ENVIRONMENTAL DOCUMENTATION

CHAPTER 9-- FUTURE ENVIRONMENTAL STUDY NEEDS (PROGRAMMATIC)

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1. INTRODUCTION.

1.1. Purpose and Scope.

The purpose of this appendix is to assess the need, as appropriate, for future environmental studies to address floodplain resource problem areas for which data and current technology does not allow an immediate solution. More specifically, this evaluation provides: (1) a historic perspective on UMRS environmental studies, (2) a description of the Corps' current environmental management philosophy, (3) a review of available technical support programs, data management systems, and analytical models applicable to the UMRS, and (4) a list of future environmental investigation needs.

1.4. Definitions & Concepts.

The following is an overview of the more basic definitions and concepts having a bearing on our attempts to define needs and make recommendations on UMRS floodplain study needs.

Sustainability. A synergistic process whereby environmental and economic and quality of life considerations are effectively balanced in project planning, design, construction, operation and maintenance in meeting the needs of the present without compromising the quality of life for future generations.

Ecosystem Management. Numerous attempts have been made to define this term. The following definition by Christensen et al. (1996) appears to fit well with the prevailing understanding and philosophy on this subject, it is "…management driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem structure and function." The two themes common to most definitions of ecosystem management are: (1) management should

maintain or improve ecosystems; and (2) ecosystems should provide a range of goods and services to current and future generations.

Ecosystem. The term was originally proposed to apply systems thinking to complexity in nature. Ecosystems are hierarchical, i.e. the complexity of nature can be best understood by approaching it in terms of a graded series of nested systems. Accordingly, commonly used spatial scales in the UMRS ecosystem are the river basin, watersheds, river reach, navigation pool, habitat area, and microhabitat. All levels of this ecosystem include plants and animals that transform inputs to produce outputs of nutrients, energy, and water. Today, most recognize that disturbances, both natural and man-made, have played an important role the existing health of this system.

Management. Management decisions within a hierarchy must be made at each level in the hierarchy, and the types of decisions made at each level will be considerably different. It is important to consider with great care how we conceptualize management and the decision-making process for complex systems such as the UMRS. We need to think about how to manage information at different scales and how to apply this information to make decisions at each step in the hierarchy. Once that is accomplished, tools to produce and process that information can be developed from existing technology.

Decision Support System. The working definition of the Upper Midwest Environmental Sciences Center (UMESC) for Decision Support System (DSS) is, "A spatially based computer application of data that assists a researcher or manager in making decisions." There is no one DSS; they are as diverse as the problems they help to solve. The types of DSS are limited only by the developer's imagination, and can range from a simple Web page to complex modeling applications. GIS tools fall into two categories, general purpose or specific purpose. General purpose tools (e.g. ARC/INFO and ArcView) have great functionality, but can be difficult for users unfamiliar with GIS principles. Specific-purpose tools are those that provide a user with specific functions in an easy-to-use format. Issues relevant at a watershed level are not limited to just hydrology and hydraulics, but include a range of issues related to water quality, sediment transport, groundwater/surface water interaction, climate change, ecosystem restoration, and economic and societal impacts. A DSS can help decision-makers by providing an integrated system of addressing these types of issues on a watershed or even on a basin-wide scale.

Geographic Information System. The Association for Geographic Information defines GIS as: "A system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data which are spatially referenced to the Earth." A simpler working definition is: "A computer-based approach to interpreting maps and images and applying them to problem-solving. The driver for this system is a constant need for timely information about human activities and expectations from the "real world."

Models. Models help to illustrate complex information in a simple manner. Models can be intuitive, verbal, symbolic, narrative, physical, and mathematical. Criteria including realism, relevance, flexibility, treatment of uncertainty, degree of development

and consistency, ease of parameter estimation, regulatory acceptance, and resource efficiency should be considered in selecting models to use in UMRS management (Wilcox et al. 2002). Models need to usable and understandable by all parties, and easily adjusted to meet new circumstances and thoughts. Models used in the UMRS can be an aid to developing concepts, educating, simulating processes, testing hypotheses, forecasting future conditions, conducting planning, assessing the results of monitoring, and identifying additional information and research needs (Wilcox et al. 2002).

Adaptive Management. An iterative approach to decision making involving a cycle of planning, implementation, monitoring, research, and subsequent reexamination of decisions, plans and priorities, based on new information.

Integrated River Management. Integrated river management is the functional union of many Federal river management activities to help better achieve systemic sustainability. The Federal activities being coordinated under the sustainability umbrella include: the navigation O&M, the EMP, the Environmental Continuing Authority Program (CAP; i.e. Sections 204, 206, and 1135), the WRDA 1999 Comprehensive Plan, the USFWS Refuge management, and the Illinois River Basin Restoration initiatives (Illinois River Ecosystem Restoration Feasibility Study and WRDA 2000, Public Law 106-541 Section 519, Illinois River Basin Restoration). In the future, integrated planning will be needed as an on-going effort to optimize NED and NER benefits achieved from efficient and effective adaptive river management.

2. HISTORIC PERSPECTIVE ON UMRS STUDIES.

Comprehensive basin planning has undergone a significant conceptual change during the past 40 years. Initially, it was characterized by a single-resource, single-agency, and non-public interactive focus. Overtime a general trend has evolved towards multi-resource considerations, greater inter-agencies collaboration, and an increased recognition of the need for public education and involvement.

A continuing authorization vehicle for UMRS scale multi-resource river master planning with provisions for periodic updates does not yet exist. However, a basic format for any future endeavor of that kind can be found in the form of the existing regional level GIS driven habitat/recreation master plans.

3. PRESENT DAY MANAGEMENT PHILOSOPHY.

The Corps' present day management philosophy is well articulated in its seven Environmental Operating Principles (EOPs): strive for environmental sustainability, recognize the interdependence of life and the physical environment, seek a balance between human development and natural systems, accept corporate accountability, assess and mitigate impacts to the environment, build and share an information base for understanding the environment and our work, and respect the views and interests of others--i.e. listen and learn.

If ecological processes are to be maintained, consideration must be given to the larger landscape pattern and associated disturbances. Lee and O'Neil (undated presentation) list the following as potential benefits and uses of an improved framework for sustainability:

- Identification of system components and their relationships
- Assistance in learning, communicating, and building consensus
- Identification of missing information
- Provides a template for management actions
- Prioritization of management actions
- Adaptive management of the river
- Provides an organizational framework integrating multiple disciplines

Two management approaches have gained widespread support in recent years. These are ecosystem management and adaptive management. Ecosystem management reflects the following: (1) it is holistic, integrating all elements of the ecosystem both biological and physical, (2) it is sustainable, i.e. with biological diversity, evolutionary potential and productive capability being maintained, and (3) it is human-activities inclusive. Due to the inherent complexities of ecosystem management, more and more ecosystem approaches are incorporating the concept of adaptive management (a practice-based approach involving a project's installation, monitoring, and modification).

4. EXISTING TECHNICAL SUPPORT PROGRAMS.

There is considerable technical resource base available at a number of federal and state research centers that could be brought to bear on future UMRS study analyses. Among the key federal entities are the U.S. Army Engineer Research and Development Center (ERDC), the U.S. Army Hydrologic Engineering Center (HEC), the U.S. Army Institute for Water Resources, and the USGS Upper Midwest Environmental Sciences Center (UMESC). The following a brief description of the missions and expertise of federal level sources.

4.1. U.S. Army Engineer Research and Development Center (ERDC). ERDC provides engineering and environmental research and development support to the Army and Nation. It develops new science and technology solutions to support war fighting, infrastructure, environmental, water resources, and disaster operations. ERDC has at least three major programs of interest to environmental information management of the UMRS: the Water Operations Technical Support (WOTS) Program, the Wetlands Research & Technology Center (WRTC), and the Regional Sediment Management Program (RSM). Each is described separately as follows:

WOTS Program. WOTS is funded by the Corps Operations and Maintenance (O&M) program. It is a source of direct technical assistance from the ERDC Environmental Laboratory to Corps' field offices for implementing technology to resolve

environmental problems at Corps projects. Technical assistance under WOTS is furnished to users at not cost, but is limited to 5 man-days, including travel.

For more information: contact Robert Gunkel, Jr., Program Manager (gunkelr@wes.army.mil); WOTS Web Site: http://www.wes.army.mil/el/wots/wots.html

WRTC Program. The WRTC consolidates the administrative, technological, and research skills in the area of wetlands science and engineering that are available at ERDC. The WRTC supports a holistic, interdisciplinary approach to the stewardship of resources entrusted to the Corps. The WRTC includes three major areas of research: the Wetlands Research Program (WRP), the Ecosystem Management and Restoration Research Program (EMRRP) and the Wetlands Regulatory Assistance Program (WRAP). The WRP was a four-year program with major research on critical processes, the delineation and evaluation of wetlands, the restoration and establishment of wetlands, and the stewardship and management of wetlands. The results of the WRP support the Corps' regulatory community, but also have broad application to aspects of wetlands management and stewardship. The objective of the EMRRP is to provide rapid, cost effective, function-based assessments, and restoration/stewardship technologies that address the Corps' most pressing needs for priority ecosystems. The WRAP program provides direct scientific and engineering technical support to the Corps' Operations and Maintenance (O&M) Regulatory business practice.

For information and technology transfer: contact Glenn Rhett, WRTC Request Line: 601-634-4217. EMRRP Web Site: http://www.wes.army.mil/el/emrrp

RSM Program. The TOOLS Focus Area develops the software and modeling approaches needed to predict the effects of sediment management alternatives. The PROCESSES Focus Area investigates physical processes at the micro- meso- and macro-scales working to increase our knowledge and understanding of sediment transport and large-scale morphology change. The ENGINEERED SOLUTIONS Focus Area develops the methodologies for approaching projects from a regional perspective. Lessons-learned from previous Corps projects and demonstrations are compiled. The regional influences of technologies and techniques for physically managing sediment are determined. Measurement and monitoring requirements and capabilities are identified.

In the past, the US Army Corps of Engineers (USACE) has focused on managing sand at coastal projects on a project-by-project basis. This approach to sand management may not adequately consider the impact of individual projects on down drift projects. To address this issue, the USACE has initiated efforts to assess the benefits of managing sediment resources as a regional scale resource rather than a localized project resource. The concept of Regional Sediment Management (RSM) is a result of the 67th meeting of the Coastal Engineering Research Board (CERB) held in May 1998.

In 1999, the Corps' Mobile District initiated the Northern Gulf of Mexico Regional Sediment Management Demonstration Program. The goal was to change the paradigm of project specific management to focusing on a regional approach in which the Corps as well as the state and local agencies stop "managing projects" and begin "managing the sand". The objectives of the demonstration program are: implement RSM practices,

improve economic performance by linking projects, develop new engineering techniques to optimize/conserve sediment, determine bureaucratic obstacles to regional sediment management, and manage in concert with the environment. To accomplish the RSM goal, it is essential that partnering and coordination with interested agencies be achieved. The approach includes the implementation of demonstration initiatives, the monitoring of initiatives for performance, the evaluation and modification of initiatives, and the implementation of a modified demonstration initiatives. Products include an RSM Plan, a working regional sediment budget, a calibrated regional prediction system, and a regional data management and GIS.

http://gis.sam.usace.army.mil/Projects/RSM/Project_Info/projdesc.htm

4.2. U.S. Army Hydrologic Engineering Center (HEC). HEC (a component within the Institute for Water Resources) is the Corps' designated Center of Expertise in the technical areas of surface and hydrologic statistics and risk analysis, real-time water control management and a number of other related technical subjects. It supports the Corps' headquarters, laboratories and field Districts with technical methods and guidance, analytical models, training and workshops, R&D, and provides technical assistance and special projects. The Corps' HEC programs have become the standard for H&H work in the U.S. HEC provides an array of H&H evaluation tools including the Hydrologic Modeling System (HMS), the Geospatial Hydrologic Modeling Extension (GeoHMS), the Reservoir System Simulation (ResSim), the River Analysis System (RAS). These tools are further described in **Table 1**.

For additional information on programs at National Level, contact HEC at 530-756-1104, or website (http://www.hec.usace.army.mil/contact/contact.html)

4.3. U.S. Army Institute for Water Resources (IWR). IWR was created to provide futuristic analysis and research in developing planning methodologies applicable to emerging national water resources issues. It examines water resources problems and offers solutions through a wide variety of technology transfer mechanisms. It hosts and leads Corps participation in national forums, these include the production of white papers, reports, training sessions and manuals; the development of new planning and decision-support methodologies, improved hydrologic engineering methods and software tools; and the management of other information systems. IWR has subject experts in a number of specialty areas, including dispute resolution, decision support methods, economic analyses, environmental evaluation, hydrologic engineering, risk analysis, shared vision planning, and wetlands and regulatory.

In July 2000 the Corps' Hydrologic Engineering Center and the Corps' Navigation Data Center were added to the Institute.

For additional information from IWR phone: 703-428-8015, (http://www.iwr.usace.army.mil/iwr/contactus.htm)

4.4. USGS Upper Midwest Environmental Sciences Center (UMESC). The majority of ecological research at the UMESC is conducted in support of Department of Interior issues and lands in the Upper Midwest. In cooperation with the five URM states, the UMESC is also responsible for the implementation of the Long Term Resource

Monitoring Program (LTRMP) component of the Corps' Upper Mississippi River System Environmental Management Program.

The UMESC links its research closely with other USGS science centers to broadly address ecological and population concerns in the Midwest. Research themes at the center include studies on river ecology, degraded habitats restoration, declining species, and invasive species. The Center has developed DSS approaches for use by National Wildlife Refuges as they develop their Comprehensive Conservation Plans. Center models are being used to bring biologists and engineers together to better plan habitat projects. The Center's Habitat Needs Assessment (HNA) Tool is central to UMR restoration planning. The newest effort is a DSS for the Middle Mississippi River to aid in conflict resolution over navigation development and endangered species.

For additional information from UMESC phone: 608-783-6451, (http://www.umesc.usgs.gov/overview/director-overview.html)

5. EXISTING MODELING FRAMEWORK.

The trend in recent years has been a movement towards integrated river management. Decision Support Systems (DSS) are being developed for the implementation of system-wide modeling, assessment, and restoration technologies into planning, construction, operation, and maintenance activities. Several DSS examples are available for potential application to the UMRS: the System-wide Modeling, Assessment, and Restoration Techniques (SMART) program, the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), the Illinois Rivers Decision Support System (ILRDSS), and the UMESC DSS. These three DSS are described in more detail below, along with points of contact for additional information and software.

5.1. System-wide Modeling, Assessment, and Restoration Techniques (SMART) Program. SMART is a strategic R&D program for the implementation of system-wide modeling, assessment, and restoration technologies into the planning, construction, operation, and maintenance activities. SMART is structured to build and deliver tools for more effective water resources and watershed management. SMART will provide a Web-based decision support framework, allowing access to information databases, numerical models, index models, habitat models, and socio-economic models. It will also link models together for system-wide assessments. It will provide the Corps with major new capabilities for integrated environmental management, will increase the overall effectiveness of partnering with others, and will promote sustainable resources management. SMART has a high potential for application to the Upper Mississippi River System.

U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS 39180
Dr. Steve Ashby (601-634-2387; Steven.L.Ashby@erdc.usace.army.mil).
Program Description; http://www.epa.gov/region7/news_events/events/proceedings/rwwrm2002/presentations/workshop1-2.pdf

5.2. Better Assessment Science Integrating Point and Nonpoint Sources (BASINS). BASINS integrate GIS, national watershed data, and state-of-the-art environmental assessment and modeling tools into a single package. It has three objectives: (1) to facilitate examination of environmental information, (2) to provide an

integrated watershed and modeling framework, and (3) to support analysis of point and nonpoint source management alternatives. It supports the development of total maximum daily loads (TMDLs), which requires a watershed-based approach that integrates both point and nonpoint sources.

U.S. Environmental Protection Agency, Modeling and Information Technology Team, Standards and Health Protection Division, Office of Science and Technology, Mailcode - 4305T, 1200 Pennsylvania Ave., NW
Washington, DC 20460

fax: (202) 566-0409, http://www.epa.gov/waterscience/basins/index.html

5.3. Illinois Rivers Decision Support System (ILRDSS). The Illinois River has become a focal point for agencies and organizations interested in integrated watershed management. Because of these issues including habitat restoration, floodplain management, navigation, erosion and sedimentation, and water quality are being discussed at the watershed scale. The ILRDSS is being developed as a network/communication framework that includes information resources, modular databases, and simulation models to evaluate the impact of water resources development, land-use changes, economic development, and climate variability on sedimentation, water quality, ecology, hydrology, and hydraulics in terms of long-term restoration and sustainability of the Illinois River. The ILRDSS will integrate and expand existing databases and numerical models of segments of the Illinois River into an integrated DSS for the entire river watershed. New databases and models also will be created for the watershed, as well as a comprehensive ILRDSS web portal to all available data and information about the river and its basin. Initial version was based on an uncalibrated hydrologic model of the Illinois River watershed based on the USEPA BASINS 3.0 software version.

Chris Jennings; Web/Database/GIS Developer ph:217-244-0904;
The website (http://ilrdss.sws.uiuc.edu)

5.4. Upper Midwest Environmental Sciences Center (UMESC DSS). UMESC DSS developers have a wide variety of options available at varying levels of complexity and ease of use. Specific types of DDS tools available include: an LTRMP Spatial Data Query and Visualization Tool, the Mark Twain National Wildlife Refuge and Illinois River National Wildlife and Fish Refuge DDS, the Habitat Needs Assessment Query Tool, Dabbling Duck Models, and GIS Tools for Conservation Planning.

Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, Wisconsin 54603
Doug Olsen, UMESC ph: (608) 783-6451
Website (http://www.umesc.usgs.gov/dss.html)

6. EXISTING MODELS.

6.1. Models Overview. Table 1 provides a sampling of the growing number of hydrology, hydraulics, sediments, bio-economic, habitat and ecological models that are now available or potentially could be made available for application in the UMRS. Most of the ecosystem models address conditions at the habitat area or navigation pool scale. Environmental assessment models are also being developed for one or multiple

navigation pools. These models draw heavily upon hydrologic and hydraulic models reflecting the importance of physical processes to the ecosystem. Except for the pool models, the existing UMRS ecological models are limited in focus by process and scale. It is anticipated that four models in particular will play a particularly important planning role in the near term: these are the Ecosystem Functions Model (EFM), the Hydrogeomorphic Approach (HGM), and the second generation Habitat Needs Assessment (HNA). These models (also listed in **Table 1**) are more fully described below.

6.2. Key Planning Models.

6.2.1. Ecosystem Functions Model (EFM). For ecosystem management, the EFM model has a high potential for application to the UMRS. This model, which also integrates the use of other HEC programs as needed, was initiated in conjunction with the Sacramento and San Joaquin River Basins Comprehensive Study of flood damage reduction and restoration opportunities (Hickey & Dunn, 2004). It is a planning tool that analyzes ecosystem response to changes in flow regime. The tool is being developed by HEC to help District's determine the effects of proposed alternatives (e.g. reservoir operations or levee alignments) on ecosystem health. EFM is a computer model that consists of a user interface and an ArcGIS extension. The hydraulic modeling portion is performed by the HEC-RAS. The tool allows a planning team to visualize baseline resource conditions, to identify promising restoration sites, and to evaluate and rank project alternatives based on there ecosystem effects. The tool is applicable to a wide-range of ecotypes and Corps projects. EFM allows users to specify and perform statistical analyses on ecosystem flow/response relationships, and to apply the GIS in support of restoration planning. For the visualization of statistical results, the data stream includes a flow and stage time series, eco-hydro relationships, digital topography, a geo-referenced hydraulic model, and potentially other special data.

Under EFM, "functional relationships" are developed by linking the hydro flow/stage time series to the ecosystem parameters of interest through combinations of four criteria: season, flow frequency, duration, and rate of stage recession. Next, the computational engine analyses the flow/stage time series for the specified criteria and produces a single flow value for each relationship. The process is repeated for all with and without project conditions to compare changes in ecosystem health. HEC-RAS is the standard hydraulic model driver for EFM, and water surface profiles produced by HEC-RAS can be translated into GIS area coverage for inundation, depth and velocity using HEC-GeoRAS.

The GIS component is a major strength of the EFM, allowing for the visualization of existing ecologic conditions, highlights potential restoration locations, computes depth and velocity data, and makes it possible to access multiple alternatives incrementally.

In February 2004, HEC and The Nature Conservancy (TNC) established an Interagency Personnel Agreement that assigned John Hickey of HEC to the Sustainable Rivers Project (SRP). The SRP is an ongoing partnership effort between the Corps and

the TNC to identify opportunities and implement plans to re-operate Corps dams to achieve more ecologically sustainable flows. The SRP is being carried out under a Memorandum of Understanding (MOU) signed between the Corps and TNC in 2000. The SRP currently involves ten rivers with thirteen dams as candidate sites for re-operation and hopes to expand the list. The effort seeks to restore more natural flow regimes to improve ecosystem health while continuing to provide services including flood damage reduction, hydropower, and water supply. To date, HEC has used the EFM at three locations: the Sacramento and San Joaquin River Basins Comprehensive Study, CA; the Truckee River, NV, and on the Savannah River Comprehensive Study, SC. While working on these project sites, HEC will attempt to identify and make betterments to the EFM as well as other HEC and Corps software. Soon the EFM will also be applied in consultation with the TNC to the West and Ashuelot Rivers in New Hampshire and Vermont, and the Bill Williams River in Arizona. The EFM at Savannah District HEC & TNC analyzed from an ecological perspective--alternative flow regimes produced by the ResSim model.

The St. Louis Corps District is currently applying the EFM methodology (with guidance from the HEC) to the Upper Mississippi River Navigation Pool 25 Dam Point Control project component of the UMRS Navigation and Ecosystem Sustainability Program. This program is being pursued under the UMR-IWS Navigation Study.

6.2.2. Hydrogeomorphic (HGM) Approach for Assessing Wetland Functions. HGM is a procedure for developing and applying indices for the site-specific assessment of wetland functions. It was originally designed for use with the Clean Water Act Section 404 Regulatory Program permit review process. In this context, it has been used to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have since been identified, including the design of wetland restoration projects, and the management of wetlands.

Regional HGM Guidebooks have been developed for assessing the functions of wetlands in selected areas of the U.S. One such guidebook was prepared for the Delta Region of Arkansas, which is part of the Lower Mississippi River Alluvial Valley. The report provides assessment models and protocols for the main wetland types in that region. The guidebook provides the rationale used to (1) select the wetlands assessment functions, (2) select the assessment model parameters, and (3) the functional index calibration curves developed from reference wetlands that are used in the assessment models. The book outlines an assessment procedure for using the model variables and functional indices to assess the wetland types. The appendices provide field data collection forms, calculations spreadsheets, and supporting GIS spatial data.

HGM uses functional indices based on multi-criteria assessment models to estimate the functional capacity of a wetland. The models are representations of the relationship between the physical/chemical/biological attributes of the wetland and surrounding landscape and the wetlands functional capacity. The model variables are scaled to data

obtained from the reference wetlands and assigned a sub-index ranging from 0.0 to 1.0 with 1.0 assigned to variables with attributes similar to those measured at reference standard sties. As the variable deviates from the reference standard, the sub-index is reduced from 1.0. Characterization of a wetland type, its associated functional indices, and the data used to calibrate those indices are provided in regional guidebooks.

Application of a regional guidebook requires collection of office and field data. Each variable is then converted to a single subindex score ranging from 0.0-1.0 and then combined with different variables in a set of models to provide a Functional Capacity Index (FCI), also ranging from 0.0—1.0 for each wetland function. This index provides a relative measure of how the assessed wetland compares to least disturbed, ecologically mature similar wetlands in the region. The FCI can then be multiplied times the area of the wetland to compute Fuctional Capacity Units (FCU) to facilitate a comparison of wetlands of different sizes. Therefore, the HGM Approach considers both the quality of a site using FCIs and the quantitiy (area) of the site to establish a common currency for comparison (FCUs). Each regional guidebook provides an analysis of multiple wetland functions representing at least the following broad topics, hydrology, water quality, plant community, and wildlife habitat.

HGM does not assign a value to wetland functions, the value represents the significance of wetland functions to mankind and often reflects local priorities and policy issues beyond the scope of the HGM Approach. The FCIs cannot be equated to the socio-economic value of that wetland function. HGM is not intended to compare different subclasses of wetlands, rather it should be used to compare wetlands from similar subclasses in the same reference domain. In addition, the results of the HGM cannot be used to assess cumulative impacts—it is designed to assess wetlands at the ecosystem scale.

The results from an HGM assessment can be used to: (1) assess a single site, (2) compare two or more sites, (3) calculate project impacts for a single site, (4) compute impacts for an “after-the-fact” permit action, (5) determine mitigation requirements, and (6) assess mitigation success.

Potentially, the FCU output generated from use of the HGM approach could be applied as one source of input to the Corps ICA procedure.

6.2.3. Habitat Needs Assessment (HNA).

The next generation of UMRS-EMP HNA could conceivably include habitat quality considerations in addition to habitat quantity considerations. The HNA tool could be configured to tie into one or more of the habitat-based species-habitat approaches to impacts assessment. At the national level, the best known of these models is the Habitat Evaluation Procedure (HEP). Two models related to HEP that are widely used at the regional level are the Wildlife Habitat Appraisal Guide (WHAG), and the Aquatic Habitat Appraisal Guide (AHAG). Each of these models is further described below.

Habitat Evaluation Procedure (HEP). HEP was developed in 1980 by the USFWS. It uses a species-habitat based approach to impact assessment, and is a convenient tool to document the predicted effects of proposed management actions.

HEP provides a method for the quantification of habitat outputs. It is based on the assumption that habitat for a selected species can be described by a Habitat Suitability Index (HSI). This value is derived by evaluating the ability of key habitat components to supply the life requisites of selected wildlife species. Habitat quality, expressed as an index or HSI, measures how suitable the habitat is for a particular species when compared to optimum habitat. The HSI varies from 0.0 to 1.0 (optimal). The value of an area to a given species of wildlife is the product of the size of that area and the quality (HSI) of the area for the species. This product is comparable to "habitat value" and is expressed as a habitat unit (HU). One HU is equal to a unit of area (one acre) that has optimal value (HSI=1.0) to the evaluation (target) species. Target species are used in HEP to quantify habitat suitability and determine changes in the number of HUs available. Consequently, a HEP assessment is only directly applicable to the target species selected. The degree to which predicted effects can be extrapolated to a larger segment of the wildlife community depends on careful species selection. Target species selection is based on the availability of appropriate HSI models and the consensus biological opinion of an Interagency Work Group. HUs can be annualized for specific target years to project changes in habitat over time. The effects of various alternative features can then be compared by applying the HSIs to the acreages for each feature considered. HEP can be applied as one source of input to the Corps CEA/ICA procedure.

Wildlife Habitat Appraisal Guide (WHAG). WHAG was developed by the Missouri Department of Conservation (MDOC) and the Natural Resources Conservation Service based on an abbreviated version of the U.S. Fish and Wildlife Service's (USFWS) HEP. WHAG has received wide-spread application on the Upper Mississippi River System—Environmental Management Program (UMRS—EMP) Habitat Rehabilitation and Enhancement Projects (HREPs).

The WHAG provides HSI values for areas classified into broad land-use types. WHAG utilizes checklist-type appraisals for each habitat type. The guide breaks down habitat into the most important characteristics which are rated on a 1 to 5 or 1 to 10 scale, depending on their importance. Field data values are entered into a computer program which rates habitat types based on life requisite requirements on the study area. HUs are annualized for the target years in order to evaluate the changes in project features over time. Because the WHAG method rates habitat quality in terms of individual wildlife species, habitat units are also relative to individual species.

Aquatic Habitat Appraisal Guide (AHAG). The AHAG was developed by the Corps' U.S. Army Engineer Research and Development Center (formerly the Waterways Experiment Station) in coordination with the Corp's Rock Island District. The HSI models for the methodology follow the format of the Missouri WHAG. The AHAG is still evolving, and needs further verification; however, the procedure does represent the state-of-the-art.

There are two phases to the AHAG: (1) preparation of habitat guilds for fishes that have been collected within the study area, and (2) determining habitat quality ratings for selected target species representative of each guild according to habitat preference and life history stage. In the first phase, a list of fish species obtained for the study area is separated into five guilds: swiftwater-large fishes (Group 1), swiftwater-small fishes (Group 2), slackwater-large fishes (Group 3), slackwater-small fishes (Group 4), and generalists (Group 5).

The AHAG uses HSI scores to relate the value of selected habitat variables to a defined guild. Physical and water quality variables used in the guides have been identified as important in structuring fish communities in a variety of stream ecosystems. Furthermore, they characterize physical changes that have or could influence habitat quality. Each variable may limit the abundance and distribution of guild members.

For each guild, the range of habitat values is divided into classes and an HSI score is assigned to each class by life history stage (spawning, rearing, and adults). Each variable class is rated as excellent (1), good (.75), fair (.5), poor (.25), or unusable (0) habitat. The rating is based on information found in the HSI models published by the USFWS and other data sources. HUs can be determined by multiplying HSIs and acres. The AHAG data forms allow the user to enter all habitat measurements and calculate HSI values directly in the field.

The AHAG method includes eight evaluation species and 16 habitat characteristics. Using a matrix, the team rates all applicable habitat characteristics at each sample site under existing and future with and without project conditions.

6.2.4. Cost-Effectiveness Analysis (CEA) and Incremental Cost Analysis (ICA).

Two methods are often used for investment evaluation on Corps of Engineers projects: the Cost Benefit Analysis (CBA) and the CEA/ICA. The CBA approach is to assign dollar values to benefits, but is regarded by many as being inappropriate for the evaluation of social or environmental factors. Within the Corps of Engineers, the CEA/ICA is considered to be an easier and standardized procedure that is of greater relevance to the decision maker. It includes an outcome consisting of a set of solutions that achieve the stated objectives at minimal cost, which determines whether the additional cost for a more effective solution corresponds to the gain in effectiveness. The output of alternative solutions is usually a single, quantified physical measure; outputs can also be environmental or social indicators.

Future more site-specific CE/ICA analyses could incorporate habitat-based and wetland functions-based output quantification procedures. The habitat-based outputs would be calculated as habitat units (or HUs, the product of site acres times a habitat suitability index), and the wetlands function-based outputs would be calculated as functional capability units (or FCUs, the product of site acres times a functional capability index (FCI)).

The USFWS Habitat Evaluation Procedures (HEP) or the HEP-derived WHAG and AHAG methodologies are logical choices for generating UMRS habitat unit outputs. The development of an UMRS Hydrogeomorphic (HGM) guidebook would enable the development of UMRS region-specific FCIs and FCUs. The Ecosystem Functions Model, currently under development at the Corps Hydrologic Engineering Center (HEC) may help add to the reliability of habitat output and functional capability output values. The Corps' Institute of Water Resources (IWR) is currently attempting to develop a new generation of CE/ICA that combines socio-economic and environmental components. Likewise, the Appendix __ provides additional information on the latest generation of environmental evaluation tools.

7. FUTURE STUDY NEEDS.

7.1. Future Programs.

There doesn't appear to be a lack of technical expertise and assistance for field offices to draw upon. The challenge for the future is in appropriately focusing that expertise of UMRS relevant issues.

7.2. Future Modeling Framework.

Wilcox et al. (Undated) identify a number of considerations for the future development of a UMRS environmental model system:

- Model system development is essential to planning and management to sustain the ecological integrity of the UMRS, and can be effectively used for integrated river management to help achieve a sustainable UMRS ecosystem.
- Model system needs to be built as a collaborative effort, perhaps along the lines of the Labinski (1993) conceptual model.
- Model system framework should be reviewed by a technical team.
- Model framework should be flexible, and have a GIS capability to generate spatially explicit simulations and visualization products.
- Model system should expand on the ongoing "pool planning" efforts underway, in a collaborative Adaptive Environmental Assessment framework.
- Model system should be used to forecast future conditions, set measurable objectives for condition of the river ecosystem, pose hypotheses about system response to management activities, evaluate and compare management alternatives, evaluate and compare management alternatives, formulate alternative plans, and aid in monitoring the effectiveness of management actions.
- Model system should be part of a Decision Support System (DSS) enabling informed management decision-making. DSS would link with existing GIS and other river data, and should be capable of calculating ecosystem monetary and non-monetary outputs.

- Model system should also be used to identify future river management information and research needs.

7.3. Future Models.

Wilcox et al. (Undated) identify a number of considerations for the future models development:

- Models should be hierarchically organized according to scale and process to effectively represent the range of natural and man-made factors that shape the ecological condition of the UMRS.
- Models could be linked to river and reservoir water quality models to simulate nutrient and sediment loadings. Such a model could be used to identify ecologically effective watershed management alternatives, and help optimize investment in best management practices. It could also help establish quantitative targets for sediment and nutrient loadings in the UMRS.
- Models to help determine effective control strategies for exotic species would be of value.

8. CONCLUSIONS.

Table 2 (shaded area) displays a potential new approach to multi-resource projects management on the UMRS. The salient differences between this study approach and the principle existing study authorities is also shown in **Table 2**. The new approach focuses on multi-resource management, collaboration at all levels, a continuous study process, feasibility studies as the need arises, periodic reports to Congress, consolidated documentation, includes a GIS-based DSS, incorporates all existing models and accommodates new models, operates at multiple planning scales, includes entire basin, utilizes an existing monitoring system, utilizes a tiered approach to NEPA compliance. More specifically, the approach could include the following:

- **Regional IMP.** This could entail the establishment of a permanent, UMRS Integrated Management Plan (IMP) (including navigation/FDR/environment/ recreation considerations). The IMP could be developed as a periodic update of the existing river master planning process. This "living document" could take advantage of state-of-the-art planning and Monitoring Modeling and Research (MMR) innovations.

- **Holistic/Adaptive Management.** A holistic watershed approach could be applied to an IMP effort. The environmental management portion of the effort could include consideration of all environmental resources including habitat, sediments and nutrients management. In addition, an adaptive management approach could be applied to any future floodplain environmental restoration.

- **SMART Based DSS.** It could be worthwhile to have regional IMP efforts founded on an interagency web-based DSS allowing access to basin (or sub-basin)

information, databases, and models. The models could be linked for system-wide assessments. A useful starting point could be the application of the Corps' System-wide Modeling, Assessment, and Restoration Techniques Program (SMART). This DSS could allow watershed mission needs to be more fully addressed, could increase the effectiveness of partnering with federal, state and local entities, and could help encourage sustainable management. SMART could become the primary planning tool for any future site-specific FDR planning activities. This regional effort could fully recognize the jurisdictional authorities, missions, and project implementation limitations of each of the federal and state agencies contributing input to this regional effort.

- **IMP Management Responsibilities.** In addition to funding support to the UMRS regional IMP (coordination potentially based at MVR with input from the 3 Districts) and the regional database (coordination potentially based at UMESC with input from the Corps laboratories), federal funding support could be continued to the state level DSS and IMP initiatives, as well as the continued funding to federal laboratories in the R&D of SMART and its component models. Also funding for continued IWR R&D of a combined economics/environmental project evaluation/justifications model could be an important interface with SMART.

- **Expedited Model Development.** It could be beneficial in the future to place special emphasis on the regional application of the Ecosystem Functions, HGM, next generation HNA, and next generation ICA models.

- **Pilot Planning Projects.** To encourage management innovation within the UMRS, selected sub-basins could be established as pilot planning projects. The environmental component (including habitat) could be planned, designed, constructed, monitored, reassessed, and modified (as appropriate) in a manner similar to the existing framework of the EMP. The performance of these projects could be reported within the program's periodic "Reports to Congress". This aspect could include the following:

    - Potential pilot project locations could be prioritized in collaboration with USEPA/USFWS/FSA/NRCS/USFS/USACE (including ERDC), and the states.

    - The cost-effectiveness analysis for the projects prioritization could consider such factors as capital costs, operating costs, opportunity costs, and economies of scale, related activities income, any potential markets, monitoring costs, and regional economic effects.

    - Research and monitoring could be accomplished in collaboration with the UMESC and ERDC, and with the affected states.

- Program could include the states and larger NGO groups as potential project sponsors.

- The pilot projects could be cost-shared at the rate typical of EMP projects (i.e. 65% Federal and 35% non-Federal).

- Using a strategy of adaptive management, and assuming the pilot projects proved successful, additional increments of project could be proposed to Congress for implementation via the Reports to Congress.

- Program could develop an outreach program to educate the public regarding the pilot projects.

- **Support to Programs.** Continued funding support to existing UMRS federal and state conservation programs could be beneficial. Key federal programs include the: Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Forestry Incentives Program (FIP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentives Program (WHIP), Wetlands Reserve Program (WRP), UMRS Environmental Management Program (EMP), UMR-IWW Navigation Study Ecosystem Restoration Program, Section 1135 Program, and Section 206 Programs.

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TABLE 1. SELECTED MODELS FOR DESCRIBING HYDROLOGY, HYDRAUSLIC, BIOECONOMIC, AND ECOLOGICAL PROCESSES IN UMRS.						
Model	**Source**	**Status**	**Factors & Processes**	**Spatial Scales**	**Type of Model**	**More Information**
Hydrologic and Hydraulic Models						
River Analysis System (RAS)	Hydrologic Engineering Center (HEC)	Existing (Add on WQ module in R&D)	Performs hydraulic routings of stream flow. In future, will also include modeling of various water quality constituents (including BOD, phosphorus, iron, etc.). Also a sediment impact assessment modeling capability is being build into HEC-RAS. The goal of this component is to balance sediment system when sub-basin loadings change (e.g. due to grade control, bank stabilization) and predict resulting instabilities/stability in downstream channel reaches.	Multiple	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil. POC for add on sediment impacts assessment model is David Biedenharn of ERDC CHL 601-634-4653 E-mail: David.S.Biedenharn@erdc.usace.army.mil
Reservoir System Simulation (ResSim)	HEC	Existing	Simulates influence of reservoir operations on stream flows. ResSim can be used to simulate historical events, in particular extreme flood and drought periods. It accounts for all major projects and primary functions considered in the regulation of a water control system.	Multiple	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.
Hydrologic Modeling System (HMS)	HEC	Existing	Translates rainfall to runoff. In combination with the Distributed Snow Process Model (DSPM) it can also simulate the combined influence of rainfall and snowmelt, which is then translated to runoff.	Multiple	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.

TABLE 1. SELECTED MODELS FOR DESCRIBING HYDROLOGY, HYDRAUSLIC, BIOECONOMIC, AND ECOLOGICAL PROCESSES IN UMRS (CONTINUED).						
Status	**Factors & Processes**		**Spatial Scales**	**Type of Model**	**More Information**	
Hydrologic and Hydraulic Models						
Geospatial Hydrologic Modeling Extension (GeoHMS)	HEC		GeoHMS analyzes digital terrain information, to transform drainage paths and watershed boundaries into a hydrologic data structure that represents the watershed response to precipitation. Results from GeoHMS are imported to HMS where simulation is performed.	Multiple	Structures data for subsequent numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.
Unsteady Flow Model (UNET)	HEC		A routing module, used for the computation and prediction of discharge and stage hydrographs.	Multiple	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.
Flood Impact Analysis (HEC-FIA)	HEC		Using historic or forecasted events (hydrographs), HEC-FIA: calculates post flood/forecasted flood damage, computes urban and agricultural damage, and the number of structures and population impacted, assists with real time maintenance and response activities, and estimates and allocates the benefits of reservoirs and levees, reports damage and impacts by user defined political and jurisdictional boundaries, and expedites the declaration of disaster areas.	Site-specific	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.
Flood Damage Analysis (HEC-FDA)	HEC		A computer program developed to assist the Corps' staff in analyzing the economics of FDR projects. The program stores hydrologic and economic data necessary for an analysis, provides tools to visualize input data and results, computes expected annual damage and equivalent annual damages, and implements required risk-based analysis procedures.	Site-specific	Numerical simulation	Publications, Training, and Software; (503) 756-1104; fax: (503) 756-8250; e-mail: http://www.hec.usace.army.mil.
Mississippi Basin Modeling System (MBMS)	MVP		A state-of-the-art hydraulic computer model of the Mississippi River from Anoka, Minnesota, to the Gulf of Mexico. This is a system-wide model that can be used in the routine day-to-day regulation and forecasting for the Corps' Locks and Dams. It allows many agencies and businesses to operate in an orchestrated manned to anticipate changes in river conditions. The model incorporates daily weather predictions with daily river stage readings. The model responds to the systemic need for a river forecast model identified in the post-1993 FPMA and Galloway Reports. The routing model used is the unsteady flow model or UNET model.	Multiple	Numerical simulation	http://www.mvp-wc.usace.army.mil/mbms/

TABLE 1. SELECTED MODELS FOR DESCRIBING HYDROLOGY, HYDRAUSLIC, BIOECONOMIC, AND ECOLOGICAL PROCESSES IN UMRS (CONTINUED).						
Model	**Source**	**Status**	**Factors & Processes**	**Spatial Scales**	**Type of Model**	**More Information**
Ecosystem Models						
Ecosystem Functions Model (EFM)	HEC		A computer model that analyzes ecosystem response to changes in flow regime (i.e. different planning alternatives). Allows planning team to visualize baseline resource conditions, to identify promising restoration sites, and to evaluate and rank project alternatives based on there ecosystem effects. It allows users to specify and perform statistical analyses on ecosystem flow/response relationships, and to apply the GIS in support of restoration planning.	Site-specific	Numerical simulation	For more information: contact John Hickey (530-756-1104, John.T.Hickey@usace.army.mil)
Hydrogeomorphic (HGM) Model	USACE in Cooperation with USEPA	No guidebook yet developed for UMRS	A procedure for developing and applying indices for the site-specific assessment of wetland functions. It has been used to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. Other potential uses include the design of wetland restoration projects, and management of wetlands. HGM Guidebooks have been developed for assessing the functions of wetlands in selected areas of the U.S.	Multiple	Indices	http://el.erdc.usace.army.mil/wetlands/pdfs/trel01-30.pdf
Habitat Models						
Habitat Evaluation Procedures (HEP)	USFWS	Existing	A speices-habitat based approach to impact assessment, and a tool to document the predicted effects of proposed management actions.	Site-specific	Indices	http://www.fort.usgs.gov/products/software/hep/hep.asp
Wildlife Habitat Appraisal Guide (WHAG)	MDOC & NRCS	Existing	Model represents an abbreviated version of the USFWS HEP, and has been widely applied within the UMRS region (especially on the UMRS-Environmental Management Program).	Site-specific	Indices	http://www.mdc.mo.gov/landown/wild/guide/ http://www.mo.nrcs.usda.gov/programs/whip/whip_apply.html
Aquatic Habitat Appraisal Guide (AHAG)	ERDC	Existing	Model provides a model for the assessment of aquatic habitat, using a methodology following a format structure similar to that of the Missouri WHAG.	Site-specific	Indices	Jack.killgore@erdc.usace.army.mil

TABLE 1. SELECTED MODELS FOR DESCRIBING HYDROLOGY, HYDRAUSLIC, BIOECONOMIC, AND ECOLOGICAL PROCESSES IN UMRS (CONTINUED).						
Model	**Source**	**Status**	**Factors & Processes**	**Spatial Scales**	**Type of Model**	**More Information**
Habitat Models						
Habitat Needs Assessment Query Tool	USGS (UMESC)		The Habitat Needs Assessment (HNA) GIS Query Tool is an ArcView® GIS extension that was developed to assist with a habitat needs assessment for the Upper Mississippi River System (UMRS) Environmental Management Program. The query tool is delivered as an ArcView® 3.x extension and is packaged with approximately 2 gigabytes of GIS data. The HNA GIS Query Tool evaluates existing habitat conditions throughout the UMRS by allowing the user to perform bidirectional queries of species/guilds and river habitat (Figure 1). Users may query on a species and obtain habitat information, or they may query on habitat to obtain species information. These queries are accomplished by using matrices previously developed to associate a species' potential to occur within various types of habitat. Various output products are generated as a result of a user query. Habitat information is produced and presented to the user in the forms of textual, graphical, tabular, and spatial information. The HNA GIS Query Tool comes prepackaged with a browser utility that allows the user to search the accompanying GIS data. The user can search for data by spatial query or by a keyword search. The data browser also allows the user to view and print available metadata. Once the user selects the GIS data that he or she wishes to load, the browser then loads the data directly into the running ArcView session with the appropriate legend for that data set.	Multiple	Numerical analyses	Tim Fox, Phone: 608.781.6342 Email: tfox@usgs.gov. **…** Geographic information system (GIS) programming, analysis, and data production at UMESC; http://www.umesc.usgs.gov/habitat_needs_assessment/query_tool.html
Economic Models						
Cost-Effectiveness/Incremental Cost Analysis (CE / ICA)			An investigation and characterization of how the costs of extra units of environmental output increase as the level of output increases (i.e. the plan becomes larger and the number of units produced increases). In such analyses, a display or array of implementable plan increments are ranked from most to least cost effective.	Multiple	Numerical analyses	USACE, Institute for Water Resources Phone: 703-428-8065

TABLE 1. SELECTED MODELS FOR DESCRIBING HYDROLOGY, HYDRAUSLIC, BIOECONOMIC, AND ECOLOGICAL PROCESSES IN UMRS (CONTINUED).						
Model	**Source**	**Status**	**Factors & Processes**	**Spatial Scales**	**Type of Model**	**More Information**
Population Models						
Fingernail Clam Distribution (Burkhardt, USGS UMESC unpublished)			Fingernail clam occurrence, density, wind fetch, water depth, current velocity, sediment characteristics	Site-specific	Numerical regression, linked to GIS	Randy W. Burkhardt USGS—UMESC 575 Lester Avenue Onalaska, Wisconsin 54650 Phone: 608/783-7550, ext. 57 E-mail: randy_burkhardt@usgs.gov
Dabbling Duck Models	USGS (UMESC)		Models depicting dabbling duck habitat were created by the Upper Midwest Environmental Sciences Center (UMESC) to help facilitate planning for a subunit of a Habitat Rehabilitation and Enhancement Project (HREP) scheduled for construction in Pool 8 of the Upper Mississippi River.	Site-specific		http://www.umesc.usgs.gov/management/dss/5004778_duck_models.html Tim Fox, Phone: 608.781.6342 Email: tfox@usgs.gov. … Geographic information system (GIS) programming, analysis, and data production at UMESC
Bird Conservation Planning Model	USGS (UMESC)		The UMESC currently has a study effort to develop statistically sound, science-based models to support public land management for high priority bird species within a regional context. Work effort includes Decision Support Tools to assess abundance of avian species of concern.	Multiple	Numerical analysis	Melinda Knutson (UMESC); (http://www.umesc.usgs.gov/terrestrial/migratory_birds/bird_conservation_description.html)
Aquatic Plant Growth (Best et al., 2001)	Baylor University		Modeling of submersed macrophyte growth in relation to underwater light climate: modeling approaches and application potential.	Site-specific	Numerical bioenergetics, linked to GIS	http://sgnis.org/publicat/bestbuzz.htm
Other Models						
Conceptual River Basin Model	USGS		This model provides a framework for a systematic approach to monitoring, assessing, analyzing, and managing the UMR river basin.	Multiple	Conceptual	http://edc.usgs.gov/sast/www/ch_10sast.htm

TABLE 2. COMPARISION OF EXISTING AND POTENTIAL NEW STUDY APPROACH

APPROACH	EXISTING STUDY AUTHORITIES					POTENTIAL NEW STUDY APPROACH
	UMRCP STUDY	UMR-IWW STUDY	ILLINOIS RIVER ECOSYSTEM STUDY	UMRS-EMP PlANNING STUDIES	OTHER STUDY AUTHORITIES	INTEGRATED RIVER MANAGEMENT STUDY
Study Purposes	UMRS FDR, compatible Ecosystem Restoration & recreation	UMRS Navigation, Ecosystem Restoration	Illinois River Ecosystem	Ecosystem Restoration	Flood Control (Sec 205), Emergency Streambank & Shoreline Erosion Protection (Sec 14), Mitigation of Shore Damage Caused by Federal Navigation Projects (Sec 111) Small Navigation Projects (Sec 107), Beneficial Uses of Dredge Material (Sec 204), Environmental Improvement (Sec 1135), Aquatic Ecosystem Restoration (Sec 206)	FDR, Navigation, Ecosystem Restoration, Recreation, and related issues (water quality, streambank/ shoreline protection, dredge material management)
Policy Oversight	Corps	Corps	Corps + IDNR	Corps + UMRBA	Corps + Local Sponsor	Corps + UMRBA + NGOs
Documentation	FDR Comprehensive Plan Report	Feasibility Study	Feasibility Study	Reports to Congress, Definite Project Reports, Fact Sheets	Continuing Authority Reports	UMRS Master Plan Report (= Integrated Management Plan), Definite Project Reports, Fact Sheets
Reporting Interval	One-time submittal	One-time submittal	One-time submittal	Periodic Reports to Congress	Various Planning Reports	Periodic Reports to Congress (Including FS on newly proposed projects)
Study Costs	$1.7 million/year for 3 years	$7 million/year for 10 years	$1.5 million/year for 3.5 years	$2 million/year	$3 million/year	$20 million—assumes most of the funds would be obtained by displacing programs under existing authorities
Evaluation Framework	Feasibility Study	Feasibility Study	Feasibility Study, ILRDSS		None	SMART
Available Models	UNET, HNA, Nav Study GIS Database	HNA, Nav Study GIS Database, Study developed navigation models	BASINS, HNA	HNA	Usually none	UNET, RAS, Res-Sim, HMS, Geo-HMS, FIA, FDA, EFM, HEP, HGM, HNA, CE/ICA, Population Models, + Others
Planning Continuity	One-time study	One-time study	One-time study	Continuing Authority	Continuing Authority	Continuing Authority
Planning Scale	Basin, reach	Basin, reaches, pools	Sub-basins	Habitat Areas	Site-specific locations	Basin, Sub-basins, Reaches, Pools, Habitat Areas
Watershed Management	Yes (study only, no jurisdictional authority)	No	Yes (study only, no Corps jurisdictional authority)	Limited	None	Yes (study only, no Corps jurisdictional authority)
Technical Programs Utilized	ERDC, HEC, IWR, UMESC	ERDC, HEC, IWR, UMESC	ERDC, HEC, IWR, UMESC	ERDC, HEC, IWR, UMESC	ERDC, HEC, IWR, UMESC	ERDC, HEC, IWR, UMESC

TABLE 2. COMPARISION OF EXISTING AND POTENTIAL NEW STUDY APPROACH (CONTINUED)

APPROACH	EXISTING STUDY AUTHORITIES					POTENTIAL NEW STUDY APPROACH
	UMRCP STUDY	UMR-IWW STUDY	ILLINOIS RIVER ECOSYSTEM STUDY	UMRS-EMP	OTHER STUDY AUTHORITIES	INTEGRATED RIVER MANAGEMENT STUDY
Comprehensiveness	FDR Comprehensive	Navigation Comprehensive	Sub-Basin Habitat Comprehensive	River Habitat Comprehensive	Non-Comprehensive	Multi-Resource Comprehensive
Established Monitoring Mechanism	None	None	None	UMESC-LTRMP	None	UMESC-LTRMP
Ecosystem Site Location Prioritization	Gross level river location prioritization using criteria such as: within pool location, degree of urban development, degree of agricultural development, number of tributary feeders, number of landowners, amount of floodplain below bank elevation, cross-sectional area below bank elevation, standard deviation of contour control point elevations		Proximity to existing management areas, geographic spacing, willing landowners, site physical diversity, potential for nutrients removal, availability of dredge spoil areas, areas need for special protection, connectivity potential, patch size potential, potential as deepwater habitat, instream riffles potential, etc.	The HNA model yields gross quantitative and qualitative estimates of habitat needs both system-wide and within river reaches. Prioritization takes into account the desires of the agencies and the opinion of river management experts on the actual sequencing of ER site locations.	None	HNA, agency interests, expert opinions, and a multitude of screening criteria similar to those mentioned for the Illinois River and UMRCP studies.
NEPA Compliance	Tiered	Tiered	Tiered	Site-specific	Site-specific	Tiered
Long-Term Capability to Incorporate New Models	None	Limited	Limited	Yes	None	Yes
Projects Justification Format	NED	NED/NER	NER	NER	NED or NER	NED, NER, NED/NER
Long-Term Adaptive Management Approach to Risk & Uncertainty	Limited	Limited	Limited	Yes	No	Yes