more than one foot of rise in the 100-yr flood profile.
    - Several flood damage reduction measures (levee setbacks, realignments, and removal of bridge obstructions) have only a very localized reduction of water surface profiles.

  - Temporary emergency actions such as flood fighting and emergency operations can generally occur, but there are some locations that the emergency raise can cause significant negative impacts on the water surface profile.

- None of the twelve systemic flood damage reduction plans had positive national economic development (NED) benefits. For many plans, the benefit-to-cost ratio (BCR) was below 0.1.

- Implementation of a large, systemic flood reduction plan would result in significant regional economic benefits related to the short-term increase in employment and construction spending. The Tennessee Valley Authority estimated that every dollar spent on comprehensive flood control at the 500-year (for urban areas) and 100-year or greater (agricultural areas), which includes Plans A, B and D, would generate as much as $5 in increased gross regional product. Also, employment is projected to increase by more than 20,000 jobs annually in the five-state Upper Mississippi Valley Region resulting from upgraded levee protection provided by implementation of either Plan A, B, or D.

- Significant systemic ecosystem restoration opportunities exist within the Upper Mississippi River System floodplain; however, there are no cost-justified systemic flood damage reduction plans that would support the inclusion of ecosystem restoration projects.

- Examination of the need for reconstruction of components the existing flood control systems should be undertaken to insure that the existing system functions into the future providing billions of dollars of benefits.

- The Army Corps of Engineers is willing and interested in serving a continued facilitation role in the interest of flood damage reduction if requested by one or more Upper Mississippi River Basin states. The purpose would be to regularly review the water resources problems, needs, and opportunities in a collaborative framework working with other Federal, state, and local agencies and non-governmental organizations, stakeholders, and interested publics. The Corps could likewise, through this continuing process, be a catalyst to address the problems and needs collaboratively. This activity could require authorization and would require appropriation. The Corps would bring its leadership and expertise in technical areas such as hydrology and hydraulics, economic and environmental analysis, and engineering to bear to address the changing problems, needs, and opportunities of the region.

C. Potential Follow-on Studies

1. The hydrologic modeling for the Upper Mississippi River System should be maintained and updated as changes occur and new data is available. This would make the modeling and results available and useful to all Federal, state and local agencies, in the future and would allow additional personnel to use the modeling and incorporate new tools as available on a regular basis. Existing information used to evaluate project benefits is, on the average, over 30 years old. Updating this information would provide decision-makers and the public with better quality data upon which to manage the system on a long-term basis.

2. To close data gaps in our understanding of the river system, investments should be made in: GIS-based computer modeling, a second generation Habitat Needs Assessment, long-term sediment monitoring, and pilot projects for evaluating wetlands creation as a management tool for nutrients control.

3. A feasibility phase analysis of the Quincy Bridge approach, located in the Fabius Drainage and Levee District, should be accomplished. The purpose would be to evaluate the increase in the level of protection for the bridge approach in Missouri to the bridge across the Mississippi River at Quincy, IL. The approach lies in the Fabius Levee and Drainage District. The major flood damage reduction benefit obtained would be transportation savings or detour cost avoided. Other flood damage reduction benefits and potential ecosystem restoration opportunities could further enhance the feasibility phase study results.

4. Reconstruction feasibility phase studies of individual drainage and levee districts will insure that the existing aging systems provide their substantial benefits into the future.

VII. RECOMMENDATIONS

It is recommended that a feasibility study for the Fabius Levee and Drainage District, Missouri, be conducted upon negotiations and signing of a Feasibility Cost Sharing Agreement (FCSA) with a study sponsor.

It is recommended that a reconstruction authorization be established for the Upper Mississippi and Illinois Rivers drainage and levee districts. Further, it is recommended that up to $1,000,000 total (up to $50,000 per district) be authorized to initiate reconstruction analysis with development of the Project Management Plan and the Feasibility Cost Sharing Agreement for individual drainage and levee districts. The cost shared feasibility phase reconstruction analysis would then be accomplished on individual flood damage reduction systems to evaluate whether rehabilitation of the aging infrastructure is needed to ensure that the systems provide their substantial benefits in the future.

ACRONYMS AND ABBREVIATIONS

AAB	Average annual benefits
AAD	Average annual damages
BCR	benefit-to-cost ratio
CRP	Conservation Reserve Program
E.O.	Executive Order
EAP	Emergency Action Plan
EAS	Emergency Action Scenarios
EQ	Environmental Quality
ENR	Engineering News-Record
EOP	*Environmental Operating Principles and Implementation Guidance*
ER	Engineering Regulation
EWP	Emergency Watershed Protection Program
EWRP	Emergency Wetlands Reserve Program
FEMA	Federal Emergency Management Agency
FFS	Flow Frequency Study
FMRC	Floodplain Management Review Committee
FMRC	Floodplain Management Review Committee
IDC	interest during construction
MR&T	Mississippi River and Tributaries
NED	national economic development
NER	National Ecosystem Restoration
NGO	Non-governmental Organizations
OSE	Other Social Effects
RED	regional economic development
RM	river mile
SAST	Scientific Assessment and Strategy Team
TVA	Tennessee Valley Authority
UMIMRA	Upper Mississippi, Illinois and Missouri Rivers Association
UMRBA	Upper Mississippi River Basin Association
UMRCC	Upper Mississippi River System resources management
UMR-IWW	Upper Mississippi River-Illinois Waterway
WRDA	Water Resources Development Act
WRP	Wetlands Reserve Program

REFERENCES

Economic Impact of the Recreation on the Upper Mississippi River System. US Army Corps of Engineers Technical Report – EL-95-16. Waterways Experiment Station, 1995.

Floodplain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries. U. S. Army Corps of Engineers, 1995

Natural Disaster Survey Report: The Great Flood of 1993. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1994

A River That Works and a Working River. McGuiness, Dan. The Upper Mississippi Rover Conservation Committee, 2000.

*Sharing the Challenge: Floodplain Management into the 21st Century (*Galloway Report). Interagency Floodplain Management Review Committee, Washington, D.C., 1994

Taming the Upper Mississippi River: My Turn at Watch, 1935-1999. William H. Klingner, P.E., P.L.S. Petterchak, Janice. Legacy Press, Rochester, IL. 2000

Upper Mississippi River Comprehensive Basin Study, Appendix G—Fluvial Sediment. U. S. Army Corps of Engineers, 1969

Upper Mississippi River System Flow Frequency Study. U. S. Army Corps of Engineers, 2004

Upper Mississippi River System—Ecological Status and Trends of the Upper Mississippi River System. U. S. Army Corps of Engineers, 1995

GLOSSARY

100-year flood: a term commonly used to refer to the one percent chance annual flood. The 100-year flood is the flood that is equaled or exceeded once in 100 years on the average, but the ***term*** should not be taken literally as there is no guarantee that the 100-year flood would occur at all within a 100-year period or that it would not recur several times.

500-year flood: a term commonly used to refer to the 0.2 percent chance annual flood. The 500-year flood is the flood that is equaled or exceeded once in 500 years on the average, but the ***term*** should not be taken literally as there is no guarantee that the 500-year flood would occur at all within a 500-year period or that it would not recur several times.

acre-foot: a unit measure of volume equal to one acre covered to a depth of one foot; often used to describe reservoir capacity or the amount of water flowing past a point in a river over a specified time period. one acre-foot equals 43,560 cubic feet, or 326,70tl gallons

actuarial rates: insurance rates determined on the basis of a statistical calculation of the probability that a certain event would occur. Actuarial rates, also called risk premium rates, are established by the Federal insurance administration pursuant to individual community flood insurance studies and investigations undertaken to provide flood insurance in accordance with the national flood insurance act and with accepted actuarial principles, including provisions for operating costs and allowances.

aggradation: the process of filling and raising the level of a streambed by deposition of sediment

agricultural levee: a levee for which the majority of benefits are derived from protection of agricultural lands

backwater lake: a lake connected to a river at its downstream end that tills principally from the rise of the river rather than from inflow from the lake's drainage area

backwater: a) a rise in upstream water level caused by an increase in flow downstream; b) an upstream water level rise caused by obstructions downstream, such as ice jams or debris

bank stabilization: use of structural measures such as rock, concrete, or other material to stabilize channel banks against movement and erosion

bankfull stage: at a given location, the maximum elevation to which a river can rise without overflowing its banks (See *flood stage*.)

base flood: a florid of specific frequency and used for regulatory purposes. The NFIP has adopted the "100-year" flood as the base flood to indicate the minimum level of flooding to be used by a community in its floodplain management regulations.

basin: a region or area drained by a river system. Also, the total land area that contributes runoff to any given point on a river or stream; often called a *watershed*.

biotechnical engineering: channel or bank modification techniques that use vegetation in innovative ways in contrast to traditional bank sloping and riprap protection

bluff line: a steep headland or cliff which in some topographical settings defines the edge of a floodplain

bottomland hardwood: tree species that occur on water-saturated or regularly inundated soils. classified as wetlands, these areas contain both trees and woody shrubs

channel modifications. flood stages can be reduced by improving flow conditions within the channel and increasing the stream's carrying capacity. Methods generally used to obtain improvements of channels include straightening to remove undesirable bendways, deepening or widening to increase size of the waterway and clearing to remove brush, trees, and other obstructions.

collaborative approach: a commitment ***to*** working collectively to solve complex, inter-related concerns. A collaborative effort requires more than consultation, coordination, and seeking public input.

community assistance program (cap): the program established by the Federal emergency management agency and intended to assure that communities participating in the NFIP are carrying out the flood loss reduction objectives of the program. The cap provides needed technical assistance to NFIP communities and attempts to identify and resolve floodplain management issues before they develop into problems requiring enforcement action.

community rating system (CRS: a program developed by the Federal emergency management agency to encourage—by use of flood insurance premium reductions—community and state activities that go beyond the basic NFIP requirements; the CRS gives communities credit for certain activities to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance

confined: flows are confined between the levees in the river channel and overbank area or between the levee on one bank and the bluff on the opposite river bank. Flood waters are not allowed to overtop any levee. It is assumed for analysis purposes, that levees would be raised as needed to keep the flood waters out of the levee areas, confined to the river.

conservation tillage: practices that reduce cultivation of soil, leave a protective vegetative layer on the surface, and thereby serve to reduce or minimize soil erosion

crest: the highest water level at a given location during a flood event

crop rotation: growing crops in a cropping sequence designed to provide adequate residue for maintaining or improving soil condition

cubic feet per second (CFS): the rate of flow (see *discharge)* past a given point, measured in cubic feet per second. One cubic foot of water equals approximately 7 ½ gallons.

cumulative impacts: the impacts on the environment that result from the incremental impact of an action when added to other past, present and reasonably foreseeable actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time

dam: a structure built across a waterway to impound water. Dams are used to control water depths for navigation; or to create space to store water for flood control, irrigation, water supply, hydropower or other purposes. The function of reservoirs is to store water when streamflow is excessive and to release it gradually after the threat of flooding has passed.

debris: objects such as logs, trees and other vegetation, building wreckage, vehicles, shopping carts or dead animals carried by water in a flood (or by wind, as in a hurricane or tornado)

degradation: a process of lowering the level of a streambed scour and erosion

design flood: the maximum amount of water for which a flood control project would offer protection. selection is based on engineering, economic and environmental considerations

dike: in most areas of the U.S., an earthen or rock structure built partway across a river for the purpose of maintaining the depth and location of a navigation channel. In others areas the term is used synonymously with *levee*.

discharge: rare of flow in a river or stream measured in volume of water per unit of time. (*See* cfs)

drainage tiles: short lengths of perforated pipe made of clay, concrete, or plastic installed in soil to remove free water for the purpose of crop production.

drainage area: total land area from which water drains to a point on a river; the Upper Mississippi River drainage area comprises 23 percent of the land area of the 48 contiguous united states.

dry detention: a dry detention area is an area that can supply temporary storage of water for a given time in an area that is normally dry. Usually the outflows are unregulated.

easement: typically reimbursing a land owner to restrict the possible use they can make of the property. There are generally two easement types:

> **flowage easement:** a permanent easement that grants to the government the right to overflow, flood and submerge land lying above a certain elevation. Generally restricts the property owner from utilizing the property for anything other than agricultural uses. Typically no structures would be allowed within the limits of the flowage easement, without prior approval of the government.
>
> **conservation easement:** a permanent easement that restricts development on a specified tract of land. Typically used to restrict an owner from developing the property for more intensive uses, such as commercial or residential development.

ecosystem: biological communities (including humans) and their environment (or watershed) treated together as a functional system of complementary relationships, including transfer and circulation of energy and matter

ecosystem integrity: maintenance of the structural and functional attributes characteristic of a particular locale or watershed, including normal variability

ecosystem management: management of the biological and physical resources of an ecosystem or watershed in an attempt to maintain the stability of its structural, functional, and economic attributes, including its normal variability

emergency spillway: see *spillway*

emergency: any instance for which, in the determination of the president, Federal assistance is needed to supplement state and local efforts and capabilities to save lives and protect property and public health and safety or to lessen or avert the threat of a disaster in any part of the United States

encroachments: activities or construction within the floodway, including fill, new construction, substantial improvements, and other development, that may result in au increase in flood levels

environmental assessment: an examination of the beneficial and adverse impacts on the environment of a proposed action, such as a water resources project, and alternative solutions

Executive Order 11988: the floodplain management executive order (E.O.), issued in 1977, specifying the responsibilities of the Federal agencies in floodplain management. E.O. 11988 directed Federal agencies to evaluate and reflect the potential effects of their actions on floodplains and to include the evaluation consideration of flood hazards in agency permitting and licensing procedures.

Federal Interagency Floodplain Management Task Force: the task force established in 1975 to carry out the responsibility of the president to prepare for the congress a unified national program for floodplain management member agencies are the Department of Agriculture, Department of the Army, Environmental Protection Agency, Federal Emergency Management Agency, Department of the Interior, and the Tennessee Valley Authority

Federal trust resources: as applied in this report, these resources include migratory birds, Federally listed threatened and endangered species and species that are candidates for listing, interjurisdictional fisheries and wetlands. Such resources are protected by international treaty, and/or Federal law in recognition of their ecological and/or commercial significance.

field borders: a strip of perennial vegetation established on the edge of a field. it involves plantings of herbaceous vegetation or shrubs

flash flood: flood with a very rapid rate of rise that is caused by intense rainfall. during flash floods the time between peak rate of rainfall and peak flow is very short

flood/flooding: a general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of river and/or tidal waters and/or the unusual accumulation of waters from any source

flood control structures: structures such as dams, dikes, levees, drainage canals, and other structures built to modify flooding and protect areas from flood waters

flood discharge: the quantity of water flowing in a stream and adjoining overflow areas during times of flood. It is measured by the amount of water passing a point along a stream with a specified period of time and is usually measured in cubic feet of water per second (cfs).

flood frequency: the frequency with which a flood of a given discharge has the probability of recurring. For example, a 100-year frequency flood refers to a flood discharge of a magnitude likely to occur on the average of once every 100 years or, more properly, of a magnitude that has a one-percent chance of being equaled or exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a 100 year flood would occur at all or that it would not recur several times within any 100-year period.

flood hazard: the potential for inundation that involves risk to life, health, property, and natural floodplain values

flood hazard mitigation teams: teams consisting of representatives of the 12 Federal agencies that signed an interagency agreement to provide technical assistance to states and communities for nonstructural flood damage reduction measures. The teams are typically employed after each major flood disaster declared by the president to provide technical assistance and guidelines to communities and states affected by the disaster.

flood insurance rate map (FIRM): an official map of a community on which the Federal emergency management agency has delineated both the special hazard areas and the risk premium zones applicable to the community. FIRMS typically identify the elevation of the one-percent chance annual flood and the areas that would be inundated by that level of flooding; they are used to determine flood insurance rates and for floodplain management.

flood insurance: the insurance coverage provided through the national flood insurance program

flood of record: the highest flood historically recorded at a given location

flood-pulse advantage: the amount by which fish yield is increased by a natural predictable flood pulse

floodplain management regulations: zoning ordinances, subdivision regulation, building codes, heath regulations, special purpose ordinances that cover, for example, floodplains, grading, and erosion control and other regulation to control future development in floodplains and to correct inappropriate development already in floodplains

floodplain management: a decision-making process whose goal is to achieve appropriate use of the nation's floodplains. Appropriate use is any activity or set of activities that is compatible with the risk to natural resources and human resources. the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to watershed management, emergency preparedness plans, flood control works, and floodplain management regulations.

floodplain resources: natural and cultural resources including wetlands, surface water, groundwater, soils, historic sites, and other resources that may be found in the floodplain and that provide important water resources, living resources (habitat), and cultural/historic values

floodplain: low lands adjoining the channel of a river, stream, watercourse, lake, or ocean, that have been or may be inundated by floodwater and other areas subject to flooding

floodproofing: the modification of individual structures and facilities, their sites, and their contents to protect against structural failure, to keep water out, or to reduce the damaging effects of water entry. there are many different flood proofing measures to consider including seepage control, wet and dry floodproofing and elevating or raising a structure or roadway.

flood stage: a site-specific river level at which flood damage may start to occur; usually at or above the top of the riverbank. flood heights are often measured relative to the florid stage elevation. (See *stage*).

flood storage pool: a volume of space in a reservoir reserved for storage of flood water

floodwall: reinforced concrete walls that act as barriers against floodwaters thereby helping to protect floodprone area. Floodwalls are usually built in lieu of levees where the space between developed land and the floodway is limited.

floodway: the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation more than a designated amount. The floodway is intended to carry deep and fast-moving water.

flow diversion: a flow diversion allows the movement of floodwater from one area to another by means of an alternate route. A by-pass channel is an example of flow diversion.

flowrate: rate of flow (discharge) at a specific location in a river or floodplain

freeboard: a factor of safety usually expressed in feet above a flood level for purposes of designing flood protection facilities and for floodplain management. Freeboard tends to compensate for the many uncertain factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge obstructions, and the hydrological effect of urbanization of the watershed.

gated outlets: conduits, such as pipes or box culverts, in which mechanical gates are placed for the purpose of controlling the discharge

geographic information system (GIS): a computerized system designed to collect, manage, and analyze large volumes of spatially referenced and associated attribute data

greenway: a protected linear open-space area that is either landscaped or left in its natural condition. it may follow a natural feature of the landscape, such as a river or stream, or it may occur along an unused railway line or some other right of way

high energy erosion zones: areas on the floodplain, such as the location of a former channel, that are subject to extensive scour and sediment transport during overbank flows

hinge-control points: points in slackwater navigation pools where the water level is used as an index to establish gate settings at navigation dams for maintaining navigable depths

hydraulics: the science dealing with the mechanical properties of liquids that describes the specific pattern and rate of water movement in the environment

hydrology: the science dealing with the properties, distribution, and circulation of water on and below the surface of the land and in the atmosphere

improved flood forecasting/warning. reliable, accurate, and timely forecasts of floods and flood stages can be coupled with timely flood fighting and evacuation to save lives and reduce property losses. The Federal government has traditionally provided the leadership in developing and operating flood forecasting systems. The National Weather Service has the primary responsibility for forecasting on the Upper Mississippi River System, with support from the u.s. army corps of engineers.

interjurisdictional fisheries: fish and shellfish resources whose habitat includes waters shared by two or more states

land treatment measures: measures used to reduce runoff of water to streams or other areas; techniques include maintenance of trees, shrubbery, and vegetative cove~ terracing; slope stabilization grass waterways; contour plowing; and strip farming

land use/construction regulation: reduce flood damages by using land use and construction regulations to control development in the floodplain

levee: a linear earth embankment used to protect low-lying lands from flooding. a levee extends from high ground adjacent to a floodprone area along one side of a river to another point of high ground on the same side of the river. As options, existing levees could be raised in place, set-back, realigned, partially degraded or removed. Using the area behind a levee for floodwater storage to reduce the flood peak is another example of an option using levees.

lock: a structure adjacent to a dam or in a canal to allow passage of vessels from one water level to another. The lock consists of a chamber with gates at either end, in which water is raised or lowered. Navigation lock and dams normally do not store flood water.

lower Mississippi River basin: the portion of the Mississippi River basin that drains into the Mississippi River from its confluence with the Ohio River to the Gulf of Mexico.

lower Mississippi River: the reach of the Mississippi River from the confluence of the Ohio River at Cairo, IL, to the Gulf of Mexico

low profile berms to protect environmentally sensitive areas: an area protected by a low frequency (example a 10-year) embankment to protect the area from frequent, seasonal flood events that negatively affect the ecosystem management objectives of the area

major disaster: any natural catastrophe or, regardless of cause, any tire, flood, or explosion in any part of the United States which, in the determination of the president causes damage of sufficient severity and magnitude to warrant major disaster assistance under the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

middle Mississippi River: the reach of the Mississippi River between its confluence with the Missouri River at St. Louis, MO, and its confluence with the Ohio River at Cairo, IL.

mitigation: any action taken to permanently eliminate m reduce the long-term risk to human life and property and the negative impacts on natural and cultural resources that can be caused by natural and technological hazards.

mitigation lands: lands acquired to offset adverse impacts of water resource (or other) projects

National Wetlands Inventory Project: wetlands mapping on a national basis performed by the U. S. Fish and Wildlife Service to provide scientific information on the extent and characteristics of the nation's wetlands and consisting of detailed maps and status and trends reports.

natural resources and functions of floodplains: include, but are not limited to, the following: natural flood and sediment storage and conveyance, water quality maintenance, groundwater recharge, biological productivity, fish and wildlife habitat, harvest of natural and agricultural products, recreation opportunities, and areas for scientific study and outdoor education

navigation channel: the channel maintained in a body of water for the purpose of assuring a depth adequate for commercial vessels

nonstructural measures: a term originally devised to distinguish techniques that modify susceptibility to flooding (such as watershed management, land use planning, regulation, floodplain acquisition, floodproofmg techniques and other construction practices, and flood warning) from the more traditional structural methods (such as dams, levees, and channels) used to control flooding

one-percent chance annual flood: a flood of a magnitude that has a one-percent chance of being equaled or exceeded in any given year. Often referred to as the 100-year flood or base flood, the one-percent chance annual flood is the standard most commonly used for floodplain management and regulatory purposes in the united states.

open river: the Mississippi River downstream of the last locks and dam located at Granite City, IL, in the St. Louis Metropolitan Area. This is immediately downstream of the confluence of the Missouri and Mississippi Rivers. The Mississippi River is free flowing with no locks and dams located further downstream needed to insure a nine-foot channel depth for navigation.

permanent evacuation: permanent evacuation of developed areas subject to inundation involves the acquisition of lands by purchase, the removal of improvements, and the relocation of the population from such areas. Lands acquired in this manner could be used for unprotected agriculture, parks, or other purposes that would not interfere with flood flows or result in material damage from floods.

permanent vegetation: perennial vegetation such as grasses, shrubs, and trees which provides cover to soil and prevent erosion.

Principles and Standards/Principles And Guidelines: "The Principles and Standards for Planning of Water and Related Land Resources" is a presidential policy statement issued in September 1973 that established a framework for improved planning for the use of water and related land resources baaed on the objectives of national economic development and environmental quality. the "principles and standards" were revised and issued in 1983 as the "economic and environmental principles and guidelines for water and related land resources for implementation studies. "

Quad Cities: the metropolitan area comprised of the cities of Davenport and Bettendorf, IA, and Rock Island and Moline, IL

recurrence interval: the average interval in which a flood of a given size is equaled or exceeded as an annual minimum

regulatory floodplain: the area adjoining a river, stream, lake, or ocean that is inundated by a regulatory flood. I riverine areas the floodplain usually consists of a regulatory floodway and regulatory flood fringe (also referral to as a floodway fringe). in coastal areas the floodplain may consist of a single regulatory floodplain area or a regulatory high-hazard area and a regulatory low-hazard area.

regulatory floodway: the area regulated by Federal, state, or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as the minimum standard set by the national flood insurance program)

relocation/acquisition/buy-outs: structures are removed from the floodplain most often using acquisition or buy-outs of the structure which reduces future flood damages

repetitive loss: a flood-caused loss of more than $1,000 to a repetitive loss structure

repetitive loss structure: a structure for which two or more losses of more than $1,000 (building and contents combined) have been paid since 1978

riparian ecosystems: distinct associations of soil, flora, and fauna occurring along a river, stream, or other body of water and dependent for survival on high water tables and occasional flooding

riparian vegetation: hydrophytic vegetation growing in the immediate vicinity of a lake or river

riparian zone: the border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The area is typically subject to frequent, short duration flooding.

risk: the probability of being flooded

rock closing dams: in reaches of rivers where multiple channels are formed by islands, rock dikes that span the side channel, generally where it departs from the main channel, are called rock closing dams. They serve to direct flow to the main channel.

scour hole: erosional holes developed as a result of breached levees. Locally called *blow, blew*, or *blue holes*.

scour: process of eroding surface soil by flowing water which results in gullies in the landscape.

Section 409 Hazard Mitigation Plan: a plan prepared as required by section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 by any jurisdiction that receives Federal disaster assistance.

sediment and debris basin: retention structure constructed on or adjacent to a watercourse to store sediment and debris

side channel: a stream or channel to the side of the major channel or stream.

slackwater navigation dam: a dam placed across a river for the purpose of creating water depth sufficient for navigation. The term *slackwater* refers to the relatively low velocity in the navigation pool compared to an open river.

slough: a swamp, march, bog or pond as part of a bayou, inlet or backwater

spillway: a feature of a dam allowing excess water to pass without overtopping the dam. Usually a spillway functions only in a large flood.

stage: the height of the water surface in a river or other body of water measured above an arbitrary datum, usually at or near the river bottom

standard project flood: a very large (low frequency) design flood standard applied to the design of major flood control structures and representing the most severe recombination of meteorological and hydrological conditions considered reasonably characteristic of a particular region

strip cropping: growing crops in a systematic arrangement of strips or bands along a contour

structural measures: measures such as dams, reservoirs, dikes, levees, floodwalls, channel alteration, high-flow diversions, spillways, and land-treatment measures designed to modify floods

substantial improvement: any repair, reconstruction, or improvements of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure either before the improvement or repair is started or if the structure has been damaged and is being restored, before the damage occurred

substantial damage: the amount of damage to a structure caused by flooding that may be sustained before certain regulatory and flood insurance requirements are triggered. As defined in NFIP regulation, a building is considered substantially damaged when the cost of restoring the building would exceed 50 percent of the market value of the structure.

tailwater: the reach of stream or river located immediately below a water control structure such as a dam. In contrast, headwater is the term applied to the pool immediately above a dam.

terrace: a raised bank of earth having vertical m sloping sides and a flat top used to control surface runoff

timed use of off-channel (behind levee) storage: critical usage of “off channel storage” was considered when the elevation of the storage areas was overtopped. The critical overtopping elevations of these units were adjusted up and down to determine a reasonable optimum condition during the alternative analysis. It is hard to predict when to use “off channel storage” but the approach that was used considered a range of possibilities over the frequency curves.

unconfined: unconfined for the Comprehensive Plan means allowing no more than a one foot water surface profile rise. The river is no longer confined between the levees or levee and bluff. With a one foot rise, the analysis lets river flows overtop leveed areas to insure no more than the one foot water surface profile rise.

upper Mississippi River basin: the portion of the Mississippi River basin that is above the confluence of the Ohio River. it includes the Missouri River basin.

upper Mississippi River: the reach of the Mississippi River from its confluence with the Missouri River at St. Louis, MO, upstream to its headwaters at outlet of lake Itasca in Minnesota.

watershed: a region or area contributing ultimately to the water supply of a particular watercourse or water body

wetlands: those areas that are inundated by surface or groundwater with a frequency sufficient to support and, under normal circumstances, does or would support a prevalence’ of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include bottomland hardwoods, swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mud flats, and natural ponds.

wetlands restoration: the restoration and/or creation of wetlands in the floodplain to provide floodwater storage which may have an impact to frequent, smaller flood events. Numerous environmental opportunities are available in these areas.

wing dikes: rock wing dikes or darns, closing dams, wood pile dikes, and bendway weirs are types of channel training structures used to divert river flows toward a single main channel used for navigation. Generally constructed perpendicular to flow, and constructed to various submergent of emergent elevations, these structures usually function most effectively at lower flows.