Long Term Resource Monitoring 3

The monitoring and computerized inventory and analysis elements of the EMP were born out of a critical need for the standardized collection, integration, analysis, and reporting of scientific information to UMRS resource managers and decision-makers. These two components have come to be jointly referred to as the Long Term Resource Monitoring Program (LTRMP).

LTRMP fish sampling on a backwater of the UMRS.

MISSION AND GOALS

The mission of the LTRMP, as outlined by legislation, the master plan, and program guidance documents, is to provide resource managers and decision-makers with information necessary to maintain the UMRS as a sustainable multiple-use large river ecosystem. The long-term goals of the LTRMP were established through extensive Federal and State agency participation. The goals include: (1) develop a better understanding of the ecology of the UMRS and its resource problems, (2) monitor resource change, (3) develop alternatives to better manage the UMRS, and (4) provide for the proper management of long term resource monitoring program information.

PROGRAM OVERVIEW

Need for the Program

The UMRS and its floodplain have been and continue to be highly affected by human actions, two of the most significant being: (1) the establishment and maintenance of a navigation channel traversing the entire 1,300-mile length of the UMRS and (2) levee construction resulting in a 48% reduction in the total amount of periodically inundated floodplain. In addition, natural processes, such as climate and sedimentation, interact with human activities to shape the river in a variety of both subtle and profound ways.

To understand how this dynamic system functions and to effectively manage it, system-wide monitoring, scientific research, and integrated information systems are needed.

Program Description

The LTRMP is funded through the Corps of Engineers as part of the EMP. The U.S. Geological Survey (USGS), in cooperation with the five Upper Mississippi River Basin states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), carries out the LTRMP. The Environmental Management Technical Center (EMTC) located in Onalaska, Wisconsin, is the USGS facility responsible for program management and administration.

Environmental Management Technical Center, Onalaska, Wisconsin.

Implementation of the LTRMP currently represents approximately 66% of the EMTC's total workload.

Six State operated field stations have been established along the river (Figure 3-1). Their primary responsibility is the standardized sampling/measuring of the following physical, chemical, and biological parameters: water quality, fish, macroinvertebrates, and vegetation in six river reaches.

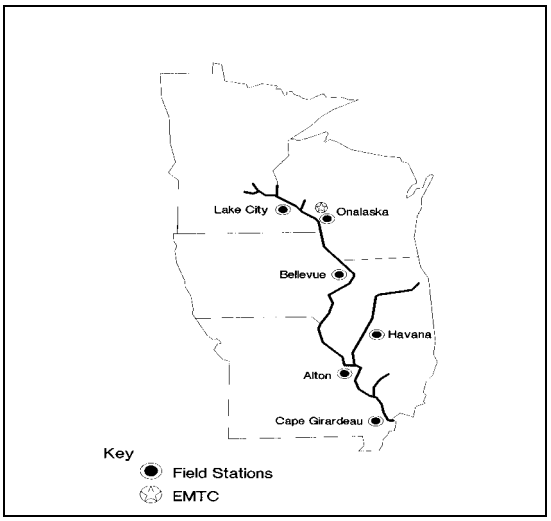


Figure 3-1. EMTC and field stations locations.

Procedure manuals for data collection have been developed to assure consistent, scientifically valid sampling. Standardized gear and sampling equipment have been acquired, and field station staff have been trained to use it. An extensive quality assurance/quality control program is in place.

Peer review is an integral part of the scientific method. At the EMTC, peer review is used routinely at several levels to ensure credible research, sound science, and useful products. This includes oversight by an international science review committee and regional expertise.

Ecological components being monitored by the LTRMP include:

- Water quality
- Water levels and discharges
- Vegetation
- Sedimentation
- Macroinvertebrates
- Fish
- Land cover and use

Natural resource and river management problems being investigated include:

- Navigation effects
- Sedimentation
- Water level regulation

The automated systems and data management practices of the EMTC provide for long term archiving of data and research results and direct access by resource managers, decision-makers, industry, and the public.

Implementation Status and Accomplishments

An Operating Plan, completed in 1988 and revised in 1993, forms the basis for Program implementation.

For management purposes, LTRMP activities have been combined and grouped under four Programmatic goals. The following paragraphs describe each goal, associated activities, and a sample of important findings and accomplishments.

Goal 1 - Develop a Better Understanding of the Ecology of the UMRS and its Resource Problems

Informed management requires an improved understanding of the ecosystem and its resource problems. The river basins of the UMRS are subject to many natural and human-induced disturbances. Navigation effects, sedimentation, and water level regulation have been identified by interagency committees as three major problem areas for the LTRMP to address.

Activities under this goal include research and analyses intended to increase our knowledge of how the floodplain river ecosystem of the UMRS operates and responds to natural events and human activities. This information is necessary for evaluating the ecological risks posed by different river uses and setting priorities for management actions. Information generated under this goal helps to identify the causal factors responsible for the system changes observed during monitoring.

One of the first steps toward implementing and refining LTRMP monitoring and research was the development of a conceptual model to describe the structure and function of the river at various scales. In a system as large and diverse as the Upper Mississippi River, physical and biological attributes of the system are affected by events at many scales. The scales recognized as important include: the basin, stream network, floodplain reach, navigation pool, and aquatic areas (backwaters, side channels, etc.). In addition to refining experimental design, the conceptual model helps prioritize effort and identify cause-and-effect mechanisms.

Concepts of ecosystem health have also been developed to characterize the UMRS. General and specific criteria are used to assess UMRS ecological factors such as: the presence of habitats necessary to support native plants and animals, the ability to recover from disturbance, and the ability to sustain itself as a viable ecosystem. The four floodplain reaches defined by the LTRMP display a wide range of health, but none meet all the criteria of a healthy, functional river floodplain ecosystem.

Commercial navigation and its adverse effects on ecological health were recognized as important research areas early in the development of the LTRMP. To elucidate the physical effects of navigation, the LTRMP funded studies of the hydrodynamic and sediment resuspension impacts of commercial and recreational boat traffic. The studies conducted by the Illinois State Water Survey aided in developing models to predict the physical impacts of commercial navigation. The data and models are currently being used by the Corps of Engineers in the Upper Mississippi River - Illinois Waterway System Navigation Feasibility Study.

Extreme hydrologic events (such as the 1988-89 drought and 1993 flood) provide unique opportunities to investigate ecological response to a natural disturbance. Taking advantage of the “natural experiments,” LTRMP researchers com-pleted investigations of plant response during the drought and following the return to more typical river conditions. Submersed plant die-offs in the upper reaches of the river were attributed to nutrient limitations and shading by algae. In southern reaches, submersed plants flourished in the atypically clear and stable waters. The flood of 1993 provided

opportunities that confirmed and quantified the beneficial impacts of a flood on the growth of some fish species and allowed the development of predictive models that estimate the flood-induced mortality for several tree species. Other flood studies investigated water quality, submersed aquatic plants, macro-invertebrates, fish communities, and reptiles and amphibians.

Goal 2: Monitor Resource Change

A primary effort of the LTRMP is to monitor and evaluate long term changes or trends in selected physical, chemical, and biological components of the UMRS.

The primary components are:

- Water quality
- Fish
- Vegetation
- Invertebrates

Additionally, selective monitoring of mussels, exotic species, sediment, and certain other system parameters has been pursued.

The LTRMP monitors UMRS invertebrate resources.

Activities under this goal are intended to create, in a standardized format, a record of how UMRS ecosystem components are changing over time. Consistent and reliable monitoring data are vital to management decisions related to ecosystem goals. Spatial analyses of the monitoring data will help to identify reach-specific habitat needs and develop strategies for habitat protection, restoration, and enhancement. Monitoring river animal and plant populations is helping managers determine which species are in need of specific management actions and document the success of ecosystem management efforts.

Aquatic vegetation is an important UMRS ecosystem component being monitored as part of the LTRMP.

- **Bathymetry.** Sediment and bathymetric surveys in backwaters provide data necessary to assess changes due to sedimentation and also to complete hydraulic models. Some highlights resulting from bathymetric surveys include the finding that sedimentation rates in impounded reaches may be slowing compared to rates experienced immediately after impound-ment, and documentation of the loss of bathymetric diversity due to island erosion and sedimentation. Bathymetric information is also used in hydraulic models that can estimate water levels, flow distribution in channels, and sediment movement. When incorporated into GIS coverages, these data are invaluable in describing ecological change to researchers, managers, and the public. In addition to routine backwater surveys in LTRMP study reaches, the LTRMP assisted with the collection and interpretation of bathymetric data collected at 1-mile intervals along the entire Upper Mississippi and Illinois Rivers. These data will be critical to systematically modeling site-specific commercial traffic impacts.

- **Sediment.** Sediment surveys are conducted to quantify sediment types in trend pools and relate them to other ecological factors. A rapid analysis tool, called a sediment penetrometer, was developed to increase the rate at which the data can be collected. Normal survey techniques required substantial laboratory analyses, but the new tool has been calibrated to conditions found on the UMRS and eliminates the need for most laboratory analyses. Additional sediment work includes compiling all the available sediment data on the Illinois River, monitoring of sediments entering from tributaries, and developing sediment budgets in several key pools.

- **Hydrology.** Hydrologic information (discharge and water levels) has been acquired for the entire period of record (some stations >100 years) for the entire river. Analyses of these data have been used to assess changes imposed by navigation dams and to evaluate dam operating procedures. Analyses that incorporate bathymetric GIS coverages and hydraulic models now provide the ability to forecast how different water level management strategies can affect river habitats. Such information is critical to assess the effectiveness of habitat restoration efforts, including island building, seed islands, and drawdowns. Another significant finding in the Open River Reach demonstrated that flood stage water levels have increased due to levee construction and low flow water levels have decreased due to downcutting in the main channel.

- **Water Quality.** Water quality monitoring has demonstrated that oxygen levels in the river are generally good, except during winter under ice in some backwaters and during summer in thermally stratified backwaters. Water clarity declines in the downstream direction as tributaries, especially in agricultural watersheds, deliver sediment eroded from the basin. The increasing turbidity downstream provides an explanation for the current distribution of submersed aquatic plants that were once more evenly distributed throughout the UMRS. Even in the Upper Impounded Reach where submersed aquatic plants are abundant, changes in ambient turbidity have been related to changes in the plant community. Analyses of chemical data collected by the LTRMP reveal a moderately nutrient enriched environment, although recent data suggest reductions in the nutrients entering the river. Increased tributary monitoring is addressing the systemic patterns of nutrient sources and sinks in an attempt to determine the UMRS contribution to nutrient loading in the Gulf of Mexico.

- **Submersed Aquatic Vegetation.** Submersed aquatic vegetation monitoring, aerial photograph interpretation, and GIS land cover-land use maps have been instrumental in creating a systemic GIS coverage of the UMRS. Annual submersed aquatic vegetation monitoring has revealed systemic patterns of aquatic plant distribution, finding the most species and the highest abundances in the Upper Impounded Reach and few or no aquatic plants in the other reaches. Annual surveys have also revealed the dynamic nature of submersed aquatic plants. Die-offs during the 1988-1989 drought have reversed and most plant beds have recovered.

- **Land Cover.** Interpretation of aerial photography has been instrumental in developing systemic land cover-land use maps. The systemic coverage based on 1989 aerial photographs will provide a baseline of aquatic and floodplain habitats that can be used for habitat rehabilitation and enhancement project planning, the U.S. Environmental Protection Agency's oil spill contingency planning, and the multi-agency Migratory Bird Strategy.

- **Macroinvertebrates.** Macroinvertebrate (mayflies and fingernail clams) monitoring has revealed important spatial distributions, both within study reaches and systemically throughout the UMRS. Generally, macroinvertebrates are more abundant in the Upper Impounded Reach than in any other. Within this reach, Pool 13 supports substantially more fingernail clams than do

Pools 4 or 8. Mayflies appear to be more evenly distributed than fingernail clams in this reach. Explanations of the distribution of fingernail clams have most often been related to municipal and industrial pollution from Minneapolis-St. Paul, Minnesota. Recent investigations also reveal within-pool patterns of macroinvertebrate distribution that are most likely related to nutrient (food) availability, flow, and substrate characteristics. Hydraulic modeling and fingernail clam sampling at the Lake Onalaska Islands HREP project is helping to elucidate the interrelations between several physical factors and macroinvertebrate distribution and abundance.

- **Fish.** Fish monitoring has documented the presence of 127 fish species in the six study reaches. There is no apparent decline in the number of species, although many species occur in lesser (blue suckers) or greater (bluegills) abundance than in the past. Changes in the abundance of some fish species have been linked to dam impacts. The blue sucker, for example, is a species adapted to swift flowing water in riverine rapids that were eliminated by the dams. Dams have also blocked migratory species such as the skipjack herring, the only known host of the ebony shell mussel whose abundance has declined dramatically in the upper pools. One of the most significant findings to date is differences in the relative abundance of backwater dependant species such as bluegill, largemouth bass, white crappie, and black crappie. Monitoring data reveal greater abundance of these species in river reaches that have high proportions of off-channel habitat. Such findings can help establish habitat goals for reaches that currently lack high abundance of these popular sport fish. Cooperative efforts between the LTRMP and the Upper Mississippi River - Illinois Waterway System Navigation Feasibility Study have provided an opportunity to sample main channel fishes that had historically been overlooked due to sampling difficulties. The results indicate that the main channel does indeed support viable fish communities, including many of the big river species suspected to be at risk from commercial navigation.

- **Birds.** Although a wildlife monitoring component was never developed for the LTRMP, land cover GIS coverages have been used to model likely bird species distributions based on habitat availability. As a cooperator in the multi-agency Upper Mississippi River Migratory Bird Plan, the LTRMP helped develop and maintains a GIS based ecological modeling tool that includes the habitat needs of almost 300 bird species.

- **Exotics.** Exotic species have been documented in submersed aquatic plant, fisheries, and macroinvertebrate sampling, as well as from aerial photograph interpretation. Eurasian milfoil is a submersed aquatic plant that has been widely dispersed by fishermen, and currently competes with native plants for space and nutrients. Terrestrial exotic plant species identified include the widely dispersed European reed canary grass that has been present for many years and recent introductions of purple loosestrife. Exotic plant pathogens, such as Dutch elm disease, have been implicated in changes to the terrestrial plant community. Exotic invertebrates include the Asian clam that has been present for many years and the zebra mussel that is a recent invader likely to negatively impact freshwater mussels. Exotic fishes detected include the highly abundant common carp and less abundant bighead carp and grass carp.

Goal 3: Develop Alternatives to Better Manage the Upper Mississippi River System

Goal 3 activities are conducted from an adaptive management approach designed to test hypotheses about the behavior of an ecosystem being changed by human use. An adaptive design permits learning from a policy action so that future decisions can proceed from a better knowledge base.

Understandings derived from monitoring (Goal II) and research (Goal I) are used to predict how the biological resources of interest will respond to alternative management actions. Learning takes place as a result of monitoring the effects of the management actions. Future actions can be adjusted in response to this new knowledge regarding ecosystem functioning.

The activities associated with this goal support and are integrated with specific U.S. Army Corps of Engineers navigation impact assessments, habitat rehabilitation and enhancement projects, and other Federal and State natural resource programs.

Development and implementation of resource management plans are the responsibility of State and Federal agencies along the UMRS. However, they increasingly are relying upon databases and information from the LTRMP. LTRMP staff coordinate with the UMR management community to cooperatively plan activities and share information.

LTRMP spatial databases have been made available to UMRS resource managers who use them to evaluate environmental conditions in their river reaches. They were used extensively by teams of managers and researchers developing ecosystem management strategies. Spatial data is continually expanded and will eventually cover all river reaches. These data will likely form the basis of the habitat needs assessment proposed for the future.

Recognizing that the LTRMP is a program based on partnerships, the LTRMP conducted an expectations survey of its partners to better address their needs and concerns. The partner expectations have provided the support for many LTRMP investigations that were designed to assist the formulation of management objectives and alternatives.

Habitat rehabilitation and enhancement monitoring has provided many applied research opportunities for the LTRMP. Cooperation among several agencies provided the information necessary to evaluate fish response to habitat improvements in the Finger Lakes and Brown's Lake HREPs. In the Finger Lakes, increased flow into isolated backwaters was shown to increase dissolved oxygen concentrations. Fish response to increased flow was investigated to determine optimum gate openings to improve conditions for fish without exposing them to stressful conditions. In Brown's Lake, LTRMP investigations helped determine the appropriate timing and duration of gate openings to improve fish habitat. Studies investigating environmental changes due to island construction have helped identify conditions favorable to fingernail clams and, consequently, to develop objectives and improve designs for future projects. The seed island concept is an innovative approach to habitat improvement that resulted from island project investigations.

With water level management for environmental benefits gaining increased attention throughout the UMRS, LTRMP hydrologic modeling and bathymetric GIS coverages have proven invaluable to managers. Hydraulic models have been used to assess the extent to which water level manipulations will affect whole pool reaches. The information is being used to modify dam operating rules in Pool 25 and also to estimate the effect of drawdowns in Pool 13. Results have indicated that for some alternatives involving dam regulation, ecological benefits could be gained without affecting commercial traffic.

Goal 4: Provide for the Proper Management of Long Term Resource Monitoring Program Information

The use of automation technology to support UMRS management decisions is a key element of the LTRMP. A high priority was placed on developing the current system to support management, distribution, analysis, and access to LTRMP data.

EMTC computer systems are used to archive and manage LTRMP data.

Activities under this goal focus on four objectives: (1) providing management and direction for automation activities; (2) providing LTRMP staff with the automation tools necessary to accomplish assigned work; (3) ensuring the management of collected data; and (4) providing resource managers, decision-makers, and the public access to LTRMP data.

Equipment maintenance is critical to providing resource management agencies and others with continuous access to LTRMP data and information.

- **Databases.** Information management and dissemination has been a high priority since the inception of the LTRMP. Standard operating procedures for data recording, entry, and verification have greatly increased the speed of data distribution, as well as the quality of the data. LTRMP data on water quality, fish, macroinvertebrates, vegetation, sedimentation, and water levels and discharge have been placed in a master database management system that is accessible by LTRMP partners and the general public through the Internet and other media. The LTRMP World Wide Web (WWW) site (http://www.emtc.er.usgs.gov), established in 1993, offers more than 8,200 files on fish, vegetation, macroinvertebrates, water quality, water levels, discharge, aerial photography, satellite imagery, scientific publications, and geographic information systems data. During 1996, the Web site was visited more than 535,000 times by individuals from all 50 states and over 70 foreign countries. In addition, the LTRMP has supported over 1,600 requests for automation services.

- **Geographic Information Systems.** The LTRMP Geographic Information System uses state-of-the-art technology and is recognized by experts for its leadership in collecting, organizing, and manipulating spatial data. Currently, the LTRMP supports data covering land cover/land use, soils, geology, transportation, hydrography, land ownership and other features. The land cover/land use information is a cooperative effort of the LTRMP remote sensing work group and the GIS work group. Thousands of aerial photographs have been reviewed by experts in photointerpretation and plant communities to produce a database that covers over 75% of the UMRS.

- **Publications.** Written reports are the standard means used to disseminate data, information, and research results to LTRMP partners. Through the years, LTRMP funds have fully or partially supported the production and distribution of more than 300 reports and related publications.

Informational pamphlets, newsletters, and project status reports have also proven to be effective mechanisms to reach the public and LTRMP partners.

LTRMP STRENGTHS AND WEAKNESSES

Background

The LTRMP has been a highly successful program primarily due to its focus on partner expectations and willingness to seek scientific and management reviews[1] of its performance. Invariably, reviews have been complementary of the efforts of the LTRMP and emphasize the rarity of such comprehensive programs among large river ecosystems, and even other ecosystem types. At the same time, each review has identified aspects of the LTRMP that should be revised, expanded, or initiated. In addition to periodic program reviews, LTRMP activities are directed by representatives of each partner agency through an advisory group known as the LTRMP Analysis Team (A-Team).

The first reviews were conducted in 1990, when the first scientific review panel of international experts and another panel of local resource managers were employed to evaluate LTRMP science and management, respectively. During 1992, the U.S. Army Corps of Engineers, North Central Division completed a review of the entire Environmental Management Program that included scientific and management evaluations of the LTRMP. The most recent reviews were completed in 1997, when the international science review committee was reconvened, another management review team was organized, and the new EMTC parent agency, the U.S. Geological Survey - Biological Resources Division, conducted scientific and administrative reviews (see Attachment 4).

[1] The specific recommendations stated in these reviews are provided as part of Attachment 4.

Program Strengths

The major strengths of the LTRMP are its partners throughout the UMRS devoted to understanding, protecting and restoring the river, the existence of six fully operational scientific field stations and the EMTC to conduct monitoring and research in several regions of the UMRS, and a long term commitment to collect and analyze information concerning UMRS natural resources. The partnership that planned and implemented the LTRMP has fostered a previously unknown level of cooperation among members of the river scientific and management community. It provides a forum for UMRS coordination, problem identification, and issue resolution. Over the last 10 years, LTRMP partners have equipped and staffed field stations; developed, implemented, and improved monitoring; refined data management; directed resources toward mutually beneficial research; and maintained support for the concept of long term data collection.

To ensure the utility of the monitoring data, the LTRMP has developed standardized methodology for data collection, processing, and distribution among the field stations and partners to assure comparability between geographic reaches of the UMRS. The development of base maps that define specific aquatic areas (habitat types) and the implementation of stratified random sampling, as recommended in previous scientific reviews, makes the data collected and conclusions that can be drawn from them quite robust. Since implementing the stratified random sampling design, monitoring results can be extrapolated to nearby unsampled sites without increasing sampling costs. The need for accurate and rapid data processing and accurate data management resulted in the development of an extensive QA/QC program and a world class data clearinghouse. LTRMP information has been accessed world-wide, but its most frequent users continue to be program partners who use the information in their day-to-day management of the river. Among the most frequent users of LTRMP information are planners developing Habitat

Rehabilitation and Enhancement Projects and conducting the Upper Mississippi River - Illinois Waterway System Navigation Feasibility Study.

The long term nature of the LTRMP is unique among large river systems and has been heralded as a model for other programs. The 15-year time frame was recognized as the minimum necessary to capture information on a dynamic system. To date, the LTRMP has collected data during the third worst drought and the biggest flood on record. Continued monitoring during "normal" conditions will help evaluate ecosystem responses to these and other extreme events. With the LTRMP infrastructure in place, the Program remains poised to capture other unique and unanticipated events.

Program Weaknesses

The LTRMP is challenged by the geographic magnitude of the UMRS that includes over 1,300 miles of navigable rivers that are influenced by a basin that covers nearly 190,000 square miles and includes over 30,000 miles of tributary streams. Monitoring such a vast system is a daunting task. Budget and legal restrictions have precluded important work at the basin scale. Additionally, the Upper Mississippi River Basin Commission initially envisioned a program that included monitoring of 22 river reaches, but current program funds support only six.

Some ecosystem components recognized as important during the initial planning stages of the LTRMP have not been incorporated into the LTRMP due to insufficient funding. Wildlife (i.e., mammals, birds, and reptiles and amphibians) and freshwater mussels are both ecologically and economically important, but LTRMP partners decided that the core resource components (water quality, fish, vegetation, and macroinvertebrates) should not be compromised to incorporate additional components. The LTRMP has instead tried to acquire additional resources to implement applied research and species-habitat modeling of a few key wildlife groups. The LTRMP infrastructure has also provided opportunities for other researchers to share equipment and expertise to implement studies of wildlife and mussels.

Costs of acquiring and analyzing spatial data have been greater than expected. The cost to develop land cover-land use maps of a typical navigation pool exceeds $60,000. Complete coverage of the UMRS would cost more than $2 million. While many partners anticipated complete annual coverages, prohibitive costs have resulted in multiple year coverages for only a few specific locations that have been identified as highly dynamic and/or important to resource management concerns. The LTRMP has been very successful, however, in acquiring outside funding to complete land cover-land use maps for almost all the impounded reaches, part of the Unimpounded Reach, and the Lower Illinois River (approximately 75% of the UMRS). In addition to land cover maps, many investigations increasingly rely on detailed bathymetric data, hydraulic models, and substrate type and distribution maps. These are expensive and currently only available for some LTRMP study reaches.

A final concern for the success of the LTRMP is that 15 years may not be long enough to distinguish trends associated with pool aging from short term cycles related to climate patterns or how stream flow variability affects physical driving forces and biological production and diversity. From an ecological perspective, "long term" for a large river system is measured in decades, not years. Hydrologic analyses, for example, reveal approximate 10-year cycles in stream flow that probably control patterns in plant and animal abundance and distribution. In an ecosystem that has evolved over thousands of years, a century may not be long enough to detect some river conditions (e.g., a 500-year flood). The LTRMP should be supported on a level that will allow it to monitor cyclical events many times to better predict ecological responses to both natural events and human activities.

PARTNERSHIP DEVELOPMENT

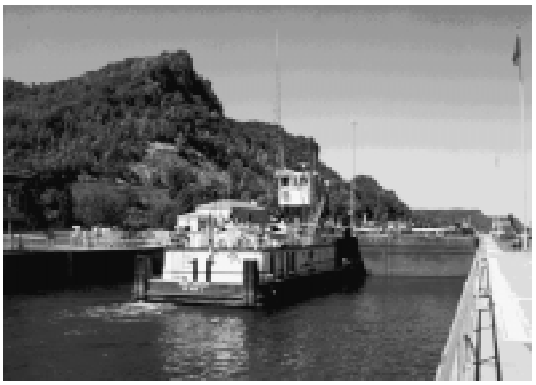
An essential role of the LTRMP is integrating and analyzing the data collected by its six field stations with data from other sources.

Partners identify and finance additional information necessary to accomplish their specific missions. In almost all cases, this additional information complements the original effort. Program partners recognize that they can combine some of their resources and data with LTRMP data and resources to create a relationship that benefits all. Following are several examples of such partnerships:

Navigation Studies

In the Corps of Engineers' 1992 Midterm Evaluation Report transmittal letter, BG Russell L. Fuhrman, at that time Commander of the former North Central Division, U.S. Army Corps of Engineers, stated:

> *The Long Term Resource Monitoring Program (LTRMP) will be a key influence in reconciliation of future conflicting interests by producing scientific, rational decisions. We have identified over $5 million in past and currently scheduled LTRMP products that are complementary to the Upper Mississippi River-Illinois Waterway Navigation Study. This research is applicable to the effects of the 2nd lock at Melvin Price Lock and Dam, as well as all future projects. We anticipate a multiplier effect from LTRMP products. The tremendous potential of the LTRMP is apparent for several Corps of Engineers missions, including operation and maintenance of navigation projects.*



Tow locking through Lock and Dam 7 at Dresbach, Minnesota.

EPA Inland Waterways Spill Response Mapping

The EMTC is funded by the Environmental Protection Agency (EPA) to manage the Midwest Inland Waterways Spill Response GIS Mapping project. This effort provides community planners, oil spill responders, and river managers with graphical and technical information on resources at risk during an inland waterway spill. Data are collected through partners such as the Upper Mississippi River Basin Association and the Great Lakes Commission. This project has provided the LTRMP with floodplain GIS data such as: sensitive areas for mammals, aquatic plants, invertebrates; water intake sites; and basin-wide transportation and hydrography data that would otherwise not be available.

Upper Midwest Gap Analysis Project (GAP)

GAP is a nationwide effort to create biological diversity and species richness spatial databases. GAP has coordinated the purchase of Landsat[2] scenes, which are being used to create land cover/land use databases for the Upper Midwest. These data, along with the habitat relationship databases and the public ownership databases that the GAP is creating, will assist the LTRMP in performing basin scale spatial analysis. This analysis is fundamental to determining

[2] Landsat is a satellite-based, passive remote sensing system that provides medium resolution land use/land cover information.

UMRS sedimentation and nutrient runoff rates. Knowledge of these rates is crucial to realizing long term ecological viability of the Upper Mississippi River. Also, these data are crucial to program partners, such as the Natural Resources Conservation Service and the EPA.

Canada geese benefit from UMRS resources.

Migratory Bird Strategy

The EMTC was funded by the U.S. Fish and Wildlife Service to provide GIS modeling support to initiate a multi-agency Migratory Bird Strategy for the Upper Mississippi River.

Conducting GIS training and collecting aerial photography of additional river reaches has been part of this effort. A prototype decision support system to help the USFWS more effectively manage refuge lands, including identification of habitat needs, is being pursued.

UMRS Vegetation Mapping

The U.S. Army Corps of Engineers has provided non-LTRMP funding to continue the high resolution 1989 land cover/use mapping project for the UMRS. This project has mapped over 50% of the UMRS from 1989 aerial photography. This project supports site-specific planning and management and systemic analysis.

MetaMaker Software

All Federal activities that create spatial databases must use the Federal Geographic Data Committee (FGDC) format when describing the content of their databases. This "metadata" (data about data) is then globally shared. The LTRMP, in cooperation with USGS Biological Resources Division staff, has developed an automated method to meet its metadata requirements. The USGS Biological Resources Division and other Federal agencies and non-governmental organizations are using this software tool.

Cooperative Education Opportunities

LTRMP staff have earned solid reputations for their expertise in the biological sciences, geography and cartography, report production, and computer technologies. Several high schools, colleges, and universities have developed close working relationships with the EMTC. These partnerships involve cooperative efforts where students gain experience in field data collection, spatial database development, technical report production, and computer technology while the LTRMP gains assistance in developing its products. As of December 1996, over 150 individuals have participated in this activity.

Biomonitoring of Environmental Status and Trends (BEST)

The EMTC is cooperating with the USGS BEST program in the Upper Mississippi basin and floodplain by collecting and automating data involving toxic threats to priority watersheds identified by the USFWS. The program will create digital spatial data and the interfaces necessary to serve them electronically. This project allows the EMTC to develop and gain access to databases that will assist in the integration and analysis of LTRMP data and be useful in long term studies of water quality on the Upper Mississippi River.

National Biological Information Infrastructure

The USGS Biological Resources Division has provided financial support for sharing LTRMP data through the National Biological Information Infrastructure (NBII). With the support of the Secretary of the Interior, the LTRMP expanded its WWW site. The Web site now offers more than 8,200 files on fish,

vegetation, macroinvertebrates, water quality, water levels, aerial photography, satellite imagery, scientific publications, and other GIS data. This effort directly supports the LTRMP requirement to ensure that data and information about the river system are readily accessible to resource managers and decision-makers.

Through the NBII, the Biological Resources Division also funded the EMTC to place automated aerial photographs of the UMRS on its web page. The EMTC scanned over 2,000 aerial photos taken in 1994 covering the entire 1,300-mile UMRS, created index maps, and placed the data on the EMTC's WWW server. These photographs can be electronically accessed and downloaded by Program staff, partners agencies, industry, and the public.

The NBII is supporting the development of a metadata clearinghouse for biological information. This clearinghouse will be used to share a wide variety of information, including metadata on LTRMP data sets.

FINDINGS AND CONCLUSIONS

Implementation of the LTRMP has provided Upper Mississippi River System scientists and natural resource managers with one of the most comprehensive large river monitoring programs in the world. The LTRMP has collected unbiased information necessary to comprehend and assess ecological conditions in four distinct river reaches. LTRMP monitoring and research findings have proven invaluable to river managers who must provide high quality recreational opportunities and ecological services to their constituents.

The LTRMP has also provided a long-needed data management system to compile, organize, and distribute information to the many interested parties on the Upper Mississippi River System. The nonadvocacy science program has fostered communication, increased the level of cooperation, and helped define expectations for the future of the river. Continuation of the LTRMP is vital to future multi-interest management of the Upper Mississippi River System.