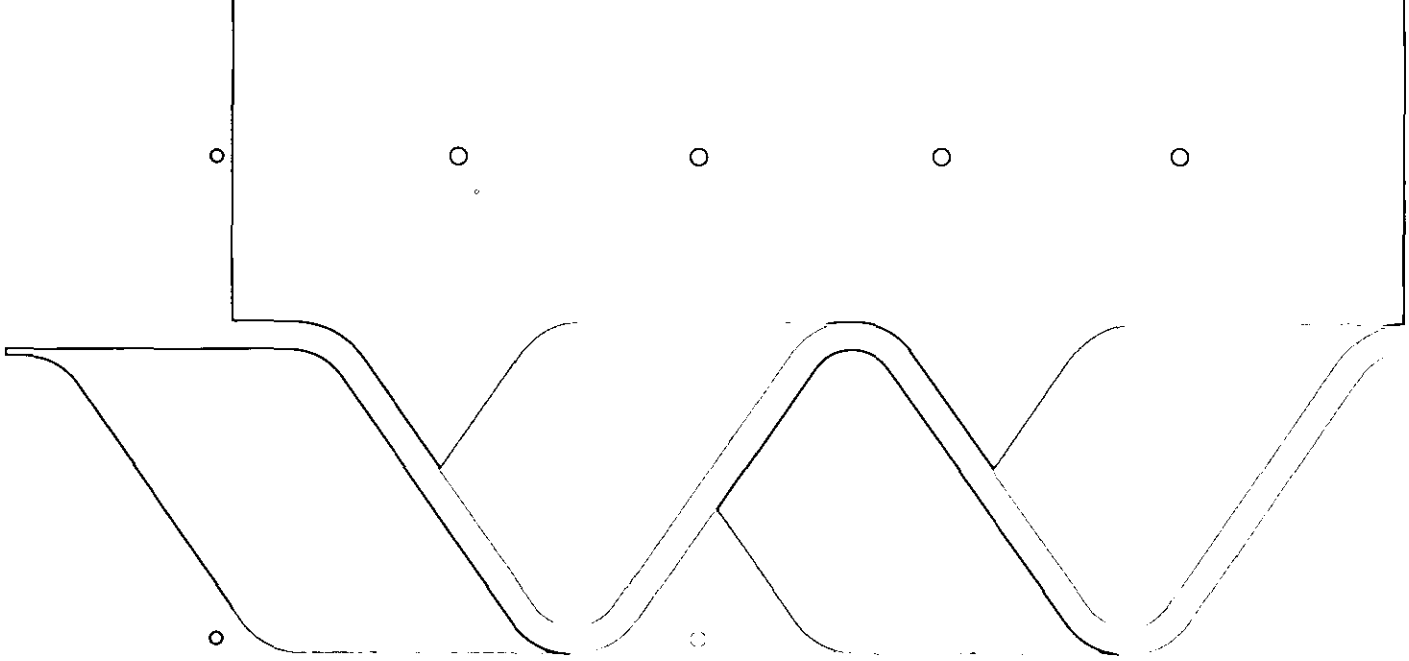

Upper Mississippi, Illinois and Missouri Rivers Association

A Balanced Management for the Upper Mississippi, Illinois and Missouri Rivers

A Provocative Outsider's View

mission report

January, 1997

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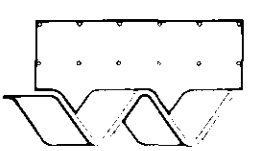
delft hydraulics

A Balanced Management for the Upper Mississippi, Illinois and Missouri Rivers

A Provocative Outsider's View



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Executive Summary

1 Background

In October 1996, The Upper Mississippi, Illinois and Missouri Rivers Association (UMIM Rivers Association) [1] commissioned a team from DELFT HYDRAULICS, [2] the Netherlands, to visit the United States to look into the way the resources of the Upper Mississippi, Illinois and Missouri rivers are presently being managed, and to provide an outsider's view on river basin and river management. Initially we, the team members fielded by DELFT HYDRAULICS, were hesitant to do this. What could we add to the wealth of knowledge already available, and what could our views add to the way we expected river basin and river management to take place in the US? Wouldn't "everything" be smoothly organized and efficiently implemented? We were in for a few surprises, however.

During an intensive two-week program (December 1996) we visited many locations along the river-system, met with numerous government officials, organizations and individuals, we studied many reports, and had many discussions on related topics. Ultimately, we came to the conclusion that there are still quite some issues that should be addressed. Why? Because we concluded that the river's resources are under-utilized, and that the potential of the river basin is not fully developed. The organization of water resources management, and the way the interest groups negotiate options for development can be improved substantially. This is not to say that any one of our conclusions has not, in some report or by some individual, organization or governmental agency, been brought forward earlier. On the contrary: An overwhelming amount of information is readily available. What is lacking, however, is a clear integration process in which all information is brought together, sensible ideas are separated from less sensible ideas, (inter-)national cross-references are made for comparison, and, on the basis of all this, decisions on development issues are clearly formulated. With this report we try to present such an overview, specifically bringing in international experiences. For this reason we have provided the subtitle:

A Provocative Outsider's View

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[1]) The UMIM Rivers Association is a private group of organizations and individuals concerned with the management of the Upper Mississippi, Illinois and Missouri Rivers.

[2]) DELFT HYDRAULICS, an independent institute for water related research and consultancy, and team members of the current mission particularly, have carried out studies of river management, river basin management and national water resource management in a number of countries of Europe, Asia, Latin America and Africa. Virtually all of these studies have involved computer simulations and extensive modelling efforts to understand river hydrology and hydraulics, morphology, ecology, and the effects of water resource management and land use measures. Many studies have resulted in computerized DSS, "decision support systems", that allow users to "see" the physical and ecological effects of different combinations of water resource and land use measures. Economic analyses can be built into the DSS systems.

2 The project

Mr. John Robb, chairman of the UMIM Rivers Association took the initiative for this project. It involved a two-week mission to the Midwest of the US by staff members of DELFT HYDRAULICS, and the submission of this summary-report. Funding for the project was provided by the UMIM Rivers Association. Many individuals and organizations contributed to the funds for the project.

The objective of this report is to present our findings concerning:

1. an evaluation of the existing management policies in the Upper Mississippi Basin and their effect on critical issues such as flood control, navigation, and environmental protection;
2. suggestions to apply integrated water resources management to the Upper Mississippi River Basin, by providing a methodology for the evaluation of alternative management strategies; and
3. recommendations how an integrated River Basin Development Study could pave the way for a detailed river basin plan, to be drafted with involvement of the various usergroups, outlining the potential development issues, the criteria for selection of the most promising strategies, and the way the best strategy will be selected.

Lessons learned world-wide with regards to river basin management issues are explicitly incorporated to provide an "outside view" on river basin management in the Upper Mississippi River Basin.

This report is only the first step in a long process of re-evaluation of water management in the Upper Mississippi Basin. A two-week mission is by no means sufficient to get a detailed picture on the diverse development issues, to resolve the divergent views around complicated issues existing in the river basin, and it is certainly not sufficient to draft an integrated plan, ready for implementation.

3 Overall findings

Three main topics are distinguishable in our findings:

1. the use of the river resources;
2. the role played by federal and state governments in river management; and
3. the interaction of interest groups (stake holders) in the process from planning to decision-making.

3.1 The use of river resources

There is currently a great deal of conflict between many governmental, non-governmental and private organizations about the use of the resources of the Upper Mississippi, Illinois, and Missouri Rivers. Much of this conflict is based on differences in priorities of the various parties concerning three **main** issues, namely:

- environmental protection;
- navigation; and
- flood protection.

Developments in navigation and flood control are of great importance for economic development. Economic development will be the result of improvements made on in particular these two issues, but can also be stimulated by increased tourism resulting from improved environmental conditions. In this line of reasoning, economic development in not an issue in itself.

It goes without saying that there are other important issues related to the various functions of the river (recreation, drinking water supply, hydro power generation, commercial harvesting, etc.). We feel these issues are not the **main** issues currently at stake.

In a balanced approach, all three aspects are considered, and compromises between divergent interests have to be reached, for the benefit of all interested parties. For example, improved navigation and flood protection leads to increased economic development, while **at the same time** positive actions for protection of environmental resources can be achieved.

In our opinion, the current approach to river management is not well balanced. There is insufficient informed negotiation among interested parties, and the outcome is farther than it has to be from the "ideal integrated approach". The 1993 flood in the Upper Mississippi River basin has focused national attention to the Rivers, and offers the possibility for reassessment. One of the conclusions of the Galloway Committee [3] (1994) is: *"The United States has a rare opportunity to make a change in floodplain management. It should not be missed"*. Many of the recommendations made by this Committee are apparently unused. It seems at this moment that the opportunity identified by the Committee is missed. What began as a national and regional debate following the 1993-flood, seems to be dissipating without any real conclusion.

Balancing ecology, navigation and flood management:
We considers the ecological and navigation functions of the river as primary resources provided by the river itself, and the intensive use of the bottomlands i.e. for agriculture, industry and housing as the major resources provided by the river basin which require adequate flood management services for full utilization. We concluded that the resources offered by the river can still be used considerably more intensively without jeopardizing the ecological integrity of the river system, if there is more intensive management and integration of the above uses and functions. The basin's potential for economic utilization and ecological functioning seems not fully recognized.

The Rivers still contain extensive and important ecological and landscape values. The development of these resources is stuck in the conflict between opposing ideologies

[3] Interagency Floodplain Management Review Committee (Galloway Committee) (1994): *Sharing the Challenge: Floodplain Management into the 21st Century.*

motivated by *"maintain all the existing material values"* and *"do not allow any changes"* on the one hand and *"we cannot sacrifice our economic well-being to some rare single animal or fish species"*, on the other hand. To the DELFT HYDRAULICS' team, these are both limited viewpoints. Ecological values should not arbitrarily be compromised in favor of economic development. However, a more active management of ecological values, including using options for ecological restoration [4] can serve environmental protection and allow sustainable economic development. Active management, with an overall approach to ecological values, requires some compromises on both sides, but also provides some important gains.

The economic advantage which the river offers not only to the communities along the river, but also for the region and in fact for the entire United States could and should be used more intensively, **also** from an ecological point of view. Navigation should from an overall environmental point of view be strongly stimulated, given the relatively low air pollution and high safety levels of river freight versus trucking and even rail. The environmental viewpoint to limit or even reduce navigation should, in our viewpoint, not be adhered to. Instead, navigation for the transport of other commodities than agricultural products, agro-chemicals, coal and steel should be stimulated. River ports and intermodal transport facilities deserve to be developed. The absence of containerized cargo transported by ships illustrates the under-utilization of the river. With such a development, the economies of the communities along the river could be revitalized.

Similarly, the use of the river and the river banks for recreation (boating, fishing, hunting) seems highly under-utilized. Impediments for such development should be removed at short notice. This will support local economies and could lead to the provision of guarantees for environmental conservation: Once river-related recreation develops, maintaining environmental integrity will be much more in the spotlight, since it is the "source of life" for this activity.

Flood Management:

The issue of flood management can be addressed in a much more integrated way. For example, a better understanding is required as to how levees influence upstream flood stages, how raising or setting back levees affect water levels elsewhere, how floodplain vegetation (particularly trees) influences flood stages, etc. In addition, the flood safety levels to be selected, and the method to protect agricultural areas needs to be considered. The Galloway report emphasizes flexibility and variations in flood protection levels. The question still remains: what flood protection levels are appropriate for urban areas/industrial sites and agricultural lands, and how can an agreement on such protection levels be reached? We would not be surprised if the outcome of a study on flood protection levels, that takes into account all flood damages including future developments, would be that higher flood protection levels are economically justified.

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[4]) With ecological restoration we mean to improve the ecosystem from the existing situation to some agreed state, not necessarily the original, pristine state.

Economic Development:
Provided that the issue of flood control is dealt with seriously, parts of the floodplain can be used for industrial development. The prime reason for such industrial development to take place in the floodplain is easy access to (river) transport of raw materials and finished products. Such development will obviously be beneficial for the local and regional economy, but also for the national economy because the resources would be used more efficiently. It seems undisputed that there is a demand for river-front industrial sites. Examples were presented to us in which such developments were not realized because of the low safety levels against flooding. Obviously, an important condition to realize such development is the provision of sufficient flood safety. In our view, such development requires support from and initiatives taken by governmental agencies. This support could be in the context of active regional planning.

3.2 The Role of the Government

To better utilize the rivers resources, a more active role of governmental agencies (state as well as federal) is essential. There also needs to be a means for private concerns to be heard and incorporated.
The Government should assume overall responsibility for providing the conditions along the river for economic growth to take place by means of actively supporting (increased) flood protection, improving and maintaining the infrastructure for navigation, and initiating ecological restoration of the rivers and floodplains.
A number of institutional issues need to be addressed, especially regarding the "mandate" of the US Army Corps of Engineers, and possibly the re-installment of an independent, permanent River Commission responsible for integrated river management. Present regulations regarding benefit/cost analysis need to be revised to allow more types of values to be considered.

3.3 Interaction by Stakeholders

Removal of a number of institutional impediments, and better cooperation by the parties involved in the decision-making process, will allow the river to play an even more important role in the regional economy, without sacrificing ecological values. We would like to present the intensive use of the Rhine river resources as an example for consideration.

The way stakeholders are involved and the way stakeholders contribute to the decision-making process should be changed considerably to avoid further frustrations as currently experienced by many who are concerned about the river and its use. Rather than a climate marked by confrontation, an open atmosphere is required in which discussions can take place without pre-defined positions. Of prime importance in this context is the availability of information. The US Army Corps of Engineers should, in our view, be enabled to make information available to the general public by having a budget for information dissemination.

4 Main conclusions

The following 10 main conclusions were drawn by the DELFT HYDRAULICS' team. Background information is provided in the main report.

1 **Leadership in river management**
A governmental agency with strong and clear leadership in river basin management, and with strong mandates to initiate and coordinate integrated river management and floodplain management, could considerably enhance the rational development of the rich resources of the Basin, while ensuring that environmental conditions will not degrade. Given the 3 **main** issues at stake (flood control, navigation and environmental protection), the US Army Corps of Engineers (USACE) could well fulfill this task. Alternatively, the installment of an independent River Commission, or an extension of the existing Mississippi River Commission (currently only active for the Lower Mississippi) could be considered. This, however, might lead to a less effective setting when compared to the alternative in which the USACE takes the lead. If a River Basin Commission is preferred, the USACE would be an important member of such Commission, as in the existing Mississippi River Commission.

2 **Role of the US Army Corps of Engineers**
The US Army Corps of Engineers (USACE) as **the** responsible agency for river management could be far more effective if the USACE were to have a "mandate" to fully control publicly owned floodplain land and all levees (public and private), and to strive for a wise and balanced use of the river for all users and functions, now and in the future. The USACE should be provided with annual budgets for river basin management in accordance with such a mandate.

3 **River Resources**
The resources of the rivers and floodplains could be used more intensively, without compromising sustainability, providing that planning of the use of the resources is carried out properly. The Government should initiate such planning. Experience in other parts of the world has shown that when stakeholders are actively involved and willing to reach compromises, societies can greatly benefit. The planning process should be steered away from one marked by "confrontation of interests" to one in which stakeholders "actively participate with an attitude of willingness to reach compromises". In developing the river resources (to enhance **both** the ecology and economy), attention should primarily be devoted to navigation, flood management and ecological functioning of the river and floodplain, but other functions of the river should also be taken into account.

4 **Economic Development and Benefit/Cost Analysis**
The nation's huge interest in the economic development of the Upper Mississippi, Illinois and Missouri River Basin seems to be poorly reflected in the restricted way future benefits are calculated in the USACE benefit/cost considerations required for federal investment plans in the river and floodplains. The present estimation of fu-

ture benefits undervalues economic development. Since environmental benefits are not translated in monetary terms, the economic benefits helping to justify environmental protection are not made explicit either. The manner in which future benefits are included in the benefit/cost calculation should be consistent for different types of projects.

5 Farming Concerns

The interests of the farmers on the bottomlands should be properly taken into account in river management, in particular concerning flood management, the farmers' interest in river navigation, and seepage and drainage issues. Damages incurred by farmers due to river and flood management operations need to be compensated (for example additional pumping costs in case higher pool levels cause increased seepage to low lying levee districts). Farmers who move buildings out of the floodplain and allow their land to be flooded in years of excess water should be compensated both for lost revenues from crops and for some of the benefits to society of not having to build more costly flood protection for other areas.

6 River Basin Development Plan

A balanced River Basin Development Plan for the Upper Mississippi, Illinois and Missouri River Basin, to be drafted interactively with wide participation of all parties concerned, will improve the understanding of the complex interrelationships between environmental protection, resource use, and river and floodplain development. Such a Development Plan should not be seen as a static plan, but should serve as a foundation to be revised on a regular basis according to new developments and insights. In such a way this plan will enhance a wise use of the river resources.

7 Decision Support and Information Dissemination

To improve the way in which river (basin) related issues are currently being discussed within and between interest groups, Governmental agencies should devote considerably more attention to providing the general public with information (Public Relations). To assist the decision makers in evaluating alternative solutions for problems encountered in integrated river management, and communicating these solutions and their consequences to the public, an interactive Decision Support System (DSS) would be of great help. This (DSS) should consist of up-to-date river and floodplain information (Geographic Information System and Data Base) and dynamic river models of the complete river network. The public should be informed of the projected results if specific measures are taken.

8 Navigation

Given the importance of navigation for the regional and national economy, and given overall environmental considerations, the Government should invest to allow river navigation to expand. With a limited amount of annual dredging, the depth of the navigation channel can easily be increased to more than 9 feet depth. Benefit - Cost analysis, along with technical analyses should be done for 10, 11, and 12 foot channels. To allow 12 foot navigation, the locks do not need adjustments. The overall environmental balance for more tonnage per tow would be considered positive in

Europe and should be reconsidered in the US, as on the whole, river transport of goods is less environmentally damaging than rail or truck transport.

The existing lock system along the Mississippi and Illinois Rivers is currently used near capacity. An expected increase in demand for river transport, and overall environmental considerations, ask for a capacity increase at the lock system to be implemented at short notice. The study [5] and decision-making process currently underway deserves to be given high priority and, if possible, even be accelerated.

9 Flood management

Given cost considerations, the provision of increased flood safety will for the near future primarily rely on improving the levee system and not on reducing flood stages by means of (large scale) dredging and lowering of floodplains between the levees and the river. Flood safety levels (height of the levees) should be based on cost benefit analysis, but benefits should include the reduction of flood damages to all sectors (housing, industry, transportation, etc.) and also include future benefits (see conclusion 4). This will (automatically) result in a flood control system in which major cities and industrial areas are protected at the highest level, and less economically important and less inhabited areas (agricultural areas) at a lower level. This will provide flexibility (variability and variance) in the flood protection system. During extreme events, the less protected areas will inundate first.

An option might be to raise rural levees upstream of large urban and industrial areas (like for example St. Louis) to 500 year levels. The rural area protected by these levees can provide storage space in extreme events. During extreme floods, these areas could be inundated deliberately to bring down the peak flood stage at urban areas. The provision of such storage space should be considered as a benefit of such development. The operation of such a system will be quite difficult, because the deliberate inundation must carried out at exactly the right moment during the passage of a flood wave.

The USACE should analyze the flood safety levels for urban and industrial areas (currently set at Standard Project Flood, SPF). Similarly, the desired safety level for agricultural levees needs to be analyzed and levee districts should be informed as to the outcome of this analysis.

Whilst observing the intensive (industrial) use of the floodplain northeast of St. Louis, we feel that higher safety levels in the St. Louis area are quite likely economically justified. It may be of interest to note that the existing safety level for levees along the Rhine River in the Netherlands is for a 1,250-year flood for **all** adjacent land uses.

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[5] The Upper Mississippi River-Illinois Waterway System Navigation Study. This study is examining the feasibility of navigation improvements to these waterways to address the problem of delays to commercial navigation traffic. The feasibility study effort is considering small-scale and large-scale improvements to the river system over a 50-year period (2000-2050).

10 Environment

The ecological values of the river and floodplains are best served by integrated management of the river and river basin.

The Upper Mississippi, Illinois and Missouri rivers, although undoubtedly impoverished compared to the "natural state", still exhibit river corridors of outstanding natural beauty and ecological importance. These resources should and can be safeguarded without violating navigation or farming interests. Apart from certain conflicting conditions, which are inherent to the way we have built and now maintain our civilization, many win - win situations are possible and should be explored. While accepting the existing conditions given by the navigation pools, the upstream reservoirs, and agricultural land use, it should be considered which ecosystem values could potentially develop. This should form the basis for a natural resource baseline against which maintenance and restoration plans can be developed.

An important guideline for the restoration of environmental values in the river system is a sound inventory of the river's ecological development potential, on the basis of the current characteristics, of the whole river. It has been noted by the Galloway Committee that information on the distribution, abundance, and ecological relationships of species and a comprehensive inventory and classification of ecosystems is largely incomplete for the upper Mississippi River Basin. It seems that this information gap has since not been filled. Nature restoration should concentrate on the rehabilitation of the river processes, rather than the exact definition or even creation of habitats for specific species. The comprehensive investigation of ecosystem information on basin-level will identify missing components and contribute to the understanding of mechanisms that enhance balanced ecosystem development. If wetlands are well distributed along the river (*"a string of pearls"*), the river ecosystem itself will develop the cover types and species populations belonging to the system.

A consistent approach should be developed to pro-actively set environmental targets, and evaluate the net environmental benefit of policies and measures. We are surprised to hear, for example, that the environmental discussion on navigation development concentrates mainly on wetlands and endangered species, whereas the significant environmental benefit of navigation compared to other modes of transport seems not to be taken into account (see conclusion 8). It is noted that in Europe the overall environmental balance for inland navigation is considered positive, as on the whole, river transport of goods is less environmentally damaging than rail or truck transport.

Contents

1 Introduction

1.1 Background

The massive flooding in the Mississippi Basin in the summer of 1993 had a severe impact in terms of loss of life, considerable damage and widespread disruption. It provided the trigger for an evaluation of the existing flood protection schemes and, associated to this, it brought forward the need to evaluate the procedures for optimal management of the rivers and floodplains in the Mississippi Basin. At the same time, the future use of the rivers and floodplains, especially in the context of economic development, coupled with restoration [6] of ecological values became issues of high relevance.

Historically, much attention has been devoted to solving problems associated with isolated interests. For the Mississippi Basin, these include navigation, hydropower generation, nature conservation and providing a certain flood safety for agricultural lands, industrial and urban areas. Many structural and nonstructural measures have been realized over the years, many of which made important contributions to the economy of the region, the safety of the inhabitants, and the protection of natural values. What seems to be less strongly developed, though, is a clear, concrete and widely accepted perspective (a policy or strategy) on the long-term future water resources development in the Mississippi Basin as a whole.

Recent studies carried out by the Federal Interagency Floodplain Management Review Committee (Galloway Committee), further supported by studies by the US Army Corps of Engineers (USACE), made important steps for such an evaluation and to (re-)formulate the future river management policy. Triggered by the 1993 flood, a basin-wide inventory was made of the flood damage, and various alternatives for floodplain management were evaluated. Although a great deal of relevant work was carried out, detailed and concrete proposals could not be drafted within the scope of this Floodplain Management Assessment project. The economic development potential in the basin was also not studied in depth.

What is called for at this stage is a more in-depth study to determine the feasibility of alternative future river management strategies. Given the wide variety of interests, it goes without saying that such a study should take into account all interests concerned, and be based on solid principles of river basin management, river engineering, land-use planning, and environmental protection. The development of such a strategy up to the level of implementable measures is a formidable task. In this context, two questions are particularly important:

1. Should the river management strategy be based on a continuation of the historic practice of river engineering works, comprising reservoirs and levees to provide a certain flood safety level, in combination with dredging works for navigation? Alter-

[6] With (ecological) restoration we mean to improve the ecosystem from the existing situation to some agreed state, not necessarily the original, pristine state.

natively, a future strategy might focus more on the utilization of the floodplain and the river, in such a way that environmental values are enhanced, while at the same time the potential flood damage is reduced.

2. How and to what extent can the river and floodplain resources be further used by society for the development of the regional and national economy, without compromising the river ecosystem?

Associated with the need for a strategy for river basin management, additional questions can be formulated:

3. How can federal and state agencies be organized in such a way that river basin management can take place effectively?

4. How can the process to arrive at management and development plans be structured so that stakeholders (industry, environmental groups, farmers, urban population, etc.) are actively involved in the planning process?

1.2 Objective of this report

Upon the initiative of the Upper Mississippi, Illinois and Missouri Rivers Association (UMIM Rivers Association), DELFT HYDRAULICS [7] was commissioned to prepare this report.

UMIM Rivers Association promotes the preparation of a plan for economic development, and for an integrated flood management system for the Upper Mississippi, Illinois and Missouri Valleys.

The mission of UMIM Rivers Association is to:
1. pursue maintenance and improvement of the flood control and navigation system;
2. pursue long-range planning to enhance the quality of life and ensure a healthy economic future for the Upper Mississippi, Illinois and Missouri Valleys;
3. educate and inform the public and decision makers on flood control issues; and
4. pursue a balanced relationship with environmental and recreational interests.

In that framework, the objective of this report is to provide a summary of findings of the

[7] DELFT HYDRAULICS, an independent institute for water related research and consultancy, and team members of the current mission particularly, have carried out studies of river management, river basin management and national water resource management in a number of countries of Europe, Asia, Latin America and Africa. Virtually all of these studies have involved computer simulations and extensive modelling efforts to understand river hydrology and hydraulics, morphology, ecology, and the effects of water resource management and land use measures. Many studies have resulted in computerized DSS, "decision support systems", that allow users to "see" the physical and ecological effects of different combinations of water resource and land use measures. Economic analyses can be built into the DSS systems.

Delft Team during its visit to the Upper Mississippi River Basin. These findings concern:

1. evaluation of the existing management practices in the Upper Mississippi Basin and their effects on critical issues of flood control, navigation, and environmental protection;
2. suggestions of how integrated water resources management could be applied to the Upper Mississippi River Basin, including a methodology for the evaluation of alternative management strategies; and
3. recommendations for an integrated River Basin Development Study, which would prepare a detailed plan for future maintenance activities and development of the river basin, including economic development as well as environmental development.

We hope that these three points can contribute to a preliminary plan for future integrated water management.

Lessons learned world-wide regarding river basin management issues, and to provide an "outside view" on river basin management in the Upper Mississippi River Basin was an explicit part of the mission.

We consider this report only the first step in a longer process of re-evaluating the water management in the Upper Mississippi Basin. A two-week mission is by no means sufficient to resolve the divergent views around complicated issues which exist in the river basin, and is certainly not sufficient to draft an integrated plan, ready for implementation.

1.3 Study area

The primary focus of the study has been on the Upper and Middle Mississippi, Illinois and Missouri rivers. The Lower Mississippi River, other tributaries, other parts of the US, or other countries will be brought in where relevant. The study area is shown in Figure 1.1.

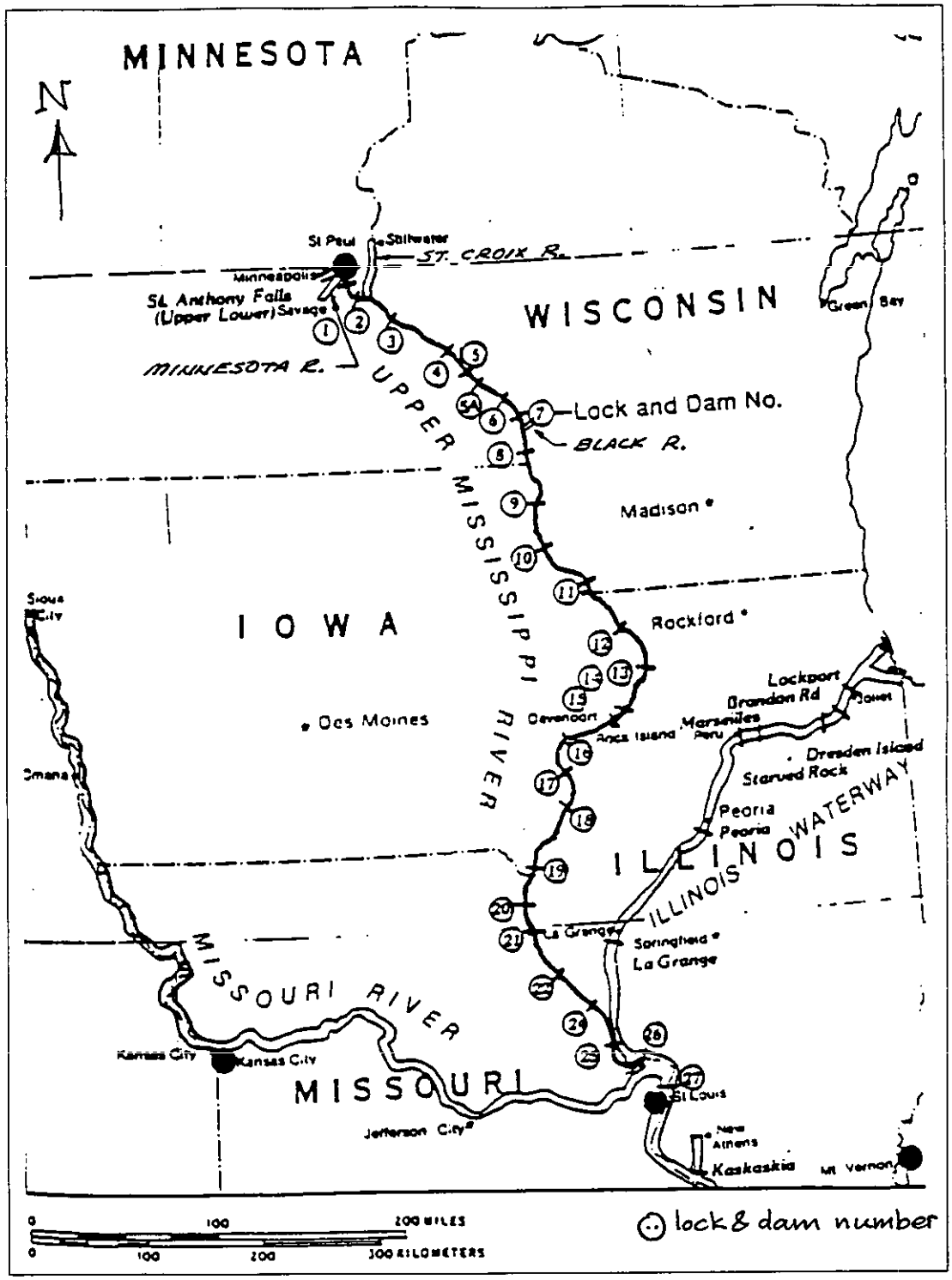

Figure 1.1: Study area (USACE map)

1.4 Activities

During a two-weeks mission in December 1996, a team from DELFT HYDRAULICS visited the US for a fact-finding mission. The team consisted of:

Jos Dijkman, water resources engineer / teamleader;
Bas Pedroli, ecologist;
Caroline Hoisington, economist; and
Wim Silva, river engineer.

While Mr. Silva is an employee of the Dutch Ministry of Transport, Public Works and Water Management, and was asked to join the project given his extensive experience in river management policy issues, his views do not in any way reflect official viewpoints of the Netherlands' government.

The team met with numerous individuals and representatives of governmental agencies, industry and various organizations. In these meetings:

- discussions were held with the UMIM Rivers Association during which river-related issues were discussed and possible alternatives were assessed;
- presentations were given on the experience in flood control and flood management elsewhere (including the Netherlands, Europe, Asia);
- discussions were held with the US Army Corps of Engineers, the Missouri Department of Natural Resources, the Illinois River Strategy Team, and MARC2000 (Midwest Area River Coalition 2000; an organization primarily aimed at improving the waterway) on a variety of river-related issues;
- examples of economic calculations were reviewed (benefit-cost analysis) of raising / strengthening agricultural levees and urban / industrial levees; and
- preliminary findings were reported and discussed.

The results of this mission are laid down in this report, explicitly addressing:

- the issues at hand and the interests of the UMIM Rivers Association;
- the methodology for the evaluation of alternatives, and, in that context;
- ways to ensure that the interests of the UMIM Rivers Association in river and floodplain management are optimally incorporated; and
- relevant options for further investigation, of interest to the Association.

1.5 Acknowledgments

The team from DELFT HYDRAULICS would like to thank all individuals and representatives of government agencies, industry and local communities who shared their time, knowledge and insight concerning the Mississippi, Illinois and Missouri Rivers.

Foremost credit for any success of this mission goes to the Upper Mississippi, Illinois and Missouri Rivers Association, in particular to Mr. John Robb, chairman of the Association. Mr. Robb's enthusiasm, drive, and perseverance regarding issues in dealing with the Mississippi River deeply impressed us. We thank him for making our stay in the US a great experience. In our normal consultancy work world-wide, we only rarely meet

people like John. There may be a few issues where we agreed to disagree with his views, but the open atmosphere that he created never impeded fruitful cooperation. Also thanks to Mike Klingner, Secretary of the Association, for his valuable input. The staff of Klingner & Associates (Quincy, IL) provided logistic support before and during our mission. We thank Norman Haerr and Mike Rausch of UMIM Rivers Association for showing us the rivers and floodplains. Many individuals in the organization of the Association are thanked for enabling us to talk to groups of deeply interested farmers, town, city and state officials, representatives from industry and other organizations. Such meetings were held in St. Louis MO, Quincy IL, Burlington IA, Beardstown IL, Jefferson City MO, Kansas City MO and Waterloo IL.

The US Army Corps of Engineers, in particular the St. Louis and Rock Island Districts and the Missouri River Division (Omaha, NE) provided us with valuable information on their work and enabled in-depth discussions with us regarding potential developments.

The Missouri Farm Bureau, Missouri Department of Natural Resources, Kansas City Chamber of Commerce, and MARC2000 (Mr. Chris Brescia) devoted much time for lengthy discussions on topics concerning farming, environmental resources, business development and river transport. Numerous individuals, city councils, and business people provided local information, personal experiences, and anecdotes on the way in which their lives and communities were integrated and influenced by activities and events around the rivers.

Many individuals and the UMIM Rivers Association reviewed the draft version of this report. We thank them for devoting their time to providing comments, most of which we used for this final version of the report.

All in all we listened to many individuals, and a wide range of opinions on many topics were presented to us. The authors of this report remain solely responsible for the way this information was condensed and presented.

1.6 Contents of this report

This chapter (1) provides the background and introduction to the study conducted. Chapter 2 of this report gives an overview of the societal functions of the Upper Mississippi, Illinois and Missouri Rivers, the complementarities and conflicts of interest. Chapter 3 presents the planning process for river management. Chapter 4 explains how the various functions of a river can be integrated to formulate a balanced strategy, and chapter 5 presents a conceptual plan for river development. In chapter 6 the outline for a complete River Basin Development Study is presented. A glossary of acronyms and terms is presented in chapter 7, while chapter 8 lists references.

The addendum to this report is prepared by the UMIM Rivers Association. It provides a conceptual plan for the development of the Upper Mississippi, Illinois and Missouri River Basins, reflecting the main issues of concern to the Rivers Association.

2 Functions of the river, complementarities and conflicts of interest

2.1 Functions of the river for society

2.1.1 General

The US has a long history in water management and water resources development. Many water control projects were planned and implemented to serve flood control, navigation, hydropower generation, water supply and other purposes, in particular for regional economic development. Hydrological regimes in watersheds were changed significantly by the construction of dams, levees and channels. Development of drainage systems and other land-use changes influenced the runoff pattern. Watershed alterations promoted human welfare, and policy makers saw opportunities to use water development as an engine for economic prosperity. The achievements were impressive: improved safety against flooding, expanded navigation on the rivers, availability of floodplains for agricultural and commercial uses, hydroelectric power production, etc.

There is, however, a flip-side to the coin. In many rivers that are highly controlled, including the Upper Mississippi, Illinois and Missouri Rivers, the natural floodplains were reduced in size due to the construction of levees, reducing the flow capacity during floods. The remaining areas flooded regularly and have slowly been rising, because of silt deposition. River runoff increased due to the loss of upland cover in the basin. The construction of wing dikes made the low flow channel narrower and deeper. Plants and animal species have slowly disappeared. Wetlands decreased gradually as land was converted to agricultural use. However, even to-day the Upper Mississippi, Illinois and Missouri Rivers still contain extensive and important ecological and landscape values.

2.1.2 Transport of water, ice and sediment

The most obvious, but (maybe therefore) also the most frequently overlooked function of rivers is the transport of water, ice and sediment. High interests are at stake to manage (control) these transport functions. The main instruments used in flood management in the Mississippi Basin are the construction of reservoirs, diversions and levees. Navigation, hydroelectric power generation, water supply and recreation also benefitted from reservoir construction. Dredging of the navigation channel at best only marginally contributes to the reduction of flood stages, because the dredging operations are relatively small and much of the dredged material is kept within the river bed.

In the Upper Mississippi Basin, protection levels against flooding vary largely depending on the use of the floodplain. Major urban areas are generally protected by levees which are strong and high enough to withhold a flood like the 1993-flood (probability of occurrence about 1/500 per year). Many small towns in the Upper Mississippi Basin are protected by 50 year levees. Examples include Village of Hull, IL; Henderson County #1 and #2, IL; Des Moines County #7, IA; and West Quincy, MO. Many of the agricul-

tural levees overtopped or failed in 1993. Levees in the Upper Mississippi Basin amount to a total length of about 7,000 miles, composed of 5,800 miles of non-federal levees and 2,200 miles of levees constructed or improved by the USACE.

Water is a source for prosperity but at the same time a source of concern. The 1993-flood refreshed human's memory as to how dangerous a river can be. The damages caused by this event was very high. Flood control works (reservoirs and levees), upland soil conservation measures, terraces and ponds substantially helped in limiting damages, but the question can be raised as to how to effectively reduce the threat of future damage while supporting future economic development in the affected areas.

An important issue for flood control management is what floods can be expected, now and in the future. Of key importance is knowledge about the river system and its "natural" development and about the effect of human interference on this system, such as construction of river works and land use changes. Insight into meteorological events leading to floods is important, as well as possible climate changes. Direct hydrologic and hydraulic consequences need to be taken into account, but also indirect effects on morphology, which may in the long run have a negative effect on the discharge capacity. For future maintenance of the required level of flood protection, insight in the morphologic behavior of rivers is essential. Potentially, a number of options is available to reduce flood risks. These may have a major or minor effect, be expensive or relatively inexpensive, be in line or not in line with the current policy, and be more or less socially acceptable. Possible measures include raising or strengthening levees, set-back of levees, dredging of the main and/or side channels, and the partly lowering of floodplains. In order to bring about sustainable protection against flooding, measures in the upstream and downstream part of the river need to be tuned to each other.

Flood protection and frequency of flood occurrence in the Netherlands
In Dutch water management, safety against flooding has the highest priority. Levees (dikes) protect the economically important low-lying part of the Netherlands; roughly the western half (the Holland part) of the country. The design levels of these levees are linked to the frequency of occurrence of a certain flood stage. These design level frequencies have been determined by Parliament. For the sea levees along the densely-populated and highly industrialized parts of the country, this frequency amounts to on average once per 10,000 years; for the less densely-populated coastal areas the frequency is once per 4,000 years. Along the Rhine and Meuse Rivers, the frequency is once per 1,250 years. The so called design floods that correspond to these frequencies also determine the flood control constraint for all landscape planning projects in the floodplain. Proposed river works for nature restoration, sand mining or any other purpose, need formal approval as stated in the River Act.
The condition of flood control works, levees and fairways is monitored regularly. Every 5 years a formal report on flood safety is made. As stated in Flood Protection Act, also every 5 years the design flood is re-determined using statistical analysis of river flows in the period 1900 to date. Furthermore, data regarding river cross-sections and regarding vegetation type and density are regularly updated. Based on that information, once again every five years, the design flood levels are assessed with flow computations during flood conditions, taking into account effect of wind set-up and a freeboard margin of 20" for overtopping of the levee crests.

2.1.3 Navigation

Inland navigation plays an important role in the transport sector. Much of the transport of goods to and from the midwestern states is undertaken by shipping in barges along the rivers in the Upper Mississippi River Basin. For instance, in 1995 about 75 million tons passed the most downstream locks in the Mississippi River. Navigation on the Upper Mississippi River and the Illinois River is enabled by an extensive lock and dam system (Figure 1.1). Downstream of St. Louis, the Mississippi is a free flowing river. Except when there is ice, the Missouri River is navigable downstream of Sioux City, because of normalization works and the release of water from reservoirs. The present navigation depth is 9 feet. For maintenance of the navigation system periodic dredging is necessary at several locations on the river. The total annual dredging amount is about 3 million cubic yard for the Upper Mississippi, Illinois and Missouri Rivers.

Safe, speedy and economic navigation demands a channel of adequate depth and width, and locks large enough to accommodate the 15-barge tows. In that respect the length of the present locks on the Upper Mississippi River and Illinois is limitative, causing considerable delays (see also section 5.4.2). Furthermore, because of the continued growth of commercial and recreational traffic, some locks are rapidly approaching maximum lock capacities. The width of the navigation channel is at many locations not sufficient for two-way navigation. This further delays navigation and adds to transportation costs. However, reliability and low cost still make inland navigation a competitive means of transport. Other strong points are the relatively low energy consumption and the large transport capacity with few nuisance and safety problems. Air pollution by navigation per ton of cargo is far below that by the equivalent number of trucks required, and is also better than rail.

Inland navigation, the preferred transportation mode in Europe

The Rhine River is the most important shipping route in the Netherlands and is the busiest river in Europe. It is the main shipping route between Rotterdam harbor and the industrial Ruhr-area in Germany: about 160,000 barges annually, or some 500 daily. About one third of the total imports to Germany enters via the Rhine. Total tonnage shipped is currently about 140 million per year.

As a result of economic growth, European unification, the increased accessibility of Eastern Europe and the opening of the Rhine/Main/Danube Canal in 1992, the flow of goods will sharply increase in future. Furthermore, it is expected that container transport, "just in time" production and transport concepts, collection-distribution centres supplying large areas and logistical networks will become more and more commonly used. Ports having suitable water, railway and road connections will develop into intermodal transport centres.

To fulfil these future demands and to offer an alternative for increasing road transport, the Netherlands Government has authorized, widely supported by all kind of organizations and interest groups including environmental groups, a modernization of the Rhine as a shipping route. The environmental organizations prefer increased river transport over the alternatives of rail or truck transport for reasons of lower energy consumption, lower noise, less air pollution and higher safety.

At present, a study is being carried out into options for improvement of the river, which focus on bend adjustment, dredging, channel deepening and the construction of overnight ports.

2.1.4 Agriculture

Agriculture is the leading commercial user of the floodplains along the rivers in the Upper Mississippi Basin. About 70% of the total 6 million acres of floodplain is used for agricultural production. (see Figure 2.1). Important crops are corn and soybeans. Due to the fertile soils, the yield in well-drained floodplains is usually substantially higher than in the upland areas.

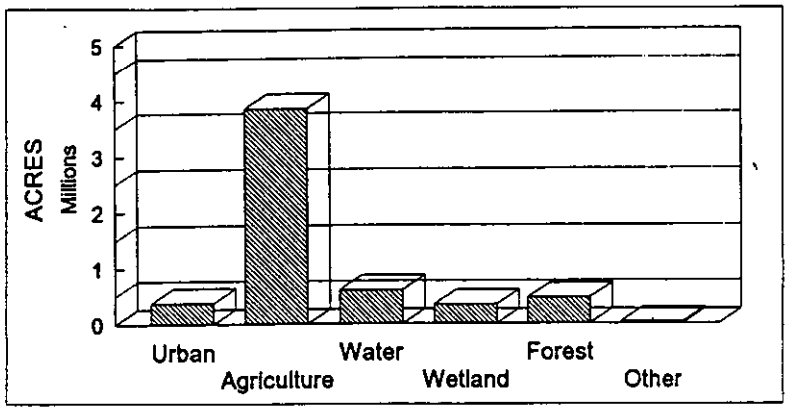

Figure 2.1: Land-use Upper Mississippi Basin (FPMA study, USACE, 1995)

2.1.5 Industry

Mainly in the direct vicinity of towns, a small but highly valuable portion of the floodplain is occupied by industries. Floodplains well protected by levees offer industry the advantage of immediate access to inland water transport to bring in raw materials and transport finished products, and immediate access to cooling and process water.

2.1.6 Environment

Originally, large wetland areas were found in the Mississippi River Basin. Wetlands are unique links between land and water. Some wetlands are almost continuously under water, whereas others may be flooded for only a short period. This means an impressive variety of wetlands and their specific habitat types and functions. Through these special conditions, wetlands are among the most biologically productive natural ecosystems in the world. They can be compared to tropical rain forest and coral reefs in the diversity of species they support. For this reason, wetlands are recognized as vital to the survival of various animals and plants, including threatened and endangered species.

Furthermore, wetlands play a role in the reduction of peak water levels during smaller flood events (flood events that occurs every few years), because of their capability to store floodwater and release it slowly. We expect that in the case of large events like the 1993-flood, the effect of wetlands on high water levels is marginal because wetlands were saturated by rainfall or already flooded in an earlier stage.

Starting in the mid 1800's the area of wetlands decreased gradually. This development

was triggered by the large scale occurrence of malaria and other water borne diseases. Wetlands were converted to agricultural land and to a smaller extent converted for residential and industrial use. Currently, wetlands account for about 10% of the floodplain in the Upper Mississippi Basin. Compared to Western European conditions, this is still a fairly large proportion; along the Dutch Rhine branches only 2% of wetlands remain today. Since the early 1970's the value of wetlands is recognized more and more, resulting in federal laws and regulations for protection of the remaining wetlands. In future, the number and quality of the wetlands should even increase.

Restoration of wetlands: higher flood levels?
The restoration of wetlands may raise flood heights due to the restriction of flow by vegetation, such as forest and brush. If this is not acceptable, flow increasing measures by (partly) lowering the floodplain by excavation or creating (more) side channels should be included in the restoration plan. Grazing by cattle and horses is an option to keep the density of forest and brush within certain limits. This method is currently used in the Netherlands.

Apparently, some eight refuges along the Upper Mississippi and Illinois Rivers are leveed. We suspect that the ecosystem in these refuges are more similar to "dry-land" (upland) ecosystems, than to the ecosystems of pristine wetlands. Therefore, in this report we do not consider such leveed refuges when discussing riverine wetlands.

2.1.7 Recreation

Wetlands, storage lakes, and the river itself provide considerable opportunities for recreation. Popular activities are hunting, fishing, camping, boating, sight-seeing and bird-watching. River-related recreation is of considerable importance for the economy of local communities.

The locks and dams provide many recreation lakes and the opportunity for boating, skiing, fishing and hunting.

2.1.8 Historical and cultural resources

Floodplains along the rivers contain numerous archeological and historic sites. These sites include historic architectural and engineering features and structures, and resources of traditional cultural or heritage significance to Native Americans and other social or cultural groups. Examples are forts, quarries, potteries and burial sites. Construction activities in and along the river, streambank erosion and extreme floods have the potential to affect these values.

Levee strengthening, saving historical and cultural values
While in the mid 70's levee strengthening schemes were underway, protest grew against their harmful effects on landscape, nature, cultural and historical values. After almost 20 years of discussion, the Government installed in the early 90's an advisory committee to look into possible options to mitigate the effects of floods and at the same time save these values. Several recommendations for alternative methods of levee construction in sensitive areas were made. The government followed the recommendations set out by this committee: Protection of historical and cultural values is explicitly integrated in the procedures for levee strengthening. Furthermore, since this new policy required a higher budget, the government decided to extend the time of completion of the strengthening program to the year 2011. This decision was, however, revoked after the 1995-flood. Presently, levee strengthening is speeded up to be completed in the year 2000.

2.1.9 Hydropower

Besides flood protection, the priority objective of the reservoirs in the basin, reservoirs in rivers also provide hydroelectric power. In the main stem of the Missouri River six such reservoirs were built. Nearly all the Missouri water passes turbines. Hydropower provides approximately 9 percent of the combined energy used in the Mid-continent Area Power Pool, which includes Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and portions of Illinois, Montana and Wisconsin.

2.1.10 Municipal and industrial water supply

The rivers are a source of water for municipal and industrial use: drinking water, processing and cooling water, and irrigation. The number of people that obtain drinking water from the rivers is quite large. In Missouri alone, some three million people get their water from the Missouri River. The amount of water extracted for these purposes is unknown but is expected to be small when compared with the river discharge. As long as the return flow from this water use (after proper treatment) is drained back to the rivers, this water use can be considered of minor importance in the overall water balance of the rivers. The export of water from the basin to other basins (ideas were mentioned to divert Missouri water all the way to Denver) deserves very careful consideration.

2.1.11 Disposal of waste and cooling water

After industrial or domestic use, the water is, in most cases after treatment, discharged into the river. This can have locally a negative effect but the water quality of the rivers is generally classified as good. A major reason for this is the small amount of waste water, compared to the river discharge.

2.2 Complementarities and Conflicts of Interest

2.2.1 Interactions among user groups

Some of the uses and users of the river listed above, but relatively few, have no effect at all on each other, even if they take place on the same river. Some have very large effects, ranging from total interdependence to mutual exclusion. In general, there is a range of degrees of positive and or negative interactions. The effect that one type of activity will have on another is determined by how and where those activities are designed and implemented. For example, an industrial plant discharging chemical effluent into the river can have a very negative effect on the riverine environment, but the same plant, if it treats its effluent completely or does not use the river for disposal may have no negative environmental effects. Similarly, soil conservation measures in an upper watershed may have positive effects on farmers downstream if erosion and sedimentation are reduced, whereas environmental protection activities that take the form of limiting agricultural practices or prohibiting cultivation of certain areas may have a negative effect on the farmers involved.

In general, the argument developed briefly here is an important one in the process of developing a river management plan. It is that:

The interactions among activities in and along the river can be made more compatible and less mutually damaging when they are well planned and when the users of the river have negotiated among themselves about their activities. Where damages are unavoidable, conflicts can be minimized if compensation is agreed upon, preferably in advance.

In Table 2.1 (Interactions among potentially conflicting river activities), a rough indication of the ranges of some of the more potentially conflict-causing interactions is shown. The table is to be read so that the columns headings give the activities that affect the activities shown in the rows. Scores of +1 and +2 indicate complementarity and positive interactions, 0 is neutral and -1 and -2 are competing or negative. The scoring is generalized, but the point is that these numbers can be pushed towards the positive side of the ranges, representing fewer conflicts and more positive interactions when planning is done.

	scoring the effects of:						
	Flood control structures	Agriculture in the floodplain	Industry in or near the floodplain	Shipping channel dredging	River-based recreation	Historical & cultural preservation	Environmental protection
on flood control		+1 to -1	0	+1 to -1	0 to -1	+1 to -1	+1 to -2
on floodplain agriculture	+2 to +1		0 to -1	+2 to +1	0 to -1	+1 to -1	+1 to -2
on industry in or near floodplain	+2	+1 to 0		+2 to +1	0	0 to -1	0 to -2
on river navigation	-1 to +1	0	+1 to 0		0 to -2	0	0 to -1
on river-based recreation	+1 to -1	0 to -1	0 to -2	0 to -1		+1 to -1	+2 to +1
on historical & cultural property	+2 to -2	0 to -1	0 to -2	0 to -1	+1 to 0		+2 to 0
on condition of river ecology	0 to -2	+1 to -1	0 to -2	0 to -1	+1 to -1	+2 to 0	

key: +2 = necessary, or highly complementary and positive effects;
+1 = generally positive;
0 = neutral: no particular advantage nor conflict (small interaction);
-1 = implementation of one means a restriction or damage to the other; and
-2 = mutually exclusive and therefore completely in competition, or highly damaging.

Table 2.1: Interactions among potentially conflicting river activities

There are other important uses of water that are not mentioned in Table 2.1, because the interactions are obvious and straightforward. Supplying municipal and domestic public water systems is one. Hydropower is another. They are left out for the clarity of the table.

Observations of the Delft Team:
We learned that some of the categories of conflicts indicated in the table above are causing serious problems in the Upper Mississippi Basin. Furthermore, some of the potential positive interactions are only weakly developed. The sharpest conflicts appear to be those between environmentalists and agriculturalists, and with those who would develop industrial sites through flood control and increased river shipping, but are constrained by legislation limiting land development in the floodplain directly or indirectly.

Currently, the following three **main** issues are at stake: environmental protection; navigation; and flood protection. Developments in navigation and flood control are of great importance for economic development. Economic development will be the result of improvements made on in particular these two issues, but can also be stimulated by increased tourism resulting from improved environmental conditions. In this line of reasoning, economic development in not an issue in itself. It goes without saying that there are other important issues related to the various functions of the river (recreation, drinking

water supply, hydro power generation, commercial harvesting, etc.). We feel these issues are currently not the **main** issues.

A significant number of farmers now consider environmental concerns by and large as expressions of urban outsiders, who have somehow gained the right to criticize the farmers' activities on their own land, and they are resentful or worse. In some cases, environmental regulations are viewed as threats to farm livelihood. Furthermore, when the reasons for regulation involve the preservation of animal or plant species that seem either insignificant or even to be nuisances to the agricultural community, the regulations are perceived to be insulting and an assault. The cartoon shown here is a fairly accurate perception of some of the agricultural community. Whatever the pros and cons of the regulations, when the conflict of interests have reached the stage that some of the parties feel threatened, willing compliance with regulations drops and conflict resolution becomes far more difficult.

Figure 2.1: Cartoon from the Colorado Springs Gazette Telegraph (Creators Syndicate, Inc, 1994)

The above Table 2.1 indicates direct interactions. Indirect interactions are not listed, although they may also be very important. For instance, the effect of industrial development in or near the floodplain on river ecology is scored at 0 to -2, because industrial effects may vary between environmentally neutral, moderately polluting to so badly polluting that they destroy habitats. Industry is rarely directly complementary or positive to

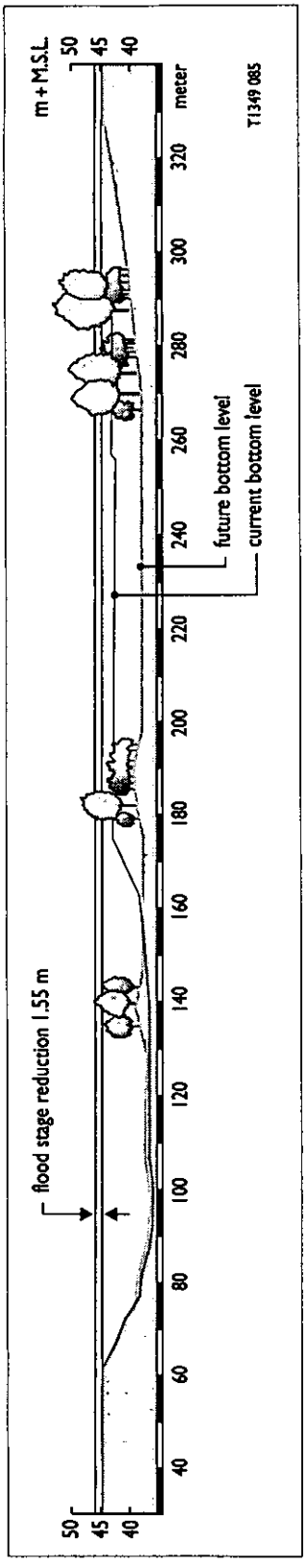

Figure 2.2: Existing and future Meuse river cross section near the city of Maastricht.

environmental concerns in floodplains. However, if the commitment is made to use some of the revenues, through taxes or other means, generated by industrial development to enhance environmental conditions (e.g. using some funds to establish conservation areas) then the indirect effects of the industrial development on the environment may be positive (score +1). Such indirect effects can be important in negotiations among user groups.

Win - win
Along part of the Meuse River in the Netherlands, a far-reaching plan is being developed to improve flood protection while at the same time restoring near-natural river conditions. This is realized by large scale excavation of the top layer of floodplain sediments (see Figure 2.2), involving some 130 million ton of sand and gravel to satisfy demands by the construction industry. At the same time, flood protection will considerably be improved, because flood stages will go down. This comprehensive plan is adopted by the regional and national agencies and is now subject to environmental impact assessment. Given the economic value of sand and gravel, the plan should be nearly budget-neutral.

2.2.2 The conflict over flood protection and changes in preferences over time

There are serious conflicts over the degree and extent of flood control that should be provided. There are various possibilities between two extremes: those who feel that flood protection levels should be raised significantly, primarily by increasing the heights of levees all along the river; and those who believe that development in the floodplain should be actively discouraged, and existing use should be reduced. Arguments for the first option are largely that economic development in the region, particularly farming and industry, will greatly be served by protection from floods. The arguments for the latter are primarily that floodplain protection and compensation for flood damages are very expensive and that there is no compelling reason for the nation to subsidize floodplain development when alternative sites for agriculture and industry exist outside the floodplain. Floodplain protection measures are also frequently not environment-friendly. Decreased floodplain development allows a return to more natural conditions.

Both arguments are rational, and their proponents are generally strong in their beliefs. Furthermore, preferences of interest groups change over time, and the policy climate changes and evolves. Environmental groups have far more influence at present than they did 25 years ago. In some cases, flood control measures are complementary to environmental interests, particularly when the measures involve setting back levees, lowering floodplains or making parallel, unregulated channels or levees that protect or encourage the re-establishment of certain kinds of habitat. In general, however, environmental interests favor less engineering and lower rather than higher levees. River dredging is highly controversial. This puts environmental groups in strong conflict with those advocating floodplain development.

Levee strengthening

In February 1993, after almost 20-year discussion over strengthening some 1,500 miles of levees, the Dutch government announced a new levee strengthening policy, which would also take the landscape, cultural and historical values along the river into account. The strengthening program was to be completed by 2011.

Then, in December 1993 and January 1995, the rivers flooded. During the 1995-flood about 250,000 people were evacuated because the local water boards could no longer guarantee the stability of the 400 miles of levees that by then still needed to be strengthened. Fortunately, none of the levees failed, but it was obvious that something had to be done. In March 1995, the Dutch government decided on the execution of the so-called "Delta program for the main rivers". This program includes acceleration and completion of the levee strengthening program by the end of 2000 and preservation of the high value of historical and cultural resources involved.

This decision could be taken soon after the 1995-flood, because just a year earlier a study was completed which found solutions: levee strengthening methods that would not destroy the cultural and historical values that the inhabitants wanted to preserve. The study produced compromises acceptable to both sides. If it had been carried out earlier, the flood protection might have been completed earlier; as it was, the solutions were ready when the experience of the flood and a near disaster provided the urgency and political will to "get it done".

2.2.3 Role of government in resolving conflicts

To resolve conflicts between difference interest groups will require:

- extensive data collection, much of which is currently being done;
- expert analyses of the implications of different measures to control flooding and different mixes of land use, with different degrees of flood protection in different areas, much of which is also done at present, but which should be even broader in scope to allow for long-term basin-wide planning;
- presentation of the results of the analyses in ways that are accessible and understandable to stakeholders and decision-makers, currently a major effort of the USACE, which should be supported and extended;
- methods to allow debate, negotiation and compromises among stakeholders;
- development plans which include decisions about what will be done where, minimizing conflicts as much as possible and possibly providing compensations for users

whose interests are damaged; and
- implementation of plans that includes sensible incentives, clear roles for the public and private sectors and plans for financing the activities.

How such planning can be achieved is described in chapter 3, and an outline of such a plan is presented in chapter 4.

Upper Missouri Reservoir Operation
An example of a currently ongoing study in the U.S. that attempts to find an acceptable solution for the question how to operate the reservoirs on the Upper Missouri river is the study on the management plan for these reservoirs. The study is exhaustive in its examination of possible management alternatives and the implications of several hundred different water release regimes. Most were rejected in the process of evaluation and comparison and only a few remained. The preferred plan is now in the final stages of approval, and has the form of a draft Environmental Impact Study. However, the results appear to be quite controversial. It also appears that the effects of reservoir operation on the Middle Mississippi were not adequately addressed by the study. A revised Impact Statement is anticipated to be completed by May 1998.

3 Planning process

3.1 The need for an integrated planning process

From the complex interrelationships between the issues described in the preceding chapter, it is clear that a proper planning of river management in the Upper Mississippi River Basin is only possible when the problems described are approached in an integrated way. We have noted that several successful attempts have already been made to shift from the traditional one-sector approach towards a more comprehensive one. However, much still remains to be improved, as has been pointed out extensively in the Galloway Report and the FPMA study.

Upper Mississippi River System Environmental Management Program
An example of comprehensive river management is the Environmental Management Program, established by Congress in 1986. It is based on a cooperative approach, enhancing the navigation system on the Mississippi by authorizing construction of a second lock at Locks and Dam 26 in Alton, Illinois, while establishing at the same time the Upper Mississippi River System Environmental Management Program. The program consists of five elements:

- Habitat Restoration and Enhancement projects
- Long Term Resource Monitoring
- Recreation Projects
- Economic Impacts of Recreation Study
- Navigation Monitoring

The recent studies have shown that ways of setting and revising goals and strategies are gradually changing. It is realized more and more that even a technically flawless plan has scant chance of success if it does not take into consideration the sociological, cultural, environmental, economic and institutional situation. Also, river stakeholders should be included in the decision-making process as early as possible. This will ensure cooperation with and commitment to river management plans that are eventually adopted.

In the 80's, river managers all over the world became aware that all types of water use should be considered together in order to cope successfully with the water related problems of modern society. This led to the concept of *Integrated River Management. Integrated* means that in river management the following relationships should be taken into account:

- the interactions between the abiotic and biotic part of a water system and the relationships between different water systems;
- the relationships between all involved interests: both sector interests such as navigation, industry, agriculture, recreation, etc., and aspects such as safety, the environment, the economy and physical planning; and
- the relationships between the many public bodies which have authority and a say in water management.

It is reported in the FPMA main report (pp. 2-20 seq.), however, that national floodplain management policy did not follow the above developments in integrated river manage-

ment. In the Water Resources Act of 1986, non-structural flood control was given greater status, but interest in nonstructural solutions had declined. Previously, the Water Resources Council's *Principles and Guidelines* had required the USACE 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. An Upper Mississippi Commission was abolished in 1980 together with the Water Resources Council.

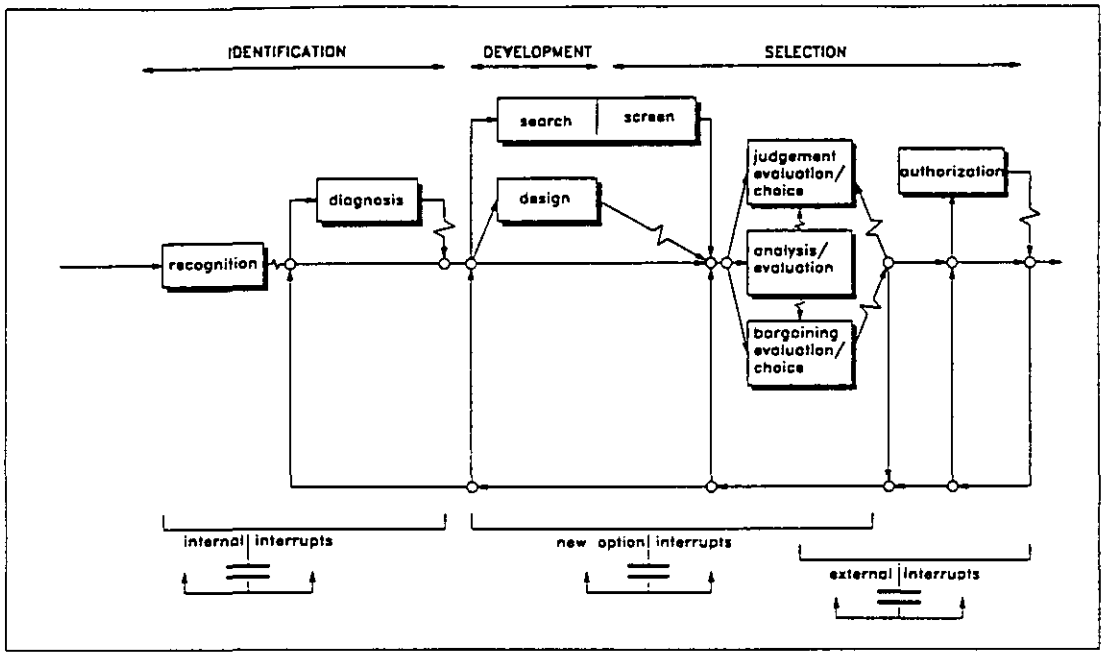

Figure 3.1: A general model of decision processes (Mintzberg et al., 1976)

A decision-making process is not a simple linear sequence of steps (Figure 3.1). Characteristic for a decision process is the presence of factors that cause a feedback to earlier steps of the process. Part of the process is thus intrinsically iterative. Feedback loops are needed when:

- solutions fail to meet criteria;
- new insights change the perception of the problem and its solutions;
- essential system components and links have been overlooked; or
- situations change (political, international, developments in society).

In this chapter, the planning process in integrated river management is discussed with reference to the planning issues in the Upper Mississippi River Basin.

3.2 Main principles of integrated river management

Three subsystems are identified within the river management system (Figure 3.2):

1. the *natural river system* where physical, chemical and biological processes take place (this is illustrated in the figure as "resources");

2. the *socio-economic system*: the human activities related to the use of the natural river system (illustrated as "population");
3. the *administrative and institutional system*, represented by the "river manager" (illustrated as "institutions").

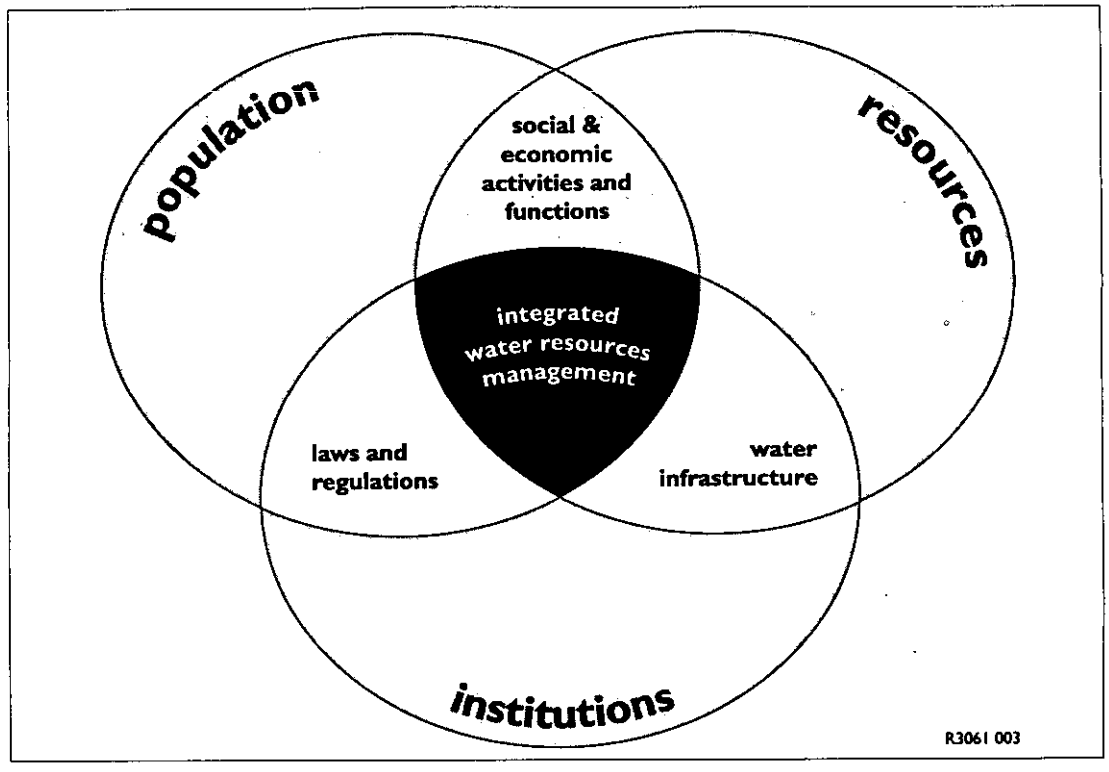

Figure 3.2: The River Management System with its subsystems

Relationship between the natural and socio-economic systems
The natural system supplies natural resources to the socio-economic system, but, as the 1993 Mississippi flood and the drought of the late 80's / early 90's showed, the natural environment can also be hostile to man. The assessment of natural and man-induced risks plays an important role in any river basin management plan.

Relationship between the natural and administrative systems
In order to counter hazards, to increase the economic development, or to strengthen the ecological function of rivers, the authorities have directly influenced the processes in the natural system through structural (i.e. engineering) measures. These types of measures physically influence the natural processes in the river basin. Traditionally, these engineering measures comprise infrastructure such as dams, locks, levees and revetments. Recently, also habitat restoration measures have been taken into consideration, such as restoring secondary channels (e.g. Boyer Chute, Omaha, NE, see text box).

Relationship between the administrative and socio-economic systems
Besides carrying out structural measures to influence the natural environment, river au-

Missouri Habitat Restoration
Boyer Chute National Wildlife Refuge is a joint federal and local partnership to restore a portion of the Missouri habitat that flows through a 2-mile-long channel paralleling the main flow of the river, 8 miles north of Omaha, NE. The project is part of the region-wide Missouri River Streambank Stabilization and Navigation project and was made possible through the local acquisition of the land.

thorities have also tried to guide the use of the river by legislation, planning, subsidies, special taxes, permits, education, flood warnings, etc. These administrative measures influence the users of the river and thus the demand for natural resources.

Towards balanced river management
A well-balanced river basin management plan comprises both structural and administrative measures, while taking into account the resources offered by the river. The costs of the measures should be thoroughly weighed against the benefits for the various users of the river. For this evaluation, data and models of both the relevant natural processes and affected user functions are required for the prediction of the expected effects of measures. The whole process of data collection, model building, strategy design, impact assessment, evaluation and communication of the results to the decision makers and the public, should be covered by the planning process.

Policy development Lower Rhine River
In 1991, World Wildlife Fund Holland issued a radical plan ("Living Rivers") to lower the floodplains along the Rhine branches in the Netherlands to increase discharge capacity and develop flowing shallow riverine habitats. Also, navigation as en environment-friendly means of transport, would benefit from the plan. The costs of the plan could supposedly be covered by benefits in selling the materials (clay, sand, gravel) won in excavating the floodplain. Parliament requested the Minister of Transport, Public Works and Water Management to evaluate the feasibility of the plan. The Minister initiated a study to analyze the consequences of the plan in several variants. On the basis of a hydrodynamic model, a thorough inventory of existing agricultural, cultural and nature values, the effects and benefits of the plan were identified. It appeared that the plans proved unfeasible, and would surely not be neutral in budget. It also appeared that it was quite difficult to assess the consequences of measures to be taken in various parts of the floodplains simultaneously, because of the complex feedback relationships *between river flow dynamics and cross sections.* Also, the morphological consequences proved difficult to assess.
In 1994 a follow-up project was defined to build a Decision Support System (DSS) for the integrated planning of floodplain use and river management. In this DSS all existing local floodplain development initiatives were included as a basis to compose alternatives for the integrated evaluation thereof. Interactive manipulation of the definition of the selected alternatives allowed for optimization in terms of flood stage reduction or navigability. The DSS now serves as an effective tool for presenting the consequences of various floodplain development alternatives to the public as well as to local authorities.
Currently, at several locations river restoration along the lines of "Living Rivers" is being authorized and carried out. The main principles of the plan have been adopted as one of the promising ways of reducing flood risk along the Rhine branches in the Netherlands.

3.3 User functions

Chapter 2 has described the various functions of the Upper Mississippi Basin System. Each function reflects an interest or value with regard to the use and management of the river system. In other words, for each function a group of stakeholders can be identified. Therefore, identification of all users, and the formulation of appropriate objectives for each user is an important activity in an early phase of the planning process. Each objective must have a matching criterion to evaluate the achievement of that particular objective. The formulation of objectives and criteria specifies the information the decision maker is most interested in when deciding on a river management plan. Criteria to measure trade-offs are discussed in some more detail in section 4.3. Table 3.1 summarizes the main uses of the Upper Mississippi.

Main uses of the Upper Mississippi, Illinois and Missouri Rivers	Natural resource
agriculture	suitable floodplain land, water for irrigation
navigation and ports	water way with certain water depth and width, possibly with certain season of navigability
recreation	hunting, fishing, bathing and boating opportunities, open space (locations for camp sites near the water)
ecosystem functioning	natural river dynamics, cover type patterns and habitat characteristics
households and municipalities	adequate (drinking) water at all times
industry	suitable floodplain land, easy access for transport (shipping), cooling and process water
hydropower	surface water head loss, reservoir

Table 3.1: Main uses of Upper Mississippi, Illinois and Missouri Rivers, and related natural resources.

3.4 Upstream and downstream relationships

3.4.1 Water: an easy medium to transfer external effects

One of the most complicating factors in the integrated management of the Upper Mississippi, Illinois and Missouri Rivers is that any measure taken has not only effects on other functions but also on the functions of other stretches of the river system. Such effects are called external effects (or externalities): they are external to the objectives of the person who caused these effects.

An obvious example of an externality is where an upstream city discharges untreated effluent in the river without compensating the additional water treatment cost at a drinking water plant that takes water from the river further downstream. Constructing the effluent drain solves the problem of the city: its objective is satisfied. In making this decision the city may not have considered that this development might harm other water users: such effects were external to its objective. Any change in the hydrologic cycle, be

it quantitative or qualitative, can also be viewed as an external effect. This phenomenon is often called the 'Tragedy of the Commons', a metaphor introduced by the biologist G. Hardin (1968). It describes the behavior of the individual farmer who lets his sheep graze on a common pasture. By increasing his own flock of sheep his individual earnings increase, even if this implies that the total pasture is being over-exploited. The burden of this degradation however, is carried by the whole community.

External effects are often of a type for which the ordinary free market does not ask payments from favored parties nor requires compensation for injured parties. Being trusted with the care for the well being of the society, the state or federal government has a task to regulate these uses and developments, making sure that detrimental external effects are avoided or compensated. The 'polluter pays' principle is based upon the notion that the polluter should compensate injured parties for damages incurred by the external effects of his activities. As a matter of fact, parallel considerations apply for the induced flood stage effects of developments in the floodplain. It requires a government agency to thoroughly analyze the potential effects of developments in the floodplain in advance, and draw up and execute laws to make the developers pay, unless federal interests suggest financial compensation under some program.

Upstream - Downstream Conflicting Interests
Typical examples of upstream - downstream relationships in river management are the problems of cross-boundary rivers.

Rhine River
The Rhine River is a major economic artery of western Europe, which drains 72,000 sq miles of land in 9 countries. During extreme events, high flood stages in the Netherlands can occur. In February 1995, 250,000 residents of levee protected areas were evacuated, because the chance of levee failure was no longer negligible. Fortunately, the levees held, but the call for international cooperation in flood protection was strong.
Also, emissions of contaminants both from France and Germany degraded the water quality downstream, affecting water intake for drinking water production and other uses in the Netherlands.
For the purpose of flood protection and of safe and unlimited navigation, an international commission was installed. Later, a commission was installed for environmental restoration, concentrating on water quality issues.

River Danube
The River Danube provides a main transportation channel of 2,000 miles long, connecting Western Europe through Central Europe with the Black Sea Basin. Also here, major structural works, among others in Austria, have influenced drastically the discharge characteristics of both water and sediments downstream. Recently, an international conflict between the riparian states Slovakia and Hungary over the disputed construction and operation of a large hydropower station on the interstate boundary has given rise to a lawsuit at the International Court of Justice.

3.4.2 Missouri upstream - downstream conflicts

Where water quantity is limited compared to needs, upstream-downstream conflicts occur, and this is presently the case in the Missouri River. Upstream users include in particular the recreation industry. Revenues are presently generated from river-related and outdoor tourism such as hunting and fishing, boating and camping. Keeping upstream reservoirs full is a high priority issue to meet these interests demands.

Downstream interest groups are concerned whether enough water will be available to keep the river navigable as long as possible each year and at the same time whether the storage capacity of upstream reservoirs is managed to maximize flood control downstream. Both these purposes imply that more water is released during the year, resulting in lower reservoir levels. The original reasons for constructing the upstream reservoirs were: 1) flood control, 2) navigation, 3) water supply, and 4) hydropower. The master plan study for reservoir management currently being undertaken by the USACE (usace, 1994), is analyzing the effects of different reservoir management regimes in detail. This study represents the sort of effort that will be needed to provide to user groups the information needed to negotiate options rationally.

A third group of users exists: those in the middle who have, or wish to have, the right to withdraw water from the river for some extractive use (which means that the water will not be returned to the river) and who have, or may have, the right to charge other parties for the use of the water. These middle groups include several Indian tribes who have filed legal claim for water rights, based on historical claims that were ignored and/or violated in the past. These tribes want to earn revenues from water resources they consider to be rightfully theirs, by selling some of the water to others. The effect of the resolution of these claims will be largely a question of legal interpretations of who will get the benefits if the resources are used. The question of how the water is to be used would be settled on a willingness-to-pay basis; the highest bidder would presumably be willing to pay the most because he was making the most efficient use of the water. However, the allocation of water rights and distribution of revenues is not necessarily considered equitable by other users.

There are developers who suggest a number of extractive uses such as water diversions in order to mine coal and transport it as slurry by pipeline. We were told that such issues were temporarily resolved by lawsuits brought by downstream water users and ruling that the USACE did not have the right to give a permit for the extractive use of the water. The ruling apparently did not state which organization, if any, had that right, and a number of other requests to use water for extractive purposes were hence withdrawn.

From our observations we hold the opinion that the condition of the Missouri River itself is not particularly poor for shipping, nor for environmental restoration purposes; conditions for both uses could even be improved and still remain complementary. However, a number of potential conflict areas exists in water allocation. To the extent that there are unclear areas in the law, so upstream-downstream user conflicts may be expected to arise again in future.

3.5 Decision making in Integrated River Management

3.5.1 Principles

As river management situations become more complex, river managers require means of tackling complex problems in a clear way. They need methods, tools and expertise that allow them (and parties of interest) to understand what is happening within the river system and be able to suggest on how best to steer it through shifting scenarios. This section addresses the decision-making process aimed at developing and implementing an integrated river management plan for the Upper Mississippi River Basin.

3.5.2 Involvement of authorities and stakeholders

Integrated river management means that, in addition to the interconnections between the abiotic and biotic part of the riverine ecosystem and the different user functions, the relationships between the various public bodies which have authority and a say in river management should also be taken into account. A large number of agencies is involved in river management in the Upper Mississippi, Illinois and Missouri River Basin.
River management acts at various geographical scales comprising the river basin level, the federal level, the regional level and the local level. Listed below are the main organizations involved in river management at different levels:

Geographic scale	Decision makers (policy decisions and permitting)	Stakeholders	Operation and Maintenance
River basin / Federal level	USACE, F&WS, NRCS, Coast Guard		USACE Divisions (Reservoirs)
Regional level	State Depts. (especially DNR), Drainage Districts, Bureau of Reclamation	Drainage districts; UMIM Rivers Association	USACE Districts; Bureau of Reclamation; Drainage Districts
Local level	Land owners, Counties	Land owners (agricultural, industrial, recreational enterprises); interest groups and business associations; UMIM Rivers Association; Environmental Groups	Land owners; sometimes state or federal organizations (like F&WS)

The multitude of authorities and stakeholders involved requires a good communication between parties and clear decision procedures. It has been stressed in all studies since the 1993 midwest flood that communication and discussion with other authorities, stakeholders and the public is a substantial part of the tasks of the river management authorities. No matter how difficult and complex discussions and negotiations may be, they should always be aimed at making the primary tasks of the river manager more effective and more efficient.

3.5.3 Role of existing institutions

US Army Corps of Engineers
We observed that the US Army Corps of Engineers (USACE) generally has a very up-to-date attitude to the responsible task they have in the river management of the Upper Mississippi Basin. This is shown in the comprehensive approach elaborated in the FPMA study, and in the Missouri River Master Water Control Manual Review and Updating study (USACE, 1994). It is also shown in the commitment of Districts and Divisions in many instances to incorporate other river uses than the traditionally covered issues of navigation, flood protection, drought prevention and hydropower. It is recognized that sensitivity to environmental impacts and environmental restoration is a primary mission and part of the actions of the USACE. However, major constraints in the effective implementation of integrated management policies presented to the Delft Team are:

1 the virtual absence of USACE control over developments in the floodplain affecting flood risk;
2 the "mandate" of the USACE, being limited to flood control and navigation, and not allowing sufficient room for integrated river management;
3 the absence of one coordinating body for the whole Upper Mississippi Basin;
4 the lack of a proper Integrated River Management Decision Support System, based on dynamic hydraulic modelling;
5 the lack of a general River Management Development Plan for the Upper Mississippi Basin; and
6 the rapid turn-over of administrative commanders, impeding continuity in Corps' policy.

Other Institutions
A large number of other institutions have a say in the floodplain management and flood control, under a multitude of policies and programs, both Federal and State. The Galloway Committee drafted recommendations regarding the role of these institutions to improve efficiency of river basin management. It is disappointing that hardly any of the recommendations have been followed up.

3.5.4 Role of the private sector

The role of the private sector is extremely important in the planning process for sound river management in the US. Since entrepreneurs and land owners have strong rights in the development, operation and maintenance of their properties, local developments in the floodplain tend to be uncoordinated in the sense of direct or induced flood risk. The UMIM Rivers Association plays an important coordinating role here, to

- join efforts in reducing flood risk basin wide;
- prevent individual interests to be affected negatively by measures taken elsewhere; and
- act as a major stakeholder in the discussion with state and federal agencies on floodplain management.

It has been stressed in many reports that the development of structural flood protection works on the rivers has in the past in fact encouraged land use in vulnerable flooding areas, which otherwise would not have been used. Although this would imply that currently in many places no wise use is being made of the bottomlands, it is unjustified to blame land owners who were attracted by former flood protection programs. Society has to account for the historic decisions that have stimulated the use of the bottomlands and led to the current situation.

Wise use of floodplains: an historical dilemma
After World War II, intensified river flood protection policies were initiated in many European countries. For example, in the Netherlands levee strengthening works were realized to guarantee 1,250-year flood protection to inhabitants of the levee-protected lowlands. Areas which formerly functioned as by-pass and overflow capacity were also protected to this safety level.
After the high 1993 and 1995 floods of the Rhine River, it was reconsidered whether these areas should be re-established as overflow areas to increase flow and storage capacity. Although this might be an effective measure in flood stage reduction, this solution appeared to be unrealistic because of the investments in housing and industries meanwhile established in these areas. The government returned to the short term solution of levee strengthening, while authorizing studies to evaluate more long term solutions, such as for example setting back levees, excavating the land between the levees and the river, and development of (large) side channels.

Another dualistic perception is relevant for the private sector, in that a strong plea is communicated by bottomland owners to federally subsidize comprehensive flood protection, without giving away property rights and freedom of enterprise. This plea is opposed by environmentalists who often propose strong centralized regulation of floodplain use.

It must be emphasized that planning through negotiation is generally far more effective than centralized planning, since parties involved should commit themselves to the planning principles they themselves agreed upon. Or, in other words, "turn environmental confrontation into cooperation", as advocated by Erik Carlson in LANDOWNER NEWSLETTER (December 9, 1996)

The role and initiating power of the private sector should not be underestimated. We learned that important business associations feel themselves hampered by legal restrictions for economic development. The private sector, including farmers, industry and transportation companies, should therefore be included more explicitly in the planning process.

3.5.5 An Upper Mississippi River Basin Commission?

Many parties interviewed voiced a strong plea for a Commission that can pro-actively coordinate policy and management issues of the whole Upper Mississippi Basin. Motiva-

tion for this call derives from the following facts:

- there is currently no one agency that can decide on an integrated policy for the management of the Upper Mississippi Basin;
- there are strongly differing interests between the upstream and downstream states' agencies, which gives rise to conflicts on the use of the river system as a whole and the management of floodplains; and
- Benefit/Cost considerations on the regional level tend to neglect interstate and international potentials for economic development.

In this Commission all parties involved should have a say, but it should be small enough to take decisions without getting into marshy conflicts. It should be led by independent persons of high credibility, nominated by the President. It could be considered whether or not the existing Mississippi River Commission (Lower Mississippi) could be expanded for this purpose.

There are examples in the US and the rest of the world (see text box) of River Commissions that prove of great importance for integrated river management.

River Commissions

International cooperation in the Rhine river basin
Because of the deteriorating water quality in the Rhine basin, a International Commission for the Protection of the Rhine against Pollution (IRC) was installed by the governments of the riparian states. The IRC drew up the 1976 Rhine Pollution Treaty. This treaty provides for bringing an end to pollution by harmful pollutants in the Rhine river. According to this treaty many industrial and domestic waste water treatment plants were built, improving the water quality of the river tremendously.

After the accident in November 1986 at the Sandoz chemical works in Basel, which caused dying of fish on a massive scale and major problems in provision of drinking water, the policy agreed upon in 1976 was incorporated in the 1987 Rhine Action Programme (RAP) in a more stringent way. Main objectives were: ensuring the provision of drinking water and the return of higher animal species, such as salmon, to the Rhine.

After the 1995 flood, the governments of the riparian states agreed on incorporation of water quantity aspects in the work of the IRC. Recently, the IRC produced a strategy document: Protection against Flooding. The relevance of this document is that all parties concerned now have a shared view on principles and strategy to cope with flooding. The document outlines the types of measures that contribute to an sustainable flood protection.

Danube
An international commission (11 Danube countries) has been founded in 1948 to guarantee free navigation on the Danube. International efforts have been undertaken in the last 10 years to also address the flooding and pollution problems basin-wide. This effort is, among others, sponsored by the European Union. In 1997, an International Commission for the Danube River Protection Convention (adopted in 1994) will start its activities.

However, for the Upper Mississippi Basin, an alternative to a River Commission seems readily available and worth considering.

The **main** three issues for river basin management at this moment are navigation, flood control and environmental protection (see also chapter 2). These topics are best covered by the US Army Corps of Engineers (USACE). Therefore, an alternative could be to expand the "mandate" of the USACE to fulfill the tasks that would otherwise be given to a River Commission. In this model, the USACE would have more involvement in an integrated river management system, would carry out this task in conjunction with other state and federal agencies, and would organize the involvement of all private stakeholders in the development of plans and the decision making process.

The task description of either a River Commission or the USACE should include:

- the promotion of wise, sustainable use of the water resources, for the benefit of society as a whole;
- the promotion of discussion on controversial items before submitting plans to Congress;
- taking initiatives for the drafting of rapid assessment studies; and
- to direct operation and maintenance of the river system.

3.5.6 Towards a Decision Support System for River Management

One of the most efficient tools for the river manager to handle the huge amount of information available may consist of a Decision Support System (DSS). A DSS is a computer-based information system that supports officials engaged in decision-making activities. It typically consists of all available data, a geographic information component, and relevant models which describe the hydrologic, hydraulic, chemical and ecological status of the river. Graphical output is available to let users "see" the effects of different strategies that are simulated.

It goes without saying that a DSS does not replace the decision makers. The purpose of a DSS is to assist the decision maker in finding adequate solutions to practical problems. Decision making is an iterative process. An alternative is designed, tried, evaluated and improved in several cycles until a satisfactory solution has been obtained. In these iterations, the user is learning more and more about the problem by doing consecutive experiments on the computer. The DSS supports this iterative way of problem-solving. Therefore a DSS should be interactive. A real-time dialogue allows the user to define alternatives, see and evaluate their impacts and adjust the alternatives again in an incremental manner. A system with short response times allows the decision maker to do many "what if" analyses. Decision makers want to run the models multiple times with minimal effort, so that more alternatives can be generated and evaluated in order to get a better understanding of the problem and the potential actions to counter the problem.

DSS's are intended to be used by (assistants to) decision makers. A decision maker has much knowledge about the problem field, but is not necessarily a mathematical modeler or computer specialist. The DSS contains one or more mathematical models, but the user does not need to know exactly how these models work. This can be compared with driving a car: it is not necessary to exactly know how the engine of the car works in order to

drive the car safely.

As is extensively addressed in the FPMA study, river modelling efforts will have to be accelerated to accommodate the increasing needs for proper flood forecasting and the assessments of effects of measures to be taken. The USACE has by now developed UNET models of the Mississippi River from St. Paul, MN, to Cairo, IL, and of the Missouri River from Sioux City (IA) to Saint Louis (MO). Also for the Illinois River a UNET model is available. The UNET model could be an important element in a DSS for the Upper Mississippi, Illinois and Missouri Basins.

As is reported in CIVIL ENGINEERING NEWS (December 1996 Issue, p. 18), major advances have already been made in digital mapping of the floodplain, providing GPS-controlled digital elevation mapping for more than 2 million acres of floodplain adjacent to the Mississippi, Missouri and Illinois Rivers in a project led by the US Geological Survey. These data can be used excellently to form a GIS basis for a Decision Support System as mentioned earlier.

Decision Support Systems (DSS)
The principle of DSS is simple, but the implementation into a working interactive version generally requires a considerable effort. Several working versions have been put into operation thus far (among others for the Rhine, Elbe and Ganges Rivers) by Dutch and Danish institutes. Using the available knowledge and expertise in the USACE, the design and putting together of an Upper Mississippi Basin DSS should not be problematic.

A Decision Support System for the Rhine River in the Netherlands
There is an avalanche of ideas for the Rhine River in the Netherlands, ranging from increased safety requirements to deal with possibly higher floods due to climatic changes, the need for modernization of the Rhine River as a shipping route allowing even larger quantities of goods to be transported over water, initiatives for the development of nature, ideas on the preservation of the cultural landscape with agriculture as the principal user of the floodplain, clay excavation for levee improvements and brick production, more recreation on the floodplains, sand mining for the construction industry and infrastructure, water supply for agriculture and drinking water, ideas on the removal of polluted sediments, and urban use of the floodplains.

There is an increasing awareness as to the question whether all these functions of the Rhine river and all the claims to the limited areas can actually be combined. Where do interests clash or will coupling of interests indeed offer opportunities? What possibilities and limitations are there from a river engineering point of view? How to landscape the riverine area for sustainable protection against flooding? Is there enough space and does the river channel have sufficient capacity to break away from the spiral to keep on raising of levees?

In search for answers to all these questions, a Decision Support System (DSS-Rhine) was built. This DSS explores the alternatives for sustainable landscaping of the riverine area but does not provide a blueprint. After all, (re-)landscaping is a response to social requirements and problems changing in time, and is therefore a dynamic process. Moreover, there is a lack of knowledge on some aspects of the complex river system, so that some caution is required in deriving conclusions. However, this DSS does supply information required for a well-founded perceptual discussion between the parties involved in landscaping the riverine area. DSS-Rhine can be deployed to react flexibly to new insights into, for example, the functions fulfilled by the river, or into flooding phenomena.

3.5.7 Public relations

Planning and decision making processes require that information is made available to all parties involved in the process. The shear number of stakeholders in river basin management requires that an explicit effort is required to inform the general public. This information not only regards the outcome of studies, but also the basic information used in the planning process. Also, the manner in which conclusions are drawn needs to be presented to the public. The use of a computerized Decision Support System is important because it provides a structure to the decision making process, but it also supports information dissemination and communication.

The Delft Team is under the impression that state and federal governmental agencies could and should be more active in the field of "public relations". Experiences elsewhere show that not only could such flow of information satisfy the need to know about the background of certain (proposed) actions, but also could be of great importance in creating understanding and approval for these actions.

Just making thick reports available is not automatically the answer. Clear and concise brochures, video tapes, TV presentations, personal appearances at meetings, internet applications, CD-roms with a Decision Support System "for home use" are but few of the many options to improve the communication with the many stakeholders and the public in general.

In discussions with governmental agencies, the Delft Team noticed a wide appreciation for the importance of "public relations". Budget limitations seem to hamper more activities in this field. This deserves to be reviewed.

Public Relations
In 1995, after a 2-year study period, the project entitled "Landscape Planning for the River Rhine in the Netherlands" was completed, providing a Decision Support System for integrated management of the Rhine River. Taking into account the large number of stakeholders, each with different backgrounds and interests, the following project results were launched:
- main report, providing an overview of the project results;
- executive summary of the main report;
- 12 background reports, providing detailed information on and results of the project;
- a slide show; and
- an interactive CD, for general use.

Especially the latter two products proved extremely useful in disseminating the project findings to the general public.

3.5.8 Government investment

One of the conclusions of the current report is that a comprehensive planning effort is required to address river basin management for the Upper Mississippi, Illinois and Missouri Basins. Assuming the outcome of such planning is acceptance of certain large

investments (be it in flood control, navigation, environmental or combined projects), the question remains how to finance such investments. To address this question clearly exceeds the capacities of the Delft Team.

Assuming substantial projects, large investments would be required. Obviously, one could think of a role for the federal and state governments to make the investments. Reference is made to the past governmental involvement in the development of the reservoirs, levees, and river engineering works like wingdikes, revetments and locks and dams. The question remains to what level the Government is willing to invest in future projects in the field of mainly navigation, flood control and environmental protection aimed at better use of the resources, and aimed to support economic development.

The text boxes below illustrate some international examples of government investments in water related infrastructure, where the expectation of economic development is the driving force for the investment.

The Rhine / Danube Canal
The Rhine / Danube Canal, completed in 1992, connects the navigation routes along the Rhine and Danube rivers. Ships can now bring cargo between the port of Rotterdam, the many ports along both rivers, and the ports along the Black Sea. The large investment, some $4 billion in total, was made based on the *expectation* that a flow of cargo will develop rapidly along this link, supporting economic growth along the entire navigation route and elsewhere. For example, it is expected that coal will be transported from the U.S. East coast, via the port of Rotterdam, to power plants in Hungary.

Port of Rotterdam
The development of the port of Rotterdam, the largest port in the world, takes place at the initiative of the Dutch government. Large investments have and are being made by the Government for expansion of the port facilities up to the quay facilities. Obviously, private industries invest in their own facilities (cranes, warehouses, industrial plants, etc.). Currently, a societal debate is ongoing about a large-scale further expansion of the port by means of reclaiming more land in the North Sea. Total project cost for this expansion will exceed $3 billion of tax payers money. This investment will be based on the *expectation* that the port facilities can be contracted out to private industries. There is no requirements that such contracts should be signed *before* the final decision about the port expansion will be made. The decision will largely hinge on an *expectation* about development to take place.

Cross-boundary financing
As the Rhine Basin covers part of 9 European countries, flood protection has an international dimension. To realize an effective and sustainable protection against flooding, it is necessary not to limit the measures to the areas affected by the flood - at the end of the chain of effects - but to include the entire river basin. For this purpose, the European Commission has developed a new program concerning transnational cooperation on spatial planning and flood protection. Projects intended to reduce flood risk which are in accordance with the guidelines of the program, are considered for co-financing by the European Commission up to a certain maximum for each member state. A joint proposal for projects in the Rhine river basin is currently being prepared.

4 Towards a Strategy

4.1 Balancing prime functions of the river

The Delft Team's view, based largely on experience in Western Europe and in other parts of the world is that with a wider planning framework, involving (1) a more comprehensive overview of the functions that the river performs, (2) wider geographic coverage, and (3) a longer planning horizon, the interests of the various user groups, and therefore the nation as a whole, will be better served. The exercise becomes a combination of river management planning and spatial (land use) planning.

The underlying premise, as stated above, is that with planning, the complementarity of some river uses can be enhanced and the conflicts reduced. Examples of complementarity of land use and engineering measures are abundant already: building fish ladders with dams represents one of many simple ways, developed many years ago, to make river engineering works more environmentally friendly.

Flood management is an essential element in any river management plan. Current engineering practices have become more sophisticated, and now possible flood control measures include integrated approaches to flood management. These combine higher and stronger levees in some areas, particularly the most developed, economically important and residential areas, with levee set-backs, dredging main or parallel channels, selectively reducing levee height or building break-points into some levees so that the areas behind them will act as storage buffers in times of high water, and so forth. This combined approach is more flood management than maximizing flood control, but it can be considerably more environmentally friendly and considerably less expensive.

The key to the success of such an approach to river management, floodplain development and flood management will be:

- good analyses of physical river behavior at present and in response to the measures taken, under different flood conditions;
- prioritizing of interests by different users' groups so that the areas of prime importance to the different groups can be, as much as possible in the development of an overall plan, dedicated to those users' priorities;
- compromises among users' groups as to land use in different areas;
- decisions about the trade-offs in costs and benefits of different flood management actions for different users, agreed ahead of time;
- planned responses to high water and emergency situations;
- adequate and fair compensation for losses (presumably crop losses, as residential and business areas would not be deliberately flooded) when land is used for flood water storage;
- budgeting and financing plans.

4.2 Outline plan: ranges for reasonable trade-offs

The users and a range of activities representing high, medium and low levels of satisfaction of their major interests are summarized in the table below. Note that this table illustrates levels of satisfaction for each function separately, without considering possible interactions between functions. The river functions are those which have been identified and discussed in chapter 2 of this report. The following example illustrates such interactions: to allow navigation on the Missouri river, reservoir releases and possibly adjustments to the wingdam system could be sufficient. If also the recreation on reservoirs needs to be taken into account, reservoir releases will be reduced and dams and locks on the river might be required. The integration between functions, and hence the question how measures to support a particular function influence other functions, is further addressed in chapter 5.

function	level of satisfaction		
	high	medium	low
Flood control	raise all Upper Mississippi, Illinois and Missouri levees to standard project levees (comparable to the Lower Mississippi); operate reservoirs for flood control only; maybe setting back levees	raise Upper Mississippi, Illinois and Missouri levees to 500 year level generally and standard project levees for cities (stepped system); operate reservoirs for flood control only; maybe setting back levees	maintain higher protection for urban and also potential industrial development areas; selective increase on some farm areas; reduction on critical habitat areas; maybe setting back levees
Agriculture in the floodplain	expand floodplain farming, with extensive flood control	continue farming in floodplain prime soils, stop in some environmentally critical areas, but compensate owners; farmers & communities to locate buildings out of floodplain gradually and accept possible flooding of lands in some years, in exchange for payment of full value of crop damage; develop bottomland-upland swap programs	encourage farming in floodplain to diminish, and floodplain communities to move, largely through attrition due to lack of subsidy for flood repairs and levee reconstruction
Industry in or near the floodplain	give incentives for industrial areas to be developed in river bottom, behind standard project levees, built with federal funds	assess & prioritize areas with greatest potential for industrial development on basis of access to different modes of transportation, need for cooling & process water, on condition that non-polluting technologies are chosen; where reasonable estimates show strong future growth potential, public-private funding to be sought	actively discourage industry in the floodplain; calculations of B/C ratios for feasibility studies not to include estimates of future growth

function	level of satisfaction		
Commercial river transport	dredge 12-foot channel & rebuild all locks on Upper Mississippi to 1200 feet length; subsidize container & intermodal shipping facilities; Missouri reservoir operation to optimize navigation conditions and increase navigation season	implement results of USACE study on increasing length of locks -- likely outcome: gradual rebuilding of locks; study possibilities for smaller incremental increases in depth of shipping lane which could be cheaper & still increase capacities; Missouri reservoirs release according to preferred alternative of Masterplan EIS	perform maintenance dredging only; no expansion of lock length on Mississippi; maintain Missouri management regime as is with probable result of continued reduced shipping
River based recreation	keep reservoirs on Upper Missouri full; expand fishing, water fowl & hunting habitat on all 3 rivers; reduce downstream water demands for navigation	review estimates of revenue from tourism & recreation and from shipping industry; manage Missouri reservoirs release according to preferred alternative Masterplan EIS; expand fishing, water fowl & hunting habitat on both rivers as consistent with overall planning	treat river-based recreation as a residual, i.e. demands for water in reservoirs to be satisfied only after other users, particularly need for navigation water and reservoir space for flood control
Environmental protection	restore river and floodplain to natural state as much as possible; restrict land owners' activities in endangered species' habitat	prioritize areas of floodplain that are of importance as habitat and ecosystem to protect & even develop; use polluter pays principle to protect water quality; use positive incentives (payment) to protect endangered species on private lands; continue soil conservation programs	allow environmental concerns to be met only after demands for growth of economic activities are satisfied
Historical & cultural property protection	prohibit development that changes character of areas; protect all historical sites	encourage the preservation of historical & cultural sites and values, both as a tourist attraction and for local quality of life; make adaptations to infrastructure as needed	ignore cultural and historical values except for those sites specifically and officially marked

Table 4.1 Possible measures required to realize a level of satisfaction for various river functions

In general, the middle ranges represent the compromises needed to allow the various users to come to common ground. The specifics will need to be worked out in much more detailed studies and analyses, including river simulations. Some guidelines and observations of the Delft Team are included here, under the following section on evaluating trade-offs.

4.3 Evaluating trade-offs and making an outline plan

A number of factors go into the process of evaluating trade-offs. Economics evaluation of benefits and costs is an obvious one, to be discussed here, but the total list of criteria to measure trade-offs is much longer. Major categories of criteria include:

- technical studies and analysis;
- economic evaluations; and
- policies and preferences.

The observations of the Delft Team will be mostly focused on the first two of the major categories above, technical studies and economic evaluations, since the third category, policy issues, is very broad and fundamentally a local and national political concern. Where contrasts with European practices are notable, they are mentioned, however. In a major water resources planning study, of the type being suggested in this report, policy variables become very important elements of the analyses. A good decision-support system (DSS), capable of handling and analyzing large quantities of data and presenting the results in a clear way, can assist decision-makers and the public in general in making policy decisions.

Technical studies and analysis
Technical studies and analyses include, in the case of water management studies and river basin planning, complex computer-based models designed to handle very large amounts of data and to simulate complex natural systems. These can provide answers to fundamental questions about what is or is not possible (e.g. amounts of water available) under existing conditions and what the options are to change the current situation (e.g. water management measures, such as reservoirs). These studies will include aspects of:

- physical abiotic systems including hydrology, river morphology, soil characteristics, sediment movement, seepage, etc.;
- biological systems in the case of environmental studies, in some economic activities (e.g. crop production, integrated pest management) and for human habitat issues such as waste treatment and water quality; and
- social systems, such as population projections and estimations of future demand for water for domestic and municipal use.

Economic evaluations
Economic evaluations include (financial and economic) feasibility studies, budgets and financing plans. These will affect private investors and businessmen including farmers directly, and may be used to justify or rule out investments by the public sector.

Policies and preferences
Policies and preferences, including national and regional (preferences expressed through voting, referendums, etc.), will directly affect availability of funds, zoning decisions and other rulings about land use, decisions on what activities should be subsidized or taxed, etc. These factors can change over time, sometimes rapidly and sometimes with a gradual evolution, but the fact that they are changeable does not diminish their importance. They often are the most heavily weighted of the decision criteria; examples are practical-

ly unlimited but a few are listed here:

- government expenditures on infrastructure (the highway system; the locks on the Upper Mississippi, airports, the railroads, ports, etc.);
- social criteria having to do with poverty alleviation (food stamps, welfare, public health care programs);
- farm subsidy programs to reduce total production and keep prices up (set aside) or to encourage reduction of erosion, or to ensure production credit;
- environmental programs to preserve remaining habitat and endangered species, to reduce air and water pollution, to establish green-belts around urban areas, National Parks, public lands etc.;
- public works programs (a prime example being the WPA in the 1930's, leading to the implementation of the famous first Pick Sloan reservoirs and river training works) to provide work in times of major unemployment while achieving social goals;
- research and extension programs, including into basic research in fields that may not produce useful products for some time to come (e.g. crop breeding and field trials, but also biotechnology, genetic engineering, etc.); and
- classic "public goods" including public schools, national defense, etc.

5 A Conceptual Plan

Introduction
In this chapter, a discussion is given as to the trade-offs or compromises which are relevant for each of the main river functions:

- flood control (associated to the river function "discharge of water");
- agriculture;
- industry;
- river transport; and
- environment.

The ranges of reasonable trade-offs have been given previously in Table 4.1. Here, trade-offs are discussed in terms of technical, economic and environmental elements. All this information contributes to the drafting of a conceptual plan, an outline for a concrete course of action, as to how integrated river management could proceed in the (near) future.

5.1 Flood control

5.1.1 Technical elements of the plan for flood control

A major system plan should set appropriate levels of flood protection for different stretches of the river(s) involved, based on the criteria of technical issues and possibilities, economic value of existing infrastructure and property to be protected, costs of different protection levels, priorities of different user groups, suitability of various sites for future use for economic purposes such as industrial terrains and importance of various sites for other uses. It is possible that different flood protection levels result for different types of land-use.

The major goals should be to agree upon different land-uses and the flood protection appropriate to those uses. Since flood protection is an expensive undertaking, the level of protection that can be provided will be a part of the decision of what can be developed and where.

Technical issues include:

- There are two main options to provide safety from flooding: (1) reducing flood stages, for example by means of dredging of the river bed, or large-scale excavation of the floodplain between levees and river; and (2) raising levees. Just from the cost aspects involved, it can be concluded that for the (near) future the raising of levees is to be preferred.
- The natural sediment loads of the river are substantial: the mean daily suspended sediment transport at St. Louis amounts to some 370,000 ton per day. Specialists in the field of river morphology are convinced that (with the exception of isolated spots) no large scale sedimentation of the river bed has taken place.
- There appears to be much confusion about the question whether or not the sedi-

mentation of backwaters significantly contributes to flood stages during extreme events. Specialists in this field are convinced there is no significant effect. This information deserves to be made available to the general public.

- The issue of a possible effect of climate change on extreme river discharges needs to be investigated.
- It is not widely understood that the considerable amount of (natural) vegetation between the levees and the river are an important factor in the flood stages that are associated to a certain flood discharge. It should be investigated if and how forest growth in this zone could be managed in such a way that it remains environmentally acceptable, while minimizing set-up of flood stages. At the same time, such growth can be of significant importance to avoid wave attacks and scouring of weak levees.
- The quality of many levees leaves much room for improvement. Levees lacking clay covers (in our view at least 2 feet thick) should be improved to avoid wave induced erosion and scouring holes during high flood stages and to minimize seepage through levees. If not already available, the USACE should take the initiative to inform levee owners of appropriate designs and construction methods for levee construction.
- Apparently it happens that some land owners in levee districts refuse to contribute to the cost of seepage control and drainage of the district. This is reported to be the case for the owners of wetlands and forest land in levee districts. This leaves the other land owners with a higher cost share. This situation needs to be addressed.
- It deserves attention to study the options to turn certain levee districts into retention basins during extreme events with the objective to reduce flood heights at urban and/or industrial areas. Given the difficulties associated to the operation of such retention basins (timely inundation, otherwise it has no benefit), the Delft Team is not overly optimistic about the feasibility of this potential measure.

Make way for rivers
To break through the spiral of ongoing raising levees and to cope with possible higher river discharges due to climate change, the Dutch government has recently decided for a new flood protection policy called "Make way for rivers". This policy include both river management and spatial planning. Important elements in the new policy are: maintenance of available river discharge capacity and creation of new capacity, for example by floodplain lowering. Raising of levees will be the finale of protective measures.

5.1.2 Economic elements of the plan for flood control

For economic reasons, there is little question that urban and large community flood protection must be done. Various scenarios for preventing and compensating flood damage to urban and agricultural areas are proposed and evaluated economically.

"Most of the urban counties in this region are located directly on the Mississippi or

Missouri River. All of the remaining medium-size towns are located directly along floodplains of major tributaries, such as the Illinois, Des Moines, Cedar and Big Sioux Rivers" (SAST, 1994, p. 193).

High-density settlement areas are more difficult to evacuate, and the danger to human life is not acceptable. The economic value of infrastructure and property in densely settled areas is so high as to make flood protection mandatory. The only question is the level of protection and issues of cost minimization.

For villages and farms on the floodplain, the issue is more complex. It is no longer simply assumed that they must be protected. Economically speaking, it is a comparison of cost estimate and risk analysis for three alternative scenarios:

1. the likely frequency of recurrence and extent (value) of flood damage at current protection levels, (including costs of current repairs to levees etc. as relevant); this is the highest risk, lowest cost option;
2. the cost of improving flood protection to various possible protection levels, (plus current repair needs) combined with an estimate of the likely frequency and extent (value) of flood damage at those improved protection levels; this option lowers the risk of flood damage, but costs more; and
3. an estimate of the costs of displacing a community out of the floodplain including the costs of rebuilding and/or physically moving residences and commercial properties. For this, local preferences and costs will be strongly affected by specific situations and factors such as the distance it would be necessary to move to reach suitable alternative (higher) sites, and the extent to which the livelihood of the population is tied to working in the plain and how difficult that will be to continue. Farmers may find moving barns and equipment to higher ground to be reasonable (if, for instance, they farm both upland and bottomland) or highly inconvenient. Shopkeepers may find little difference if they remain in the center of the community and with good access to roads. This option removes the risk, but the costs will vary by site.

A diagram showing graphically how the USACE costs potential flood damage is shown in figure 5.1

General economic guidelines for flood control are that:

- The river represents an important resource for the region in many ways. Where it can be used as an engine for economic growth, without damaging community interests generally, including environmental and historical values, this should be actively encouraged. Where compelling economic reasons to locate industry in the floodplain exist (access to water transport, water for industrial processes) and flood protection can be economically justified, it should be encouraged. Environmental costs for such activity must be quantified and must be compensated.
- Where compelling economic reasons to locate in the floodplain itself do not exist, new growth should be encouraged outside the floodplain and relocation of existing plants, over time, should be encouraged. (The fact that it is cheaper to build on flat ground would not, for instance be adequate justification, since flood protection costs, if born by the developer would easily offset the cost savings from flat ground.)

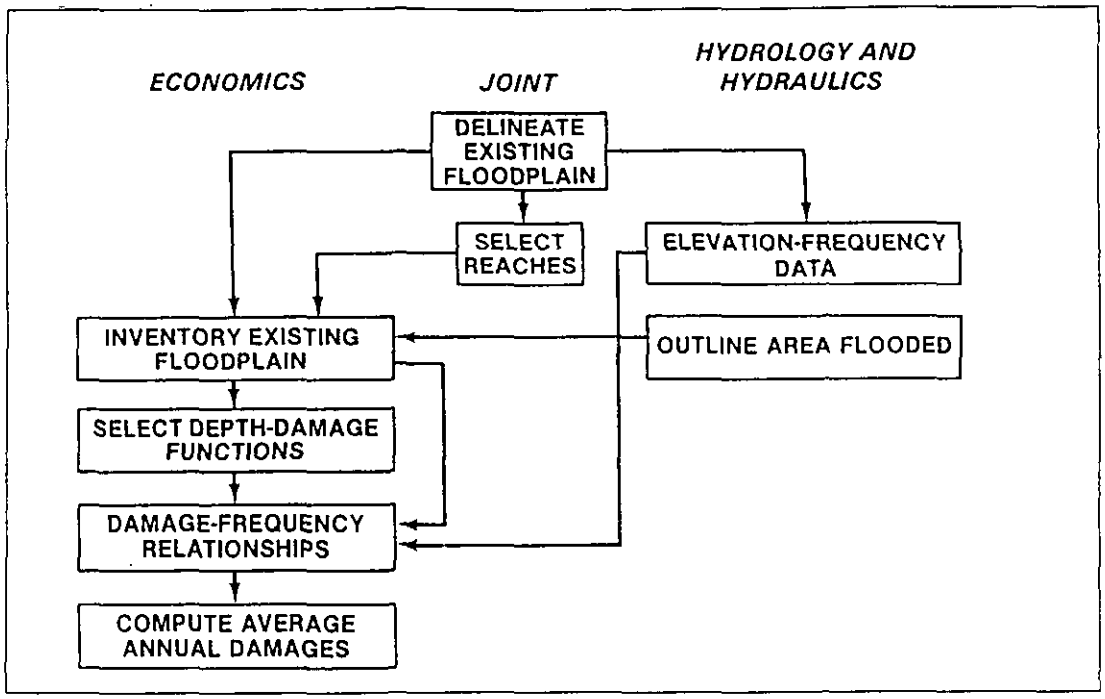

Figure 5.1: USACE calculations of flood damage

- For industries remaining in the floodplain, flood protection and flood evacuation plans will be necessary, and plants would need to be of sufficient size and value, or else grouped into assemblages of sufficient size and value (industrial parks) to justify this.
- Agricultural production alone will most probably not provide economic justification for raising levees to (very) high levels of protection. It seems justified to also take into consideration flood damage to other sectors (transportation costs roads and railroads, production losses, etc.) as well as reasonably expected future benefits. Benefit-cost calculations should be carried out to decide what levels could be justified, how much risk farmers are expected to assume if they keep buildings and equipment in the floodplain, and how much should be insured by the government or private insurers and on what terms.
  Benefit-cost calculations should also be carried out to decide what safety levels are appropriate for the protection of urban and industrial areas. The first impression of the Delft Team, observing the intensive use of the floodplain southwest of St. Louis, was that higher levees in the St. Louis area could be likely economically justified.

Important additional factors would be that:

- Historical and cultural values, will presumably add weight to the arguments against moving an old community; and
- The prospect of future growth of a community will probably be stronger if it is out of the floodplain as most new construction (businesses and residences of people working in areas other than farming (fewer farmers but more people involved in agro-business), since the total employment in the farm sector is not likely to increase much; housing for factory workers, even if the factory itself were on the plain)

would not need to be on the plain, and owners would be uninterested in assuming the risks and costs of building on the floodplain.

Technical issues in economic analysis are that:

- Estimates of future growth, especially in a new area are more difficult than projections of existing activities extrapolated from past experience, trend modeling, expert judgment, etc. Nonetheless, reasonable estimates can be made, even for new activities when markets are known, potential investors are showing interest, and similar experiences exist. A failure to include estimates of future growth of an area after infrastructure such as flood control is developed, will automatically tend to disfavor all projects based on innovation and future growth compared to those just protecting existing developments.
- The USACE has been severely limited in the estimates it can make by decisions that have specifically not permitted estimations of benefits from future economic development to be included in B/C calculations, except where industries have committed themselves on paper to invest. Similarly, benefits from job creation cannot be included unless the area is one of higher than average unemployment. These rules may be understood as efforts to avoid artificially high B/C ratios made on the basis of unrealistic assumptions about future revenues. We recommend to apply the same means of B/C analysis to all developments considered.
- A more balanced approach would be to allow estimates of benefits from future growth to be made on the condition that all assumptions about growth be stated very clearly and some sensitivity analyses run where the assumptions would be varied. This would provide more useful information, and the debate could then center on whether the assumptions about growth were realistic enough to justify the investments. [see text box on the L385 project].
- Where different regimes of reservoir management have economic effects at times of high water events, it will be useful to use benefit-cost evaluations to calculate these effects. The USACE is currently doing this, but in this case, the sheer magnitude of the effort may argue for a more generalized computer-based management system that could tie economic calculations into physical water models [text box Osage River].

Benefit/Cost analysis of Project Levee L385

Project L385 for levee construction on the Riverside - Quindaro bend on the Missouri River can be used as an example of Benefit/Cost analysis. In the levee redevelopment plan, opportunities for development after completion of the levee were taken into account and assessed as very positive. The absorption of the proposed industrial, retail and commercial spaces is feasible. All the critical factors required for an industrial complex (highway and rail access, river and barge facilities, infrastructure and flexibility of space for development) are available, but are to be considered of no value if the levee is not completed. Since then, the developer has increased his contribution, and the city has agreed to earmark some of the revenue from the casino tax to this project.

Osage River and management of the Missouri River reservoirs:
An example of a call for a combination of physical modelling and economic calculations comes in the form of a protest letter from the Osage River Flood Control Association, Inc.:

"This letter is to express our concerns over the effects of the Preferred Alternative proposed by the Corps of Engineers (Corps) which would affect flows of the Missouri River by changing the use, storage and discharge of water from upstream Missouri River reservoirs. Our concern is over the lack of study showing the impacts on the Osage River and other tributaries. ..."

"The property owners on the lower Osage River are paying a heavy price for the federal government's cost cutting steps and are now bearing a greater burden than should be expected. As a practical matter, we are being asked to donate our land to the federal government to make their projects cost effective regardless of the impact on individual land owners. Any additional flooding during the agricultural season would add to an already intolerable burden. ..."

"We believe the only way to determine the effects of Preferred Alternative versus the current plan in the Master Water Control Manual for the Missouri River is to model all flows under both plans which flood property, including the tributaries, and tributaries to the tributaries to the full extent of the effects. For the purpose of determining the effect on flood levels, studies should show peak elevations, including duration's, not average monthly flows."

5.1.3 Environmental elements of the plan for flood control

The construction of levees or implementation of measures aimed at lowering flood stages will deprive ecosystems that require regular flooding of part of the natural ecosystem dynamics. This makes these ecosystem evolve into more upland type of ecosystems, that can be very valuable from the point of view of biodiversity and habitats for endangered species, but nevertheless at a loss to the original ecosystem. It is therefore, that we classify the environmental effect of flood control measures that affect ecosystems that are regularly flooded as generally negative. The environmental effect of heightening existing levees, however, is generally neutral (in case of agricultural and urban levees), maybe positive (in case of levees that protect more upland type of ecosystems), and positive (in case of industrial levees, preventing pollution by inundated industries).

In addition, newly evolved upland ecosystems tend to be vulnerable to flooding. It is reported that large tracts of hardwood forest died due to the 1993 flood. Although this is a natural process, leading to interesting recovery processes, it should be considered whether it is desirable to protect these ecosystems from flooding. In that case the landowners of the nature conservation areas should contribute to the levee taxes, set by the drainage districts. If not, they should not be included in flood protected areas. A problem here is the acquisition of land within drainage districts for the purpose of nature restoration. As a member of the drainage district, the new owner of the land should be involved in the planning process of the whole drainage district, to balance trade-offs from developing part of the land in the district with different purposes than the remaining lands. Proper zoning, or differential heights of levees may be solutions.

The area between the levees is generally left for free development of vegetation. On the one hand, this natural growth, often providing valuable habitat for riverine bird species,

protects the levees from wave attack and scouring, on the other hand the hydraulic roughness of the shore lands increases and thereby the water conveyance of the main channel decreases. The Delft Team has the impression that more attention could be paid to this effect. Proper management of these foreshores in river ranges where conveyance is problematic might decrease flood stage to a significant extent. This management could for example consist of grazing, introducing self-subsistent grazing animal species.

5.2 Agriculture in the floodplain

Various issues concerning agricultural practices in the Mississippi River Basin are discussed regarding technical, economic and environmental elements.

5.2.1 Technical elements of the plan for agriculture

Technical elements of the plan for agriculture include solutions for the following issues:

- The issue of seepage in and drainage of various levee districts. Depending how high pool levels are maintained by the operators of the dams in the river, various levee districts, in particular those at the downstream end of river pools, have to deal with larger or smaller amounts of seepage water that have to be pumped out. Levee districts should be compensated for negative effects of changes in pool levels.
- In developing a plan for flood management, one option might be to use agricultural levees as retention basins to accommodate storage of the peak shaving of a flood wave during an extreme event. Elements of this option are the development of proper inlet structures (to avoid damage to the levees), raising or otherwise floodproofing of barns or other structures in the levee districts, and an agreement how damage to farmers will be compensated. The technical feasibility of this measure needs to be addressed. The Delft Team is not overly optimistic about the feasibility of this measure, given the intrinsic difficulty in the operation of such retention basins: when exactly should the basin be inundated? Too early or too late renders the measure useless.

5.2.2 *Economic elements of the plan for agriculture*

The floodplain of the rivers offers excellent agricultural land, and its productivity should be used. It is true that there is plenty of agricultural land outside the floodplain areas, but the quality is different. Bottomlands along the upper Mississippi floodplain are fertile, flat and, where drainage is good, ideal for corn (maize) and other crops. In areas visited by the Delft Team, in Illinois, corn yields in well-managed bottomland fields can average nearly 200 bushels an acre in a good year (more than 12 tons per ha.) which is very high. Such farmland sells in the general range of $2,000-$3,000 per acre (roughly $5,000-7,500 per ha) whereas for example upland farmland in Missouri will be valued in a range about 2/5 that price, which reflects the relative fertility and revenues that can be earned per acre (some upland Illinois land does bring very similar values, however,

these areas were also drained).

The bottomlands are the most productive, and lucrative, as long as flooding risks are low. There is also a certain function of risk-balancing between the two types of soils. In dry years, the bottomlands will out-produce the uplands; in the occasional wet years, if waterlogging of low-lying soils becomes a problem, and where regular rains guarantee good crop growth on the upland soils (most of which are non-irrigated) the uplands may produce higher yields.

A major impetus for improving transportation on the river (see below) is the projection of the future global demand for grain and the supposition that American farmers will be able to meet a good part of that demand by increasing production. At least one study, done for the USACE, has projected that the demand for grain worldwide will double in the next 50 years. This is projected to be caused partly by the fact that populations will continue to expand, but more importantly because of rising incomes in the developing countries. As populations in low-income categories become more prosperous, spending on food increases as people diversify away from the simplest, grain, tuber and bread-based diets to include more cooking oils initially and then more meats. The demand for food and feed grains and oil-bearing crops grows more rapidly than the growth of population when low-income consumers become middle-income consumers. The supply side of this equation may, in some parts of the world, be achieved by intensifying production on relatively low-productivity areas.

In the region of the upper Mississippi Basin, where yields are already high, the projected yield increases are expected to come from the application of even better cultivars.

General economic guidelines would be that:

- Field agriculture on the best river bottoms is an important part of agricultural production generally in the region, and farmers should be encouraged to continue to use the land well. Their prosperity is an important element in the regional economy.
- For bottom-land farms, a preferred scenario would be to have farm houses and buildings above the floodplains, regardless of level of protection, but this may be impractical. Bottomland-upland swaps would be possible measures to encourage this, along with assistance in moving.
- Over the long term, agriculture should remain an important element in the regional economy because of the very good soil and water resources, which also implies serious attempts must be made to maintain land and water quality. Where viable possibilities for additional processing of agricultural products in the area can be found, this should be encouraged in the interest of overall regional economic strength.

Important additional factors would be that:

- Flood protection for farms may not be as high as that for cities, Ideally, in the rare years of very high runoff and danger of high floods, most of the farmland in the floodplain could be used for flood-water storage in exchange for full crop compensation; that is why buildings and properties in the low-lying agricultural areas should

be minimized.

- Environmental concerns may dictate that marginal farmlands that are sandy or those that are fragmented (e.g. bluff lands) or are located in particularly difficult areas to protect may be allowed to flood or to revert to woods; if some sites of the best farm lands are seen as particularly valuable in an overall environmental plan, this should be allowed, but on the basis of reasonable price negotiations with owners or land-swaps.

A technical issue in economic analysis is that the projections of future demand for grain are always difficult, and projections for 50 years down the road are particularly so. More useful may be the estimations of comparative advantage in production and transport costs with other major grain-producing areas of the world, particularly in South America that are clearly emerging as major competitors. These could be used as guidelines for investments to improve comparative advantage, such as in transportation infrastructure.

5.2.3 Environmental elements of agriculture in the floodplain

The Delft Team noticed that farmers often feel themselves intimidated by environmentalist's views, although they themselves generally have true concerns over the state of the environment. Farmers could enhance biodiversity and thereby considerably improve their image by openly adopting nature conservation objectives on parts of their land not optimally located or suited for agricultural use. Also, drainage districts could contribute to these environmental goals by coordinating such initiatives to enhance connectivity in the ecosystem pattern of the floodplain. On the other hand, farmers should not have to bear an unjust burden for meeting environmental regulations.

5.3 Industry in the floodplain

5.3.1 Economic aspects of industry in the floodplain

An increase in local industrial development is considered to be desirable by the agricultural community largely for reasons of employment and income: large farms can be managed by relatively few people, and the demand for labor in the farming sector does not increase dramatically. Thus industrial development provides alternative employment options. Industrial development also offers the prospect of higher-paying jobs. The hope is that economic growth would counter the out-migration of the younger generation to find work and would also encourage the development of the area generally as more goods and services would be in demand locally due to higher incomes in the area.

An expansion of agro-processing industries in the area would also offer the prospect of more value added locally for crops and livestock produced in the area, and potentially more of the revenues returning to the producers.

For these and other reasons, there is an interest in expanding industry in the area, but there are obstacles. There are numerous reports of industries that were nearly ready to come into the area, but where lack of flood protection was the reason cited.

General economic guidelines would be that:

- Industrial development that relies on the advantages of the river should be encouraged, provided that the advantages of being located on the floodplain outweigh the risks and costs of that location, and that industrial development takes place in the context of overall land use planning and does not damage the river and its environment.
- There are two major reasons to develop industry on the floodplain instead of outside it, namely:
  - access to river transport; and
  - access to water to use for cooling and process water.
- Most investors who want to locate in floodplains for the above reasons will only seek to locate in areas where the flood protection is considered to be adequate; to justify investment in higher flood protection, either the industries should be high-value or enough industries should be grouped together to justify flood protection investment.
- If the community considers that prospective investors are to be encouraged, it should be possible to offer incentives such as tax breaks or federal/state assistance, but investors could also be encouraged to help pay for flood protection in return for other assistance.
- An old reason to be close to rivers, namely cheap disposal of wastes, is somewhat lessened by the fact that surrounding communities and the nation as a whole no longer tolerate the disposal of dangerous wastes to rivers. Rivers still offer the possibility of some waste water disposal, but not so cheaply, since all discharges must be treated to acceptable levels.

Important additional factors would be that:

- intermodal connections between water, rail and roads are essential for transport of domestically consumed goods. These transport connections may make the difference between economic viability and failure for an enterprise; grain and some other products for export may be exceptions.
- river transport of grains for export may be reaching the capacity of the present infrastructure on the upper Mississippi and may need to be expanded soon.
- environmental concerns may limit industrial expansion if industries are either refused permission to develop or if regulations are considered to be prohibitively expensive.

Technical issues in economic analysis would be:

- the same issue as for flood control above: there is a need to be able to look at the potential benefits and costs of new industries to decide whether additional flood protection could be justified if economic development is to take place in the floodplain;
- availability of adequate skilled and/or unskilled labor, relative costs of production and a good prospect of having comparative advantage in the market, domestic and/or international, are as crucial on the bottom-lands as for industrial development anywhere else; it should be examined whether these factors are limiting; flood protection

is not automatically sufficient to bring in industry.
- an aspect that should not be overlooked is that minimizing pollution risks of industries located in floodplains could urge for additional investments for flood proofing of facilities or storage locations that might cause serious pollution at the time of an inundation.

5.3.2 Environmental aspects of industry in the floodplain

Certain types of industry located in the floodplain can pose environmental risks. Specifically, industries which use or store hazardous materials could be a source of water pollution during a flooding event. This aspect should be taken into consideration when analyzing what flood safety level to choose for an industrial site. These industries should only be located in areas with a high design flood level.

5.4 Commercial river transport

5.4.1 Technical elements of the plan for river transport

River transport is currently operating near capacity in the Upper Mississippi River Basin. Maintaining the existing level of transport or expanding river transport has many technical elements:

- there is much discussion about the question whether or not the existing locks are deep enough to allow safe passage of 12 foot barges. We were informed that the sill levels in the existing locks are 18 feet deep, allowing for ice growth under 9 foot barges. Our impression is that with careful operation during winter time, the existing locks should be considered sufficiently deep to allow 12 foot barges to pass.
- At this moment, the 9 foot channel can be guaranteed during about 90% of the time. If the river discharge is sufficiently high (i.e. high water levels), already in the existing situation 12 foot barges can be used. This is possible during about 80% of the time. To increase this percentage to say 90% of the time (one could interpret this as "the channel will be deepened from 9 to 12 feet"), the annual amount of dredging will increase by an estimated additional 20%, on top of the current annual dredging amount of about 3 million cubic yard in the Upper Mississippi Basin, and 5 million cubic yard in the Lower Mississippi.
- Since changes in the fleet composition (smaller but more importantly shorter tows) can not be realized economically at short notice, the only realistic way to increase the lock capacities is to build new locks of 1200 feet length at congested or soon to be congested locations.
- To further reduce delays in navigation, the feasibility should be investigated of developing locally wider (two-way) channels in long one-way (narrow) stretches of the river at say 5 mile intervals (length say half a mile).

5.4.2 Economic elements of the plan for river transport

A general economic guideline would be that river transport is crucial to an internationally competitive agriculture sector and is essential to keep costs down domestically. Shipping costs of river transport are considerably lower than rail or truck transport costs for a given weight per distance traveled. Obvious limitations are time and access, however. Shipping is most suitable for high volume, heavy goods that can be shipped in bulk, where timing of deliveries does not have to be as fast as possible. Grain is a primary example.

On the upper Mississippi River, transport delays due to lock and navigation channel capacities are major issues. The information shown in Figure 5.2 gives an indication delays at the various locks recorded for the year 1989. Since then, lock 26 has been replaced by a 1200 foot lock, bringing down waiting times at that lock considerably. It should be noted, that from a European perspective, the waiting times as well as the average lockage time at the various locks would be considered totally unacceptable.

The major issues are particularly the length of locks and the extra time involved for double lockages and the fact that some the locks generally appear to be approaching their capacities, at least as currently managed. The USACE is currently completing a program of lock rehabilitation, wherein all the locks on the river, most of which were built in the 1930's, have been resurfaced, doors, electrical systems, pumps etc. have been replaced.

The USACE is currently engaged in a large study ($47 million, $21 million of which is devoted to environmental aspects), the Upper Mississippi River - Illinois Waterway System Navigation Study. "This study is examining the feasibility of navigation improvements to these waterways to address the problem of delays to commercial navigation traffic". The feasibility study effort is considering small-scale and large-scale improvements to the river system over a 50-year period (2000-2050). Small-scale measures are less costly items such as powered traveling kevels or guidewall extensions, or nonstructural measures such as scheduling programs or tolls. Large-scale measures are new 1200 foot locks. Various disciplines are involved in providing engineering, economic, environmental, and public involvement input to develop existing, future without-project, and future with-project conditions. In addition to the no action alternative, the small-scale and large-scale measures will be combined into various alternative plans for evaluation and ultimately selecting a recommended plan. (Hudson, 1996). This major study is to be completed in 1999. The Delft Team is of the opinion that the environmental return on investment of the $21 million environmental component of the current $47 million study on river navigation is quite low when compared to other options such as ecological restoration, which could be pursued with such a high budget.

Shipping on the Missouri River is limited by the fact that the season does not go throughout the entire year. The "preferred alternative" [8] for managing the reservoirs on

[8]) "Preferred Alternative": outcome of USACE Master Water Control Manual Missouri River, Review and Update, Draft Environmental Impact Statement

Lock No.	Tonnage (k/tons)	Average Lockage Time (min./tow)	Average Delay Time (min./tow)	Estimated Capacity (k/tons)
Upper St. Anthony Falls	657	26	1	16,070
Lower St. Anthony Falls	1,207	28	3	16,520
1	1,202	31	3	13,820
2	11,488	80	39	50,230
3	11,519	77	34	39,330
4	12,038	79	25	44,010
5	12,158	77	29	45,040
5A	12,203	72	25	46,670
6	14,125	83	34	42,600
7	14,084	81	35	42,430
8	14,674	86	40	46,300
9	15,557	88	32	48,480
10	17,868	74	30	51,630
11	17,395	86	55	41,800
12	21,089	80	68	46,120
13	21,534	77	52	48,580
14	26,843	79	102	48,200
15	26,967	86	110	46,300
16	28,771	84	93	48,800
17	30,857	98	157	45,300
18	31,370	88	99	50,100
19	32,908	62	43	68,900
20	33,524	89	169	47,200
21	34,362	101	151	48,700
22	34,938	106	369	44,600
24	36,138	99	287	44,100
25	36,219	95	238	41,700
26	68,431	109	1,427	N/A

Figure 5.2: 1989 Upper Mississippi Lock Tonnages and Average Delays (USACE, 1992)

the Missouri River would limit that season further, by one month. Overall economic benefits from the proposed alternative are about the same as current economic benefits, but they are distributed slightly differently. The environmental benefits (calculated not in money, but in improved habitats) are higher for the proposed preferred alternative. This alternative has, however, raised some fears regarding flood control (see the box on the Osage river, above) and about limiting shipping, both on the Missouri as well as the (Middle) Mississippi.

There is concern about the potential loss of barge transportation on the Missouri generally. A study from the University of Missouri, Columbia (FAPRI, 1994) estimated potential losses to farmers of Missouri of $17 million because of lower grain prices that would be caused by higher transportation costs if grain were to be shipped only by railroad and truck, plus higher input costs for the same reason. The study estimated $14.52 million lower receipts for corn, soybeans, wheat and grain sorghum for counties within 100-150 miles of the river. This is based on the estimate that without competition from barge traffic, railroad shipping rates would increase by 34%.

The cost of different systems of dredging is a fairly controversial item as well. According to the Rock Island office of the USACE, dredging costs on the Mississippi River average about $7.50 and $10.50 per cubic yard when all of the costs related to dredging are considered. Actual on-site costs are about $3.50 and $5.50 per cubic yard respectively. For very large volumes, the costs could be lower. Examples of dredging costs for different types of operations, taken from the DMMP Report Appendix C, show that the thalweg system has definite cost advantages over depositing dredging material on land. There is considerable local opposition to the thalweg system, based on the idea that dumping the material back in the river is not effective enough. The USACE maintains that thalweg is effective, and it may be a question of information. There are also frequent suggestions that the USACE should be encouraged to spread dredged material along the levees rather than depositing it in piles. The costs of spreading are higher, but the material could strengthen the levees. Trade-offs could be analyzed and used for public discussion about whether the USACE or communities involved should bear costs if it is decided to spread dredged materials.

Technical and environmental issues in economic analysis are that:

- Environmental issues are critical in the shipping question. There is considerable concern about the effects of dredging, maintaining the shipping channel or any prospect of deepening it. Morphology specialists are convinced that the effect of navigation on suspended sediment concentrations in the river is small, except at isolated locations. This has to do with the fact that the natural suspended sediment (silt) concentrations in the Upper Mississippi, Illinois and Missouri rivers is already quite high, while the bottom material in the navigation channel generally consists of course material (sand) that may be brought into suspension, but quickly settles again. It would, however, be useful to look at ways to both maintain the shipping channel and enhance some natural areas in the floodplain with additional back channels, oxbows, etc. because there is also an environmentally positive side to shipping in that it is far less polluting of the air than an equivalent transport of goods by truck or rail.
- The above mentioned ongoing navigation study apparently does not include the options of deepening the shipping channel. There is some call for a 12 foot channel and considerable opposition to the idea, particularly on the grounds of environmental risks. It would, however, be useful to know whether a smaller increment in channel depth could be achieved by selectively deepening the channel, and at what costs, both economically and environmentally. There is some basis for thinking that an increment of one foot could be achieved at relatively small cost, and that this could alleviate some of the impending capacity problems.
- A larger study, as mentioned above, of the comparative advantage of producing and transporting grain in the area of the greater Mississippi river basin compared to other areas internationally, particularly South America, would be useful. This evaluation could be part of an overall study to plan for future production and transport of grain, and to help to answer some of the questions about investments in shipping in the longer run.

5.4.3 Policy elements of the plan for river transport

In contrast to what appears to be the general practice in the United States, it is common in the Netherlands and in Western Europe for governments to decide to fund the development of waterways, ports and similar structures to stimulate economic development by improving transportation infrastructure.

Government Investments in Infrastructure
In the Netherlands and in Western Europe generally, it is not difficult to find examples where the government has decided to make major investments in water transport infrastructure based on expected future growth. Two current examples would be the canal connecting the Danube and Rhine Rivers, recently completed, and an expansion of the Port of Rotterdam in the Netherlands. The Main (a tributary of the Rhine) - Danube Canal, connecting hundreds of inland ports from the North Sea to the Black Sea, was developed for a cost of over $ 4 billion. Currently, plans are being developed for an additional expansion of the Port of Rotterdam, already the largest sea-port in the world, of which the water related infrastructure will exceed $3 billion. Regarding both projects, the policy is that the Governments will make the investments based on *expectation* of future growth and *expectations* that increased future tax revenues will be sufficient to repay the investment.

5.4.4 Environmental aspects of river transport

It is important to realize that commodities will be transported by one mode or another. The real environmental costs of river transport and other modes of transportation need to be fully captured before decisions are made about what mode of transportation is lease detrimental.

It may initially seem contradictory to promote increased river transport as being environmentally friendly, when extra barge traffic would intuitively seem to be somewhat damaging the riverine environment. However, when viewed on larger scale, other environmental issues must be considered, namely air and noise pollution and safety issues, both for the environment and casualties in accidents.

Figure 5.3 illustrates the equivalent number of trucks required to haul the cargo load of a single barge and a single 15 barge tow. Depending on the source, this number of trucks amounts to an impressive one thousand.

5.5 Environmental protection and development

5.5.1 Technical elements of the plan for environmental protection

Technical elements of the plan
It is realized more and more that the most effective way of river management is to use as much as possible the natural conditions of the river itself. Since the river can not be con-

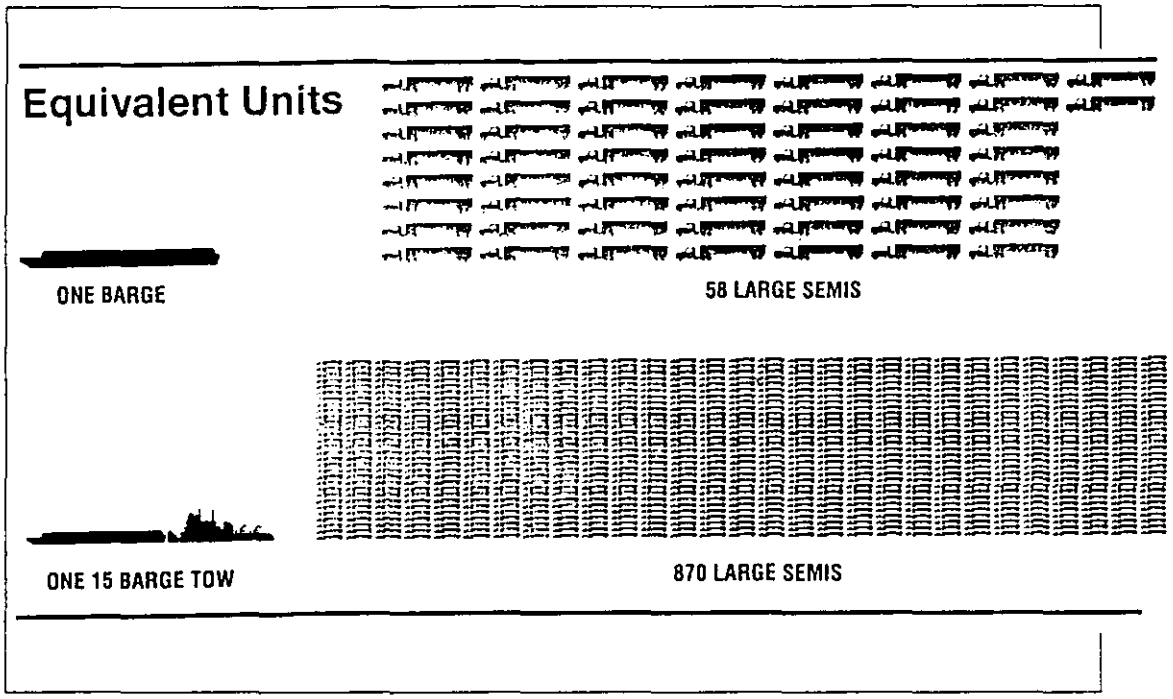

Figure 5.3: Truck units required to transport the load of one barge and one tow (source: Iowa Department of Transportation)

sidered to be as natural as before human intervention, this implies a thorough knowledge of the river dynamics under the current conditions. While accepting the existing conditions given by the existing navigation pools, or by the existing reservoirs, and also agricultural land use is a part of these boundary conditions, it should be considered which ecosystem values could potentially develop. This should form the basis for a natural resource baseline against which maintenance and restoration plans can be developed.

According to European standards, the Upper Mississippi, Illinois and Missouri rivers, although undoubtedly impoverished compared to the "natural state", still exhibit river corridors of outstanding natural beauty. These resources should, and in the opinion of the Delft Team can, be safeguarded without violating navigation or farming interests. Apart from certain conflicting conditions, which are inherent to the way we have built and now maintain our civilization, many win - win situations are possible and should be explored.

One of the issues arising in the discussions on the environmental value of the Upper Mississippi River branches is the constriction of the main channel into a narrow navigation channel, which moreover is disturbed to a certain extent by the wake and propeller-induced water movements of tows. "Natural" flowing water ecosystems in other, less disturbed parts of the river system, such as secondary channels have often been closed, and now suffer from siltation. On the one hand it should be realized that this is a natural process: every river reach not significantly contributing to the discharge of the river has lower stream velocities, and consequently sedimentation will result. The result of this process can well be seen on topographic maps and aerial photographs (oxbow or horse-

shoe lakes all around). On the other hand, since the river has been confined to essentially one channel, no new side channels are allowed to form. This leads to an imbalance in the distribution of ecosystem types in the river system. The potential for secondary channels to be restored should be evaluated for as many locations as possible. If they are properly located, based on geomorphological and hydraulic consideration, the siltation may be relatively restricted or even nearly be compensated by flushing at high stages. But eventually, secondary channels will silt up, as part of the natural succession, and new secondary channels should be allowed to develop.

An important guideline for the restoration of environmental values in the river system is a sound inventory of the river's ecological development potential, on the basis of the current (or designed) characteristics, of the whole river. It has been noted by the Galloway Committee (p. 149) that information on the distribution, abundance, and ecological relationships of species and a comprehensive inventory and classification of ecosystems are largely incomplete for the upper Mississippi River Basin. It seems that this information gap has since not been filled. Nature restoration should concentrate on the rehabilitation of the river processes rather than the exact definition or even creation of habitats for specific species. The comprehensive investigation of ecosystem information on the basin level will identify missing components and contribute to the understanding of mechanisms that enhance balanced ecosystem development. If wetlands are well distributed along the river ("*a string of pearls*"), the river ecosystem itself will develop the cover types and species populations belonging to the system.

Setting target values for ecosystem development

For the purpose of policy development, an inventory was made of potential ecosystem development for the Dutch rivers. Since the landscape in the Netherlands is a man made one (i.e. virtually no "natural" landscape still remains), there is no sense in trying to define target values for natural ecosystem development in terms of population sizes of key species arbitrarily reported or assumed to have been present in past times. The river system has indeed changed so much that other ecosystem patterns and dynamics would result when continuing river management even in the most environment-friendly way.

On the basis of historical maps and current hydraulic and geomorphological characteristics of the separate river stretches, a hypothetical distribution of habitat types was mapped, which conforms with the current river dynamics. This distribution of covertypes was subsequently used to determine the potentials for selected target plant and animal species through habitat evaluation procedures. This yielded an estimation of habitat area or numbers of individuals of target species ideally supported by the separate stretches of the river system, to be used as a reference in the comparison of policy alternatives (Duel et al., 1996). [see Figure 5.4] The selection of species includes not only endangered species, but also typical river bound species, and even species indicating indifference for habitat type. This allows for the comparison of a more complete cross section of the species community than when focusing on endangered species only.

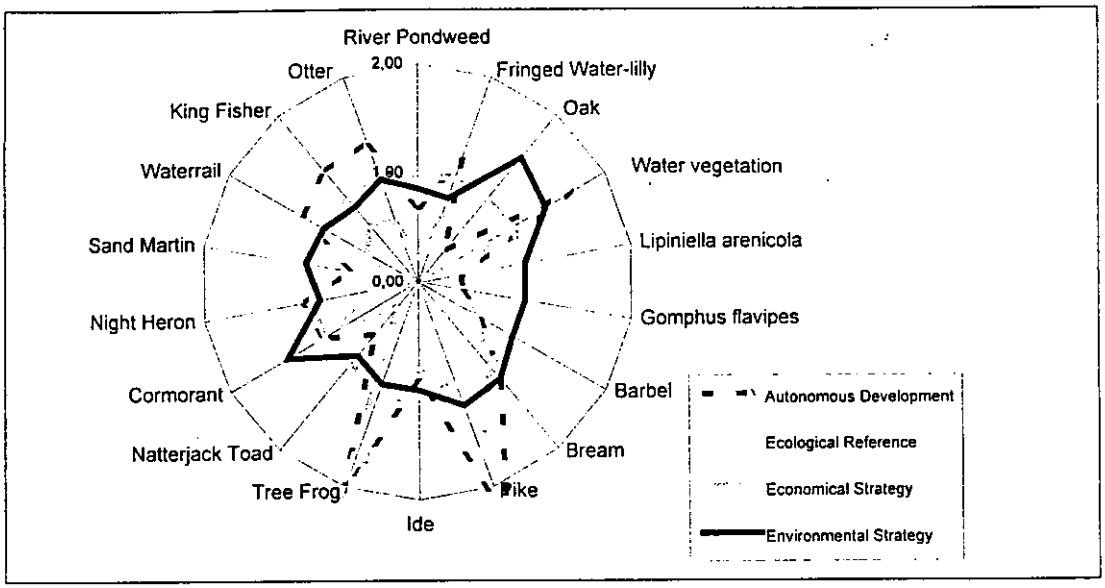

Figure 5.4: Example "amoeba" available habitats Rhine River

Although often concentrating on only few arbitrarily chosen target species, the currently used Habitat Evaluation Procedures (HEP) in the US offer a wide range of approaches and methodologies to look at improvements, and recommend options for an enhanced ecosystem development.

Net environmental benefit

A consistent approach should be developed to pro-actively set environmental targets, and evaluate the net environmental benefit of policies and measures. The Delft Team was surprised to hear that the environmental discussion on navigation development concentrates on wetlands and endangered species mainly, whereas the enormous environmental benefit of navigation compared to other means of transportation seems not to be taken into account.

5.5.2 Economic elements of the plan for environmental protection

A general economic observation is that the USACE is not required, and actually not allowed, to make environmental B/C analyses. The argument is that since many values cannot be captured economically, an environmental B/C would automatically under-estimate the value of environmental measures. The Delft Team recognizes that this is a potential problem with environmental economics. The outcome to be avoided is a sort of calculation where the cost of a habitat restoration program would be divided by an estimated number of animals or fish, coming up with a high unit cost per creature, an outcome that is easily subject to ridicule. The point is not to provide a given number of high cost animals or fish but to provide a functioning ecosystem that will offer habitat

for various species, some of which may be endangered or dwindling in numbers. An additional goal is to protect environmental services provided by ecosystems (clean water, bank stabilization, etc.) and contribute to the long-term stability of the river as a life-supporting system, as well as to protect some natural environments that people want to enjoy and pass on to their children.

The current habitat units used in the Habitat Evaluation Procedures offers a reasonable way to look at improvements in habitat that can be achieved and to compare costs for doing so. It may be, however, that there are instances in which clear economic benefits from environmental restoration or protection programs can be seen and calculated. An example would be for bank stabilization or sediment reduction. Where it is feasible to include environmental benefits in B/C analyses, it may be useful to do so. The Rock Island office of the USACE, for example, has expressed interest in such calculations.

5.5.3 Incentives for implementation

Some cases of antagonism between groups may be explained as much by the ways in which incentives are shaped by laws, as with fundamental differences of opinions. A clumsy ruling can alienate local populations and even produce perverse reactions (i.e. the reverse of what was intended by the ruling). Examples of the effects of environmental protection regulations are given in the three text boxes below. The two American examples involving farmers are anecdotal, and illustrate how regulations can backfire. It does not actually matter in this case if the farmers' perceptions of how the rulings work is legally accurate. If rules are perceived to be unfair, and the results they produce are perverse, another set of rules providing incentives more consistent with the policy objective should be found, because it will be more effective. The Dutch example shows a simple policy which meets the objective while compensating the farmers.

The contrast here is simplistic. No doubt there are mitigating circumstances that make solutions for one situation unrealistic for the other. The principle, however, holds: regulations that are perceived as unfair, shifting burden of payment of outsiders' priorities to locals, or threats stand little chance of being implemented unless forced, and they increase antagonisms.

Protecting trees

One example relating to trees and repair of flood damage was cited by a farmer who said that where there were trees in the floodplain, even small ones, it was not allowed to drive a bulldozer in that area and use the soil or sediment there to repair levees. Soil to repair levees had to be taken from areas with no trees. According to him, the old technique would have been to bulldoze in and out of the trees, leaving some standing, a process which would amount to a heavy thinning, but some trees would be left to grow. After the new ruling, farmers carefully avoided the trees until they got their payments for rebuilding the levees, and when the observers had gone, many bulldozed out all the trees so that they would not have to deal with the same irritating limitation the next time.

The "Triple S"

Farmers are not necessarily antagonistic to camping, hunting and other outdoor recreational activities, but some farmers along the upper Mississippi River have professed familiarity with the procedure known locally as the "Triple S" when an endangered species that is protected is found on their land. The presence of an endangered species is considered a potential threat to their livelihood, because it immediately entails regulations limiting the use of that land. In some instances farmers are not allowed to cultivate field areas and they may also be prohibited from cultivating or driving equipment in the vicinity to avoid making disturbing noise. Their reaction is predictable on finding such an animal or bird on their property: "SSS" stands for "shoot, shovel and shut-up."

Whatever environmentalists or others may think about such a reaction, it is clear that this kind of ruling creates perverse reactions. In economic terms, what such a ruling is saying is: "We as a society have decided that it is important to preserve endangered species. You, as farmers who own the land are required to pay the cost of this decision." It is also clear that such a ruling will cause antagonisms and make compromises in the future on other issues more difficult. The alternative is to try to devise measures or rules that will align the incentives differently so that farmers will not feel that SSS is the best answer to a threat to their livelihood.

Dutch bird nests

The Dutch government's approach to environmental incentives is not antagonistic. For instance, the government protects bird species that are considered endangered or threatened by paying farmers to ensure the protection of nests found in their fields. Farmers will work around a small nesting area, and may even erect a temporary wire fence in a pasture, in exchange for a payment per nest, which is high enough to make the effort worthwhile (Payments are in the range of about $25 to $150 per nest, depending on the species). It is seen that it is actually easier and arguably cheaper simply to *pay* farmers, instead of trying to regulate them. Farmers are reported to actually feel proud of the fact if they have several nests of endangered birds. It is seen as a badge of honour that they can help protect a bit of threatened wildlife, and the payment is a small bonus rather than a large cost.

6 The River Basin Development Study

6.1 Focus

As discussed in previous chapters, we see a clear need for a comprehensive, integrated river basin development study that should lead to a concrete plan for implementation. The study will therefore identify possible future actions, recommend opportunities for system wide projects, and investigate appropriate actions to improve the long term management of the river basin in the interests of flood control, economic development, operations, maintenance, rehabilitation, and ecosystem restoration and development activities.

The integrated study should detail, as far as possible quantitatively, the (many) inter-relations between the various elements of the river system. It goes without saying, that each of the 3 main subsystems discussed in section 3.2 (natural system, socio-economic system and administrative and institutional system), as well as their inter-relations, should be properly addressed.

The study should be a collaborated effort of federal and state agencies, and local interests. Special attention should be devoted to ensure the involvement of stakeholders in the planning process, and to inform the public about the project and its (preliminary) findings. Given the often conflicting viewpoints of many stakeholders, it may be important to have an impartial mediator, experienced in river basin management, leading the project.

The orientation of the planning process should be such that planning is carried out even with incomplete basic information. This is specifically meant as to not loose the societal attention for river management, which was stimulated by the unfortunate 1993 flood, but is about to dissipate. The planning process should immediately start, based on available information and models. Incomplete data bases and simplified models may lead to only tentative conclusions. However, also tentative conclusions are worth considering. Once the need is identified (this can also happen at the beginning of the project, parallel with planning activities), additional data collection and fine tuning of models can be undertaken.

In order not to loose above mentioned momentum, the Delft Team feels that a rapid study, even if this study reaches only tentative conclusions, should be preferred over a much more in-depth, but unavoidably slower process. The maximum study duration should be no more than three years, so that (with time for preparations) by the end of the year 2000 an agreed upon plan is ready for implementation.

It should be well understood that the resulting water resources management plan will need regular updates, say every 10 years.

The addendum to this report is prepared by the UMIM Rivers Association. It provides a conceptual plan for the development of the Upper Mississippi, Illinois and Missouri River Basins, reflecting the main issues of concern to the Rivers Association.

We agree that the topics addressed in the conceptual plan by the Rivers Association are the topics that should be included in the development study as described in this chapter. As far as the actual contents of the plan is concerned, we feel that these need further analysis in the proposed planning process. The final plan should be reached by a consensus building process.

6.2 Approach

Given the clear need for a systematic analytical process, a reliable conceptual framework for planning needs to be applied. One such framework is depicted in Figure 6.1. This has been applied in many water resources development projects world-wide. The framework makes explicit the procedure for the analysis of water resources systems and the development and assessment of integrated management strategies. Analysis, development, strategy formulation, implementation, and evaluation phases are the logical steps of the framework. Continuous communication and interaction with decision makers and stakeholders is an essential characteristic of the process. Economic, social and institutional analyses, as well as resource assessments are key elements of the framework, and lead to an integrated approach to planning. Including stakeholders as early as possible in the decision-making process ensures co-operation with and commitment to water resources management plans that are eventually adopted.

By monitoring the progress achieved by implementation of the chosen strategy, the lessons learned are taken into account in the planning of subsequent steps, and this results in integrated planning for water resources management.

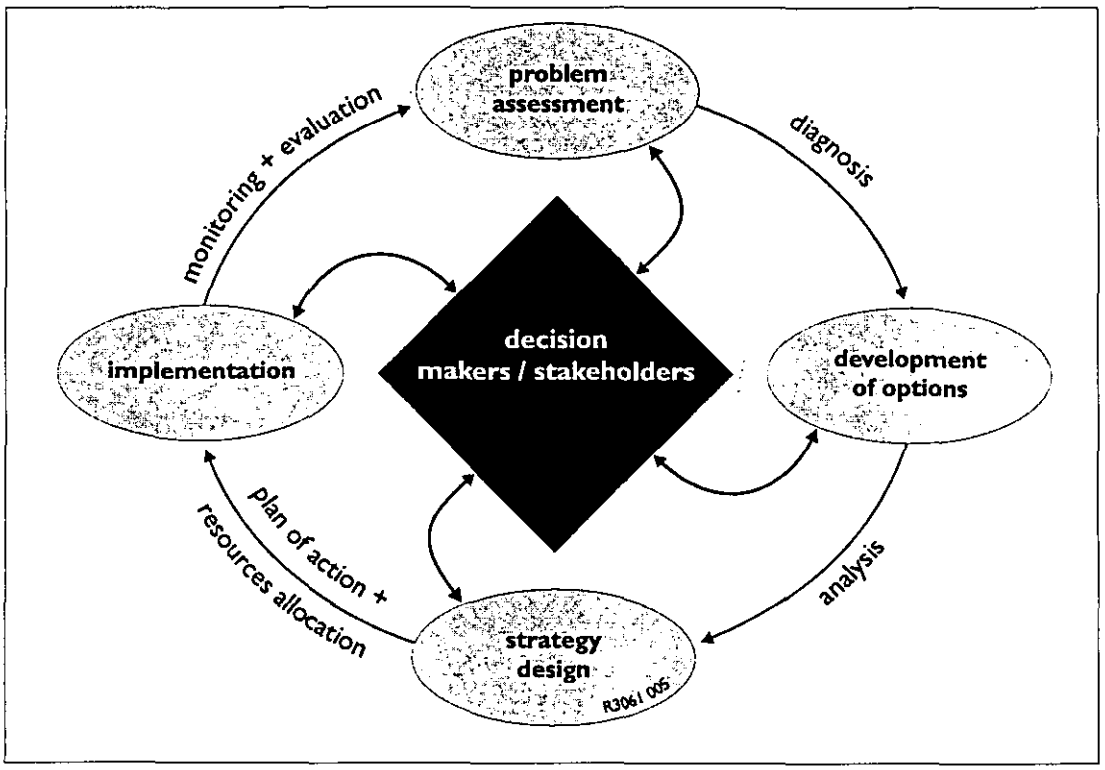

Figure 6.1: Logical Planning Framework

6.3 Output

The output of the River Basin Development Study should include:

- An integrated river basin development plan at feasibility level, with at least the years 2010 and 2025 as time horizons. Feasibility level implies that general concepts of individual projects are worked out, but not in complete detail.

- Summary material to be used for public relations, as well as a program for disseminating this information.

- A computerized Decision Support System, along the lines described in chapter 3, which already has been applied in the study in order to screen alternative measures and formulate the development plan. A simplified version of it (or the entire system) should be made available for the general public (for example by means of CD-rom technology or the Internet) as part of the public relations and information distribution program. At the same time, this system will be kept for further and future use, and serve as the starting point in a new planning cycle 10 years from now.

6.4 Timing

As indicated in the above, the Delft Team is of the opinion that a (relatively rapid) 3 year study with possibly less detail should be preferred over a longer, more detailed study. During these 3 years, a process should take place in which studies are performed and involvement of stakeholders takes place. The result of the study will not be the end, but merely the beginning of a continuous planning and management process.

Activities to occur in each year of the study are given below:

First year:

- set up the extensive coordination that will be required between all interested parties and agencies;
- during the first three months of the study: carry out an inception analysis to identify the issues to be addressed in the study, and to detail a work plan for the remaining part of the study;
- carry out basis studies, including:
  - hydrology: rainfall/runoff, discharge series, "design floods" 1/100; 1/500; 1/1000; etc.
  - morphology;
  - hydraulics;
  - economics; and
  - further work on SAST data base where required.
- development of a Decision Support System.

Second year:

- Involvement of stakeholders in development of options. This includes listing potential measures and strategies;
- Screening analysis of different measures and groups of measures (using the DSS);
- Strategy design (a strategy is defined as a consistent set of measures) and assessment of impacts.

Third year:

- Further involvement of stakeholders, discussion on findings;
- Reporting;
- Decision-making process, leading to a concrete plan of action.

Throughout the project, ample attention should be devoted to public relations, the continuous development of data bases, etc.

6.5 Budget

The total budget for a large study project as outlined above is rather difficult to estimate for an "outside organization" like ours. Including the cost of the input by governmental agencies, we estimate a total cost of between $20 to $30 million.

Providing a detailed cost estimate could -in our view- be a task for the US Army Corps of Engineers. The Corps could assess study needs in detail (keeping an eye on the objective of a rapid study) and come up with a more accurate budget estimate.

7 Glossary of acronyms and terms

B/C	Benefit / Cost ratio
DSS	Decision Support System
FAPRI	Food and Agricultural Policy Research Institute
FPMA	Flood Plain Management Assessment Study, USACE, 1995.
F&WS	Fish and Wildlife Service
GIS	Geographic Information System
GPS	Global Positioning System
HEP	Habitat Evaluation Procedure
DNR	Department of Natural Resources
SAST	Scientific Assessment and Strategy Team
SPF	Standard Project Flood
UMIM	Upper Mississippi, Illinois and Missouri (rivers)
UNET	Computer simulation model to describe unsteady river flows
USACE	United States Army Corps of Engineers

Abiotic: not pertaining to life (abiotic elements of a river system include flow velocity, water depth, size of bottom sediment, etc.).

Biotic: pertaining to life (biotic elements of a river system include fish, water-fowl, plants, micro-organisms, etc.).

Delft Team: four team members, comprised of three staff members of DELFT HYDRAULICS, the Netherlands, and an employee of the Dutch Ministry of Transport, Public Works and Water Management.

Environmental restoration: improving the ecosystem from the existing situation to some agreed state, not necessarily the original, pristine state.

Galloway Committee: Interagency Floodplain Management Review Committee (1994).

Institutional measures: policies or regulations controlling or specifying activities (examples: a regulation prohibiting housing development in the floodplain; a policy requiring all communities to have a flood evacuation plan; a policy to promote river transport over road transport, etc.).

Mississippi River Commission: a river basin commission active for the Lower Mississippi River.

Morphology: study of sediment movement, deposition and erosion in rivers.

Non-structural measures: measures to modify susceptibility to flooding (such as watershed management, floodproofing techniques, flood warning, etc.).

Standard project flood: a 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 reasonable of a particular region.

Stakeholder: a person who has an interest in river (basin) management.

Strategy: a plan to reach a specific goal, composed of a set of individual measures (for example: a strategy for navigation to meet all demands as of the year 2010 comprises the construction of bigger locks, regulations that limit noise produced by barges, development of intermodal facilities, etc.).

Structural measures: measures such as dams, reservoirs, levees, side channels, locks, deepening the navigation channel, etc.

Upper Mississippi Basin: the river basins of the Upper Mississippi, Illinois and Missouri rivers.

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