Final Report

Adaptive Management and ESA-Driven Habitat Restoration in the Middle Rio Grande

Prepared for:

US Army Corps of Engineers®
Albuquerque District

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August 2011

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ADAPTIVE MANAGEMENT AND ESA-DRIVEN HABITAT RESTORATION IN THE MIDDLE RIO GRANDE

EXECUTIVE SUMMARY

Understanding and managing resources in complex, interrelated ecosystems can require an extended process built around cyclic steps of speculation (including hypothesis formation), management planning, implementation (including experimentation), evaluation, adaptive learning, and improvement of any or all of the previous steps. The ability to formulate, experiment, and test hypotheses over a sufficient time that allows meaningful data to be gathered and evaluated can be the key to making sound resource management decisions. Models can help by providing mechanisms to evaluate the potential effects of policies, activities, or practices that are being considered for implementation. This is the repeating cyclic process that has been incorporated into adaptive management. Adaptive management cuts across these activities to provide a framework to formulate testable hypotheses regarding, for example, expected responses by habitat and populations to management actions, to model environmental relationships, to document consequences of management actions, and to improve strategies for better management.

For adaptive management to be successfully applied, certain elements must be in place at the start. First, all affected stakeholders must be incorporated into the adaptive management process; decision making activities must include a mechanism to ensure that all voices are heard and program decisions reflect the diversity of views. The decision making process most often will be dominated by the majority voice(s), but provisions should allow incorporating minority views to refine management actions, as appropriate, in later cycles. Second, a clear set of objectives must be agreed upon by all stakeholders and formally stated in, for example, a vision statement or program charter. These objectives must build from clearly defined baseline conditions, which may include consideration of both historical and contemporary conditions. Third, an appropriate monitoring program must be thoughtfully defined and implemented that focuses on measuring progress at appropriate temporal and spatial scales. Such a monitoring program must assess the specific target resource responses required to evaluate progress toward the stated objectives. Fourth, there must be a firm, long-term programmatic and financial

commitment to maintaining the monitoring program – many population, community, and ecosystem responses take years to show significant change. Monitoring, correctly implemented, supplies the necessary information that enables adaptive management to operate and produce the beneficial changes necessary to achieve program goals. Lastly, there must be an equally firm commitment to applying the information gained through monitoring to modifying the management directions, as deemed appropriate. Without such a commitment, the very nature and goals of a given adaptive management program are effectively nullified. Effectiveness monitoring or any monitoring program by itself is not adaptive management. In adaptive management, all monitoring efforts must be specifically linked to the goals, problems, and priority hypotheses that have been defined by the stakeholders through the adaptive management process and the results from monitoring, their assessment and interpretation must be linked to a set of potential post-monitoring action alternatives that also have been similarly defined through that process.

The following report results from an effort to compile, review, and summarize a cross section of the diverse information available on the topic of adaptive management. The report's sections describe common links of adaptive management to other cyclic assessment and environmental management processes. The U.S. Department of Interior's technical guidance for implementing adaptive management is summarized, how the Endangered Species Act and its supporting regulations tend to limit opportunities for adaptive management is also described, and potentially differing roles for single-species recovery plans, multi-species recovery plans, and ecosystem-based adaptive management plans are characterized. Then, brief summaries are provided on where adaptive management appears to be working for North American waterfowl hunting regulations, red wolf recovery in North Carolina, the North Platte River, Glen Canyon Dam and the Colorado River, the Klamath River Basin, Kissimmee River, and the Healthy Waterways Partnership in southeast Queensland, Australia. The final portion of the report summarizes information on how to better apply adaptive management to resolve environmental issues. The discussion includes information on what works and what does not, pitfalls to avoid, requirements to deeply involve stakeholders, how monitoring aids the decision process, needs to overcome inherent human and institution limitations, and key questions to answer to help ensure adaptive management is correctly established and implemented. Two brief discussions are included on approaches and limitations for integrating adaptive management into agency decision making processes, in general, and into the Corps of Engineers planning and management processes, in particular. The report concludes with a brief discussion of the developing adaptive management plan for the Middle Rio Grande Endangered Species Collaborative Program.

ACKNOWLEDGEMENTS

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CONTENTS

INTRODUCTION

Background

Adaptive management is a systematic, iterative process to continually improve management practices over time through "learning by doing" (Walters and Holling 1990, see Figure 1). The process promotes the implementation of progressive management actions defined through the lessons learned. Adaptive management involving environmental issues typically involves directed efforts to enhance collaboration among stakeholders, managers, and scientists who are responsible for and knowledgeable about the system under consideration. Adaptive management can provide a rigorous approach to environmental management, when properly implemented.

The use of adaptive management as an improved approach to environmental management primarily stems from the work and influences of ecologists and other environmental scientists starting in the 1970s (Holling 1973, 1978; Waters and Holling 1990). Therefore, it is not surprising that it shares a common framework with the scientific method, as well as other natural resource assessment and management approaches. Fundamentally, the scientific method includes an iterative process of problem characterization, hypothesis formulation, experimentation or testing, analysis of results, and problem reevaluation in light of the obtained results. Several cycles of new hypothesis formulation and testing through the same steps may be involved until the problem is, at least in part, resolved. The cyclic decision process using a sequential stepwise mode can effectively addressing issues having relatively high uncertainties, while concurrently also yielding inherent cost efficiencies, since the earlier cyclic steps typically depend more on the use of available or easily obtainable data, potential reducing the number issues requiring resolution in subsequent steps that typically require larger targeted data collection efforts.

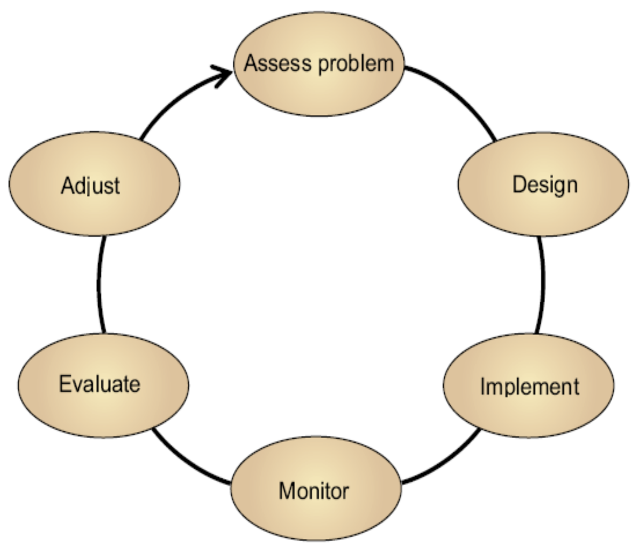

Figure 1. General Schematic of Adaptive Management process (from Williams et al.2009).

To be successful, adaptive management plans must explicitly define the steps and procedures necessary to reduce uncertainty in defining the best actions required to reach management goals and objectives for the targeted resources. Seldom are all “best actions” known at the start of the adaptive management process. Adaptive management is therefore a recurring, cyclic assessment, decision making, and implementation process, which becomes more refined with each iterative application, used to correct undesirable environmental conditions (Figure 1).Unfortunately, the term “adaptive management” has been widely misused, for example, by simply characterizing a management plan that includes a monitoring program as being adaptive management and by including a brief discussion in the plan that “adaptive management will be applied.” This practice dilutes both the concept and its application (Murray and Marmorek 2004). Monitoring is only one of the several key components of adaptive management, as discussed throughout this report.

The Middle Rio Grande Endangered Species Collaborative Program (MRG Program) is developing an adaptive management plan as an element of consultation for endangered species. The comprehensive, iterative, and collaborative nature of an adaptive management approach is why adaptive management being considered as part of the long-term management strategy for the Middle Rio Grande. To help the Corps of Engineers (Corps) integrate into this process, the Albuquerque District of the Corps, contracted to Tetra Tech the task of compiling existing adaptive management plans and associated literature that can assist with defining a central framework to support adaptive management plan development.

Problem Statement

The following report provides a summary of the recent literature and a context framework that can aid the Corps to help in the development of a Middle Rio Grande Adaptive Management Plan for the Rio Grande silvery minnow and Southwestern Willow Flycatcher. More generally, this framework is intended to be valuable for the action agencies and other Middle Rio Grande stakeholders to understand the adaptive management process and become better active participants in developing an effective plan. As discussed below, the Corps has a number of constraints limiting how much adaptive management can be incorporated into their projects. Some of these come from historical and cultural practices and some from limitations defined by Congressional funding and some from Corps regulations and guidelines. Nevertheless, use of adaptive management by the Corps is increasing with benefits being accrued. Real potential exists within the Corps for adaptive management to be increasingly included in programmatic efforts involving ecological resources, and specifically in projects involving initial project design studies, habitat restoration, monitoring and assessment studies (particularly those involving biological resources), re-vegetation, modifying floodplain inundation patterns, some areas of water management involving discharge re-regulation, and through modification operations and maintenance activities; the least potential for adaptive management exists in the areas of post project design and modification .

Report Organization

The following sections present the approach used during this project to compile and organize relevant adaptive management plans addressing management needs for both endangered and non-endangered fish and wildlife species. Appendix A presents the set of 95 documents we reviewed as part of this project. The list includes single-species plans, multi-species plans, area-specific plans, reviews of adaptive management plans, referenced literature on the practical and theoretical approaches to adaptive management, and approaches for incorporating adaptive management into river re-regulation. A companion CD for this report includes summary information for each document, in Microsoft Word format, that was extracted from each document. Typically, this is the abstract contained in the documents; where such abstracts were lacking, information from their executive summary or introductions are provided. Portable Document Format (PDF) copies of each document in their entirety have been supplied separately on DVD to the Corps Project Manager.

The next section of the report gets into the details of adaptive management for those having little background, beginning with a brief of the U.S. Department of Interior's technical guidance for implementing adaptive management, including brief introductions to and a selection of key questions to address during the development and implementation of each of the nine adaptive management steps they include. Next, we describe how the Endangered Species Act and its supporting regulations have tended to produce impediments to actively using adaptive management in the recovery of threatened and endangered species; then we describe how some of these impediments may be starting to change and these changes are creating the potential for misuse. Next, we characterize potentially differing roles for single-species recovery plans, multi-species recovery plans, and ecosystem-based adaptive management plans, noting that most of those tend to provide little or no details on how adaptive management is to be implemented. While many recovery plans for listed threatened and endangered species include mention, at least, of adaptive management within the plans, they provide little or no details on how adaptive management would be implemented. As we found no good single-species recovery plan for freshwater fish where adaptive management was obviously being actively implemented, none are summarized in our report.

Next is a brief discussion characterizing constraints, opportunities, and ongoing efforts to implement adaptive management into the Corps of Engineers planning and management processes, where; much of the current effort focuses particularly on large-scale environmental restoration challenges. A selection of what works and what does not work, as identified by a cross section of experts in the field are next presented, keys in on pitfalls to avoid, requirements to deeply involve stakeholders, application of monitoring in the decision process, then concludes with pointers necessary to identify and overcome an array of inherently human and institution limitations

The report concludes with eight case-example summaries that show a cross section of where adaptive management appears to be working for North American waterfowl hunting regulations, red wolf recovery in North Carolina, the North Platte River, Glen Canyon Dam and the Colorado River, the Klamath River Basin, Kissimmee River, and the Healthy Waterways Partner in southeast Queensland, Australia. The concluding case summary overviews the adaptive management plan and program being developed for the Middle Rio Grande, and points to the new opportunities that effort can produce.

DOCUMENT COMPILATION

The initial search for adaptive management documents was a general, web-based search using standard search engines with basic keywords such as “adaptive management” with and without modifiers such as “plan,” “review,” “ecosystem,” “conservation,” “learning by doing,” “recovery implementation,”and “endangered species.” The search also included some of the earliest advocates of adaptive management to address environmental issues: “C.S. Holling,” “C.J. Walters,” and “F.A. Johnson.” In addition, we searched the peer-reviewed literature through the

University of New Mexico's elibrary system using Google Scholar, Web of Science, and Biosis using many of the general keywords and modifiers listed above. Direct access searches of biological and ecological journals were completed using JStor and more directly through the journals' archives. Reviews of literature cited sections in the compiled documents also led to identifying other documents. Several journals that provided useful articles included Ecological Applications, Restoration Ecology, Conservation Biology, Environmental Management, BioScience, and Ecology and Society.

After the documents were complied they were numbered and selected information for the document was compiled using Microsoft Excel. Each document's executive summary, abstract, or other introductory section was extracted, numbered, and placed in a separate file for easy review. The spreadsheet includes the document number, title, author(s), document type, characteristics of the adaptive management target or publication aim, and publication date.

Through a concurrent, but independent project, we also compiled all available recovery plans for endangered freshwater fish. For those plans that included potential commitments to adaptive management, follow-up literature searches were completed to identify the availability of follow-up actions to document whether adaptive management plans were, in fact, being implemented. Unfortunately, none of these single-species plans for freshwater fishes demonstrated with clearly accessible documentation a long-term and meaningful commitment to adaptive management.

IMPLEMENTING ADATIVE MANAGEMENT

This section first introduces the general approach and requirements typically included in defining and implementing an effective adaptive management program. The discussion is focused on the steps included in the US Department of the Interior's Technical Guide on Adaptive Management, which has general applicability to many water issues in the West, including those along the Rio Grande and across New Mexico that are shared by both Reclamation and the Corps. Unfortunately, some established agency rules and regulations tend to inhibit the implementation of adaptive management (Stem et al. 2005). As such, the next two subsections explore the issues and opportunities for implementing adaptive management under, first, the Endangered Species Act and then the Corps. This section concludes with a synthesis of what works and does not work with adaptive management, as has been determined through reviews by a selection of active participants in the process. This section overviews background information useful for reviewing adaptive management plans and program approaches. Then in the next section, several adaptive management programs are reviewed to highlight what works and does not work for them.

US Department of the Interior Technical Guide on Adaptive Management

Agency-based efforts to implement adaptive management have been widespread, but not always effective. In 2009 the Department of Interior (DOI) updated its extensive guidance document on adaptive management; this guidance is intended to promote successful implementation of adaptive management in a consistent and coherent manner across all parts of the DOI (Williams et al. 2009. Early in the document it presents an operational definition for adaptive management adopted from the National Research Council (Williams et al. 2009, page v):

> Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders….

From this, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. While many suggest that adaptive management include six key steps (e.g., see Figure 1), Reclamation's guide includes a series of nine steps: (1) stakeholder involvement, (2) setting management objectives, (3) selecting management alternatives, (4) building predictive models, (5) implementing monitoring plans, (6) making decisions, (7) follow-up monitoring of the responses to management decisions,

(8) assessment, and (9) adjustment to management actions. The first five steps are collectively characterized as the *setup phase* and the final four steps are termed the *iterative phase* of adaptive management in the Reclamation guide. Steps 1 and 2 from the Reclamation guidance equate to *Assess Problem* in Figure 1, Reclamation steps 3 and 4 equate to *Design* in that figure, Reclamation's steps 5 and 6 equate to *Implement,* step 7 is *Monitoring,* step 8 is *Evaluate,* and step 9 is *Adjust* in the figure. These nine steps are described in greater detail below. Of note, the additional steps provided by Reclamation recognize the embedded feedback loop of monitoring, evaluation, and management adjustments and the need for a specific focus on the processes of stakeholder involvement. Indeed, this first step in the Reclamation guide, *Stakeholder Involvement*, is often the most critical part of the problem assessment and the point where many collaborative adaptive management efforts stall or fail, when the stakeholders fail to agree on the problem definition and the approach to be adhered to in addressing the iterative approach to solving the problem. Also, the Reclamation steps are intended to aid in recognizing that the adaptive learning feedback, and the execution of the overall adaptive management process, can occur at any given point in the cyclic loop, causing the cycle to re-set. This, then, allows for the adjustment of any of these stepped processes whenever undesirable environmental conditions become evident (suggesting a change in management approaches may be needed) or when monitoring results do not indicate a plausible response. The latter may imply the initial model(s), metric(s), or sampling plan used to monitor and evaluate the system might be ill conceived or inadequate. Thus, the cyclic 9-step process is truly adaptive.

As explained in the guide, while these nine steps are generally recognized by the scientific community as being valid, adaptive management programs have produced scattered success to date. The guide points out that this is commonly due to the stakeholders not understanding the basic concepts, commitments, and costs required to correctly implement adaptive management. Adaptive management includes many more components, including stepwise pre-monitoring planning and post-monitoring management actions, than included in typical monitoring and assessment programs. Therefore, along with a brief introduction to the nine steps presented in the DOI technical guide, the following also includes key questions that should be considered seriously by the stakeholder and responsible managers at each step.

Setup Phase

Step 1 – Stakeholder Involvement

Ensure stakeholder commitment to adaptively manage the enterprise is for its duration.

The stakeholders for any proposed action are people who must act as decision makers. The first step in this process is to identify the stakeholders and encourage their participation in the project. Stakeholders must be clearly apprised of the adaptive management process, must strive for agreement in all phases of the process, must commit to the timeframes agreed upon, and must commit resources for achieving habitat or environmental management goals. Stakeholders may include federal, state, and local governmental agencies or other organizations tasked with managing the project area, property owners, non-profit and local interest groups, community members, and any group with a vested interest in the project or project area.

Key questions:

- Who decides how to manage the project area?
- Has a systematic process been developed that facilitates effective participation by stakeholders?
- Have all key stakeholders been identified?
- Have agreed upon lines of communication been established and is their importance to the adaptive management process understood?
- Are stakeholders committed to and involved in the adaptive management process including the monitoring and assessment process?
- Is the adaptive management process able to adapt to changes in stakeholder and public viewpoints?

Step 2 – Objectives

Identify clear, measurable, and agreed-upon management objectives to guide decision-making and evaluate management effectiveness over time.

It is essential to agree upon clear and measurable management objectives. These are crucial to evaluating performance, reducing uncertainty, and improving management over time. Objectives should be specific and unambiguous, measurable through on-site data collection, achievable under the current environmental and socioeconomic conditions, and should specify desired results and the timeframe for these results. Examples of measurable objectives include improving nesting habitat for a targeted species, improving physical or chemical water quality, increasing native flora and fauna, or reducing non-native invasive species, to name a few.

Key Questions:

- What are the goals of the project?
- Have explicit and measurable objectives been identified and developed?
- Are the management objectives achievable and sustainable?
- Have performance metrics relating to the management objectives been developed?
- Are such metrics and sampling regimes appropriate for the temporal and spatial scales of the project?
- Has a system of monitoring and assessment relevant to the management objectives been developed and implemented so that progress in meeting the objectives can be tracked?
- Have tradeoffs among management objectives been considered and are they understood?

Step 3 – Management Actions

Identify a set of potential management actions for decision making.

In this step, stakeholders identify a set of management actions that are intended to achieve project objectives. It allows for stakeholders to design and structure the kinds of management actions that will be taken, determine the timeframe or life of the project, the checks needed throughout the project life, and the decision-making process for changing management strategies to meet management objectives. Multiple management actions may be implemented to further increase learning about which strategies are successful. Examples of management actions might be a plan to physically remove non-native invasive plant species or to plant native riparian plants to improve nesting and foraging habitat for a targeted species.

Key Questions:

- What is the initial management plan?
- Has a range of potential management actions been developed?
- Have the specific tasks to implement the management alternatives been identified?

- Is the range of potential actions appropriate for the timeframe under which changes are likely to occur?
- Can the set of management alternatives be adjusted through time if needed?

Step 4 – Models

Identify models that characterized different ideas (hypotheses) about how the system works.

Stakeholders must now identify a model that can be used to measure variables that indicate if the project is a success. This is the stage at which the "clear and measurable objectives" come into play. The model selected may be qualitative or quantitative; it can be as informal as a verbal description of system dynamics or it can be as formal as a mathematical equation. A Habitat Evaluation Procedure (HEP) is an example of a mathematical model. It combines Habitat Suitability Indices (HSI), which are models that describe the health of a habitat for a specific species, to mathematically calculate habitat health for a suite of native species. Qualitative models must have benchmarks for measurement. Once a model is selected, and prior to implementing management actions, an initial onsite survey must be conducted to establish baseline conditions within the project area.

Key Questions:

- How do we measure the success of our management plan?
- Are hypotheses underlying the strategies for resource management expressed as testable models?
- Have explicit links between management actions and resource dynamics been incorporated into the models?
- Are the ecological/resource processes that drive dynamics understood?
- Are the relevant environmental factors incorporated in the model?
- Are the models calibrated with available information?
- Are the model(s) appropriate for the temporal and spatial scale of the project?

Step 5 – Monitoring Plans

Design and implement a monitoring plan to track resource status and other key resource attributes.

Once the models are identified, the next step is to design a way to collect data to plug into the models. If our model asks us to collect canopy cover data, then our monitoring plan will determine when and how that data is collected and how it is used in the model. Monitoring plans should be designed to assess the existing system conditions, which describes the current state of the system, and allows us to compare it to future existing conditions. Monitoring plans should be efficient and provide maximum data collection for minimum cost.

Key Questions:

- What is the plan for monitoring success of our management plan over time?
- Is the monitoring plan appropriate for the temporal and spatial scales of the project?
- Will the monitoring plan support the testing of alternative models and measurement of progress toward accomplishing management objectives?
- Is it clear what monitoring data need to be collected to estimate the relevant resource attributes?
- Has the level of accuracy that is needed been identified?
- Are commitments among managers, scientists, and other stakeholders in place to sustain an ongoing monitoring and assessment program?
- Will meaningful and useful data and information be available in timeframes that allow for adaptive decision making?

Iterative Phase

Step 6 – Decision making

Select management actions based on management objectives, resource conditions, and understanding.

In cases where the models do not indicate successful management actions, a process should be identified for changing management plans. This is the crucial piece of the process that makes a management style adaptive. During Step 3, a number of alternative management actions should have been identified. In the event that the selected actions are not successful, as determined by the modeling, then the alternative actions may be implemented. In this step, the process of choosing a new management plan is defined.

Key Questions:

- What will our response be to unsuccessful management plans?
- Is it clear how decisions will be made?
- Are decisions at each point in time based on current status and understanding of the resource?
- Are decisions being guided by management objectives?
- Are stakeholders informed and consulted before decisions are made or changed.

Step 7 – Follow up Monitoring

Use monitoring to track system responses to management actions.

This is the actual gathering of onsite empirical data. Data are gathered following the guidelines set in the monitoring plan. Regular data collection, recording, synthesizing, and reporting should be scheduled and carried out through standardized, repeatable methods.

Key Questions:

- What is happening in our project area?
- Are the analysis needs understood?
- Is monitoring conducted on a timely basis?
- Is monitoring targeted to system attributes that are useful for evaluation and learning?
- Does the data suggest an expected or plausible response?
- Can model data be used to update the measures of model confidence?

Step 8 – Assessment

Improve understanding of resource dynamics by comparing predicted and observed changes in resource status.

In this step, data are calculated through the established model and results are reviewed to capture a description of the existing conditions of the project area. The monitoring event outcome is then compared to the baseline data to determine if project objectives are being achieved.

Key questions:

- Are we achieving our project objectives?

- Have expected impacts of alternative management strategies been evaluated?
- Is it clear how results are to be understood and interpreted?
- Have thresholds that indicate a change in management been recognized?
- Have action(s) to be taken when a threshold is reached been identified?

Step 9 – Iteration

Cycle back to Step 6

If conditions have improved according to the model's outputs, then management actions appear to be successful and continued monitoring and assessment should be carried out for the life of the project to ensure continued success. If data are placed into the models, and outcomes indicate that management actions are not successful, it will be necessary to return to Step 6 and begin the process of adapting the management plan according to available alternative management actions. The cycle from step 6 to 9 is iterated until the end of the previously determined project life. If data are unavailable or inconclusive, it may be necessary to return to step 4 to revisit model selection.

Key Questions:

- What's next?
- Are management actions and decisions reviewed frequently based on monitoring and assessment?
- Have incentives been developed to encourage experimentation and learning?
- Have resource management alternatives been revisited and/or modified over time?
- Has uncertainty related to resource dynamics and the impact of management actions been reduced through learning over time?

In brief, the DOI adaptive management approach, like others, is intended to actively engage stakeholder involvement in all phases of a project over its timeframe, facilitating mutual learning, and reinforcing the commitment to information- or fact-based management. Of key importance, adaptive management in DOI is implemented within a legal context that includes statutory authorities such as the National Environmental Policy Act (NEPA), the Endangered Species Act, and the Federal Advisory Committee Act.

Integrating Adaptive Management into the Corps of Engineers Planning and Implementation Processes

The Corps of Engineers started to use adaptive management approaches in the 1990s, with the ecosystem restoration mission that Congress gave the Corps. Traditionally, the Corps developed projects through an extended planning and design process, from which the project to be constructed was determined to be the "best plan" and that plan was funded by the U.S. Congress, with few, if any, funds allocated to monitoring or potential "redesigning." For most Corps civil works projects, there is a local sponsor that participates in cost-sharing of the project.

This approach to planning, designing, and constructing projects, whether they are flood control, navigation, or ecosystem restoration, makes the general assumption that the number of unknowns, the degree of uncertainty, and need for additional monitoring are minimal. It assumes that a detailed planning effort at the start will preclude or, at least, minimize any problems that occur after construction is complete.

Unfortunately, this assumption, particularly with regards to ecosystem restoration and endangered species activities, is rarely accurate. To successfully recover a species that is either endangered or threatened, the need for the flexibility in "learning by doing" commonly is essential. This requires the flexibility to make adjustments to regulations, policies and management measures by analyzing results of scientific monitoring following management actions and then reformulating the management plan based on this new information from the habitat to ecosystem levels, as well as very often at the endangered or threatened species level, which are increasingly involved in the decision process. It is rare that all such necessary information, requirements, and techniques are known at the start of any management planning and decision making. Therefore, adaptive management techniques provides the structure and promotes the flexibility for decision making that can be adjusted as outcomes from management measures become better understood through monitoring and reanalysis.

Unfortunately, certain present policies and regulations within the Corps tend to limit the use of adaptive management. For example, the Planning Guidance Notebook (PGN), the planning "bible" for the Corps (Corps 2000) appears to provide the principal present the guidance for the majority of Corp projects regarding adaptive management and defines the constraints on time intervals and costs that can be devoted to adaptive management (Chapter 3, page 25):

> *(8) Monitoring and Adaptive Management. Monitoring may be necessary to determine if the predicted outputs are being achieved and to provide feedback for future projects. Cost-shared post-implementation monitoring will rarely be required. If cost-shared implementation monitoring is being considered, it must be clearly defined, justified and the period of cost-shared monitoring shall not exceed five years following the completion of construction. The cost of monitoring included in the total project cost of ecosystem restoration features. For complex specifically authorized projects that have a high level of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended. The cost of adaptive management action, if needed, will be limited to 3 percent of the total project cost excluding monitoring costs.*

Despite such restrictions, the Corps has undertaken several significant projects applying an adaptive management framework, primarily in response to Congressional direction. These include, but are not limited to activities on the Missouri River Dam and Reservoir System, the Florida Everglades, the Upper Mississippi River, and coastal Louisiana. Largely from a review of these projects, in 2004 the National Research Council (NRC 2004) issued a report on the past, present and potential use of adaptive management by the Corps. It found that,

> "Adaptive management is often implemented in river and aquatic ecosystems that are experiencing ecological decline, sharp differences of opinion among stakeholder groups, and an inability to make significant departures from the status quo. Many parties, however, view the concept with skepticism; defenders of the status quo naturally resist new management directions, managers may interpret its implementation as indicating failure of their past decisions, some may view it as a vehicle to help circumvent environmental and other standards or for taking only minimal actions, and budgeteers may be concerned that it implies a blank check for an endless stream of monitoring and science-based programs. Whatever perspectives are held, successful implementation of adaptive management will require sustained participation. In addition to these barriers, actions taken under an adaptive management framework may not yield an abundance of positive and clearly understood results.

> "Paradoxically, however, these conditions may actually enhance the chances of the usefulness and success of adaptive management….
>
> "Decisive management actions and ecological recovery have, for the most part, not been realized, but given that it has often taken decades to arrive at the current situation, the way forward will require patience (whether adaptive management is used or not). Increased social preferences and attendant legislation aimed toward restoration of some degree of natural ecological processes and sustainability offer opportunities for adaptive management actions. Initiating communications among stakeholders is of great importance to the Corps and to the adaptive management process. The backing of the administration and the Congress, in terms of resources, as well as legislative authority, is crucial in encouraging sustained stakeholder participation in such efforts …. Beyond the provision of resources, the administration and the Congress should help provide clearer direction to the Corps when the agency is obliged to respect legislation and administration guidance that reflects internal inconsistencies."

More recently, the Corps has raised several issues it has with the implementation of adaptive management (Corps 2009a), including:

1. How will monitoring and adjustments extend project life (construction) and increase costs?
2. Will benefits obtained from an adaptive management approach be worth the cost and time?
3. Will future adaptive management actions require NEPA analysis?

While such concerns persist, efforts by the Corps to respond to the will of Congress and the Administration have continued on a few targeted projects. For example, the Corps (2009b) has issued an Adaptive Management Appendix as part of its Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report to reinforce the requirement and application adaptive management for LACPR, stating, "Incorporation of AM (Adaptive Management) will allow projects to move forward even if data is incomplete or if there is uncertainty with scientific understanding. It is critical that AM principles be integrated throughout project and program development and implementation through project planning, engineering/design, construction, operation and maintenance, while promoting updates to account for changes in future conditions."

In 2011 the Corps Omaha District released the Adaptive Management Process Framework as part of the Missouri River Recovery Program (MRRP, Bonneau et al. 2011). This document explains "how AM principles will be used in the MRRP to reduce uncertainty and ensure that Program objectives are achieved over time. The AM Process Framework is intended to be broad so that it can be applied to all aspects of the MRRP and be understood by a diverse audience of managers, federal and state agencies, scientists, engineers, the Missouri River Recovery Implementation Committee (MRRIC), stakeholders, Tribes, and the public. The AM Process described in this document generally follows the U.S. Department of Interior's (DOI) Technical Guide on Adaptive Management…."

Also in 2011, Corps' Jacksonville District jointly issued with the South Florida Water Management District (RECOVER 2011) the "Adaptive Management Integration Guide, Version 3.4" as part of The Comprehensive Everglades Restoration Plan (CERP). It explains that this "document was developed by an interagency and interdisciplinary team and provides detailed guidance to support implementation of the CERP Adaptive Management Program, required by the 2003 Programmatic Regulations. It describes how to apply adaptive management to the CERP program, and its related projects, by identifying key uncertainties and incorporating adaptive management activities into existing CERP planning and implementation processes to address these uncertainties. In doing so, adaptive management links science to decision making and facilitates adjustments to implementation, as necessary, to improve the probability of restoration success…. The Guide provides several key resources and sufficient detail for project managers and teams to reduce or eliminate key uncertainties and increase the likelihood of meeting restoration goals and objectives."

Implementing Adaptive Management in the Endangered Species Act (ESA)

Constraints and Opportunities for Linking Adaptive Management to the ESA

Since much of the ESA's structure was enacted 20 to 30 years ago, before adaptive management had any practical integration into natural resources management, it fundamentally does not fit well with contemporary concepts of adaptive management, nor does it fit well with the contemporary understandings regarding the complexities of species decline and relationships to natural ecosystem variability (Ruhl 2004). Adaptive management is a "pre-impact" or "pre-project" management strategy, whereas the ESA law and regulations have more of a "post-impact" or "post-project,", if not a "last-ditch" emphasis to prevent total population failure for a species. Adaptive management requires flexibility throughout the regulatory process. Ultimately, adaptive management could greatly enhance potentials for producing successful species recoveries, especially whenever uncertainty exists regarding the threats to the species, species-habitat relationship, or potential benefits resulting from various management actions.

Many recovery plans, critical habitat designations, and biological opinion requirements from Section 7 consultations define, often with apparent certainty, the causes of species declines in terms of past failures in critical species-habitat relationships, and the habitat modification approaches required to resolve the declines. In reality, considerable uncertainty more commonly exists related to actual magnitudes and relative importance of environmental conditions adversely affecting the species, their appropriate solutions, key habitat requirements, and, even, the fundamental biological function or ecological needs for the listed species, many of which have had little scientific study, often specifically due to their un-commonality.

In its application, implementation of the ESA depends on species-specific authorities that lead to policy decisions and management requirements producing often complex ecosystem-level effects. This focus can produce unintended consequences. In effect, the ESA process often redirects potentials for an effective, adaptive management process into more of a single-cycle, recovery-planning function, with monitoring and assessment activities primarily focused on the suite of environmental variables initially perceived as key. Opportunities to benefit from the knowledge gained through a recursive learning process and to initiate a more integrated ecosystem management framework are minimized or altogether lost. Traditionally under the ESA process, the cyclic scientific-method process receives little consideration, and the most effective means to advance species recovery can be missed. In short, the ESA, as originally constructed, appears ill-equipped to handle the task for which it was intended; the lack of a cohesive adaptive management architecture points to opportunities for judicial and administrative interpretations to supplement this deficit (Ruhl 2004).

Despite such overall shortcomings in the ESA's structure, potentials appear to be increasing for expanding adaptive management benefits into the process (Ruhl 2004). For example, Section 10 establishes "incidental take permit" procedures to approve the take (or killing) of listed species, which otherwise would be prohibited under Section 9. A Habitat Conservation Plan, or HCP, in which the applicant describes the project and its impacts on the species, provides the approach for potential approval. The HCP includes the characterization of how "the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking," and that "the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild." Therefore, we find the ESA's structure designed around a process that, at the start of the process, projects future often long-term conditions regarding project impacts on species (Ruhl 2004), which may be incorrect in the end. That is, as with the Section 7 consultation process, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) may impose "terms and conditions" in the permit, "including, but not limited to, such reporting requirements as the [agency] deems necessary for determining whether such terms and conditions are being complied with."

The HCP permit program did not have a very substantive role under the ESA process until the middle 1990s, when the Secretary of the Interior started pushing for the expansion of HCPs (Ruhl 2004). Subsequently, toward the end of that decade the USFWS announced it would begin to administer HCP permits using adaptive management as a means to "examine alternative strategies for meeting measurable biological goals and objectives through research and/or monitoring, and then, if necessary, to adjust future conservation management actions according to what is learned." Adaptive management was acknowledged as an important and practical tool that "can assist the Services and the applicant in developing an adequate operating conservation program and improving its effectiveness" (USFWS 2000).

While there has been considerable acknowledgement in words for implementing adaptive management within the Candidate Conservation Agreement, HCP, and Safe Harbor programs developed under Section 10, frequently its actual implementation falls short of its potential; continued evaluation will be necessary to assess the actual effectiveness of the adaptive management within these processes into the future (Ruhl 2004).

Ultimately, when correctly implemented, an adaptive management approach has the potential to yield more sustainable results. Yet, there are also examples of adaptive management being misused under ESA applications. For examples, some permits from the FWS have includes assessment decision points that depend on results to be obtained through some vague future analysis instead of depending on the legally required pre-action analyses (Doremus et al. 2011). For example, applications for incidental take permits require that the Services know enough about the species and the effects of the proposed actions to prevent any jeopardy to the species that cannot be appropriately offset by a proposed HCP. The FWS, however, has sometimes taken a position that it can issue such a permit, even when there is substantial uncertainty about the effects to the listed species, if the plan includes general, typically not specific, adaptive management provisions (Doremus et al. 2011).

Indeed, a 2007 federal court ruling may have considerable implications concerning the use of adaptive management in such ways in the ESA process. The United States District Court for the Eastern District of California issued an interim order and injunction requiring that the FWS issue a new biological opinion with regard to the federally-managed Central Valley Project (CVP) based largely on a court finding that FWS misused adaptive management (Bloom and Boer 2008). This ruling in *Natural Resources Defense Council, et al. v. Kempthorne*, No. 1:05-cv-1207, concerned the effects due to the operations and future expansion of the CVP on the delta smelt, which is federally listed as threatened, presumably due to the operation of the CVP. In anticipation of increased water diversions and new facilities for the project, a Section 7 consultation with FWS was requested by CVP. The resulting revised biological opinion concluded that, "although CVP operations would adversely impact the delta smelt, those impacts would be avoided or minimized through the combination of conservation measures and implementation of an adaptive management program. The … biological opinion included a risk assessment matrix … [that] incorporated a list of criteria, which if present, would require a designated working group, comprised of biological experts from federal and state agencies, to convene and consider whether and what protective measures may be necessary" (Bloom and Boer 2008).

Subsequently, a coalition of environmental and sports fishing groups filed suit challenging the FWS's "no jeopardy" finding, alleging, among other issues, "that the FWS failed to consider the best available science; relied upon an overly flexible, uncertain, and inadequate adaptive management processes to monitor and mitigate potential operations of the CVP; failed to meaningfully analyze whether current and future operations of the CVP would jeopardize the continued existence of the delta smelt…. [and] the entire mitigation process set out in the biological option was 'discretionary, uncertain, and unenforceable'" (Bloom and Boer 2008).

The District Court found that mitigation requirements under the ESA must be "reasonably specific, certain to occur, and capable of implementation; they must be subject to deadlines or otherwise enforceable obligations; and most important, they must address the threats to the species in a way that satisfies the jeopardy and adverse modification standards" (506 F. Supp. 2d at 351, Bloom and Boer 2008). Nevertheless, the court also recognized that properly designed adaptive management can have benefits and provide necessary flexibility, but when used, the "law requires that a balance be struck between the dual needs of flexibility and certainty." Moreover, such a balance can be achievable by ensuring that "[i]ncorporting *some* ascertainable mitigation standards and enforceable mitigation measures is not inconsistent with avoiding unduly restrictive 'hard-wiring'" of an adaptive management plan (Bloom and Boer 2008).

A 2007 National Marine Fisheries Service report, in discussing adaptive management for ESA-listed salmon and steelhead recovery, provided a parallel concern to that coming from the California District Court, while also providing a potential pathway for addressing the concerns expressed by the Court:

> All the adaptive management criteria and plans will not be helpful if the initial actions cause or allow events that preclude future options. For example, if the adaptive management plan calls for an action, and the action has some probability of (unintentionally) changing some population metric from desirable state X to undesirable state Y, then the decision whether to allow the action should not be made without considering whether the change from X [to] Y is reversible and, if so, with what probability and on what time frame. In such a situation, a monitoring program that can reliably detect whether state Y has been reached will be of little consolation if there is no way back to X. The key point is that, for

> adaptive management to be effective, there has to be some assurance that a particular action is not headed down a one-way street. If it is, this fact must be understood, and the attendant risks must be considered to be acceptable.

While adaptive management strategies have not made marked inroads in most parts of the ESA process, there are indications this may be changing. Most notably, the NMFS (2010) recent interim recovery planning guidance announces that (NMFS 2010, page 26),

> Adaptive management can be an extremely useful tool for moving toward recovery when uncertainty exists regarding the threats to the species, the species' life history, or the effectiveness of various management actions.…in cases of significant uncertainty, the description of a recovery action within a recovery plan should include an adaptive management plan for the action. This adaptive management plan should include the hypothesis to be tested, how the effectiveness of the action will be monitored, what criteria will be used to determine if the action is effective, and how the action will be adjusted if these criteria are not met. Every recovery action should have two accompanying actions: "Monitor effectiveness of the action," and "Adjust the action based on effectiveness, if necessary."

This guidance characterizes the goals of recovery monitoring as (NMFS 2010, page 25):

> … the measurement of an action or an environmental characteristic to determine compliance, status, trends, or effects of the action or characteristic." It goes on to distinguish three basic types of monitoring that are to be conducted in the recovery program: "(1) implementation (compliance) monitoring, which is used to see whether the plan is being implemented fully (Did we do what we said we could do in the recovery plan?); (2) status and trend monitoring, which determines whether a population or threat is increasing or decreasing (What is happening to our population right now? To what extent has the threat been controlled? Is the population increasing over time and what can we predict for the future?); and (3) cause and effect monitoring, which tests hypotheses and determines (via research) whether an action is effective and should be continued (Is the dam hindering fish migration? Is our management action causing the population to increase?).

The guidance is clear that the keys to effective use of adaptive management in recovery plans are (NMFS 2010, page 26):

> … (1) appropriate monitoring of an action, (2) agreed upon criteria to determine whether an action is effective, and (3) agreed-upon actions to take as a necessary step for a research action or for a management action if the effectiveness threshold is not reached during the agreed upon timeframe. When uncertainty exists, management actions should have specific criteria for evaluating their effectiveness…. Finally, it is important to determine up front what actions will be taken if the objective is not reached. For instance, in a case where the objective is not reached, it should already be decided whether additional habitat will be protected, the habitat will be protected more intensively, the management should be changed, or the management will be curtailed.

Unfortunately, the guidance doesn't explain how to develop permits to allow the implementation of adaptive management for an endangered species, whether it is possible to include adaptive management as a Reasonable and Prudent Alternative (RPA) in a Biological Opinion, or how one could get adaptive management included in a Biological Opinion as an RPA during consultation. The guidance also reports the additional information on increasing the role of adaptive management within the ESA processes will be included in an upcoming revision of the *Implementation Chapter* in the joint USFWS and NMFS (1998) Recovery Handbook. Perhaps that document will incorporate the needed guidance missing from the evolving 2010 draft NMFS document.

Could adaptive management have a role of much greater importance in the future? The current focus of ESA legislation and regulations is directed at species at the end of population decline. Although it is possible, most species do not suddenly become threatened or endangered. So, how can adaptive management become effectively applied to help keep species from declining into a threatened or endangered condition? These are questions that may require an adaptive management style of assessment to answer.

Single-Species versus Multi-Species versus Ecosystem-based Adaptive Management Plans

Clark and Harvey (2002) assessed the recovery plans compiled by the Society for Conservation Biology recovery plan review process (Hoekstra et al. 2002). They reported, not surprisingly, that the USFWS relied increasingly on a multi-species, rather than the more traditional single-species, approach to recovery planning under the ESA. The found that by the end of 1998, more than 55% of all of the then listed species having recovery plans were included in multi-species plans. But then, Clark and Harvey (2002) also reported that species within multi-species plans were significantly more likely to exhibit a declining status trend. From their comparison of single- to multi-species plans, they found that multi-species plans often tended to reflect a poorer understanding of species-specific ecology, were less likely to include adaptive management provisions, and are revised less frequently. While USFWS guidelines recommend combining species into a multi-species framework based on similarity of threats, Clark and Harvey (2002) reported that nearly half of the multi-species plans failed to display threat similarities for the species combined in the multi-species plans more often than they found for randomly selected groupings of species.

While Clark and Harvey (2002) expected that the more recently produced multi-species plans, compared to the older single-species plans, would have more emphasis on adaptive management and be more flexible in response to new information or changing conditions, their results showed the opposite. They found that the extent of species-specific biological understanding tended to be greater in the single-species than in the multi-species plans, perhaps due to reducing the relevant information presented in the plans related to the biology and ecology requirements for the individual species included, the threat factors, and per species management requirements. Perhaps more importantly, they found that the USFWS had "lumped species into multi-species plans simply because it had insufficient information about individual listed species to draft adequate single-species plans." This practice is perhaps an expected consequence from an agency increasingly required to address the needs for more listed species. Given the problems identified with multi-species plans, Clark and Harvey (2002) recommended that the USFWS reevaluate its use of the multi-species approach to recovery planning.

Beyond that recommendation, Clark and Harvey (2002) identified clear advantages in the development of multi-species plans and ecosystem-based approaches. Specifically, they also conclude that in correctly grouping species in a multi-species plan according to the actual threats that they face, managers can resolve conflicts between species early in the recovery planning process. In fact, the process of species grouping may often identify unknown or ill-defined threats and patterns in ecosystem decline. They note that conflicts between species-specific plans for the Northern Spotted Owl (*Strix occidentalis caurina*) and the Marbled Murrelet (*Brachyramphus marmoratus*) made recovery efforts for the spotted owl more complicated. Similarly, water management plans tended to pit recovery efforts for Snail Kites (*Rostrhamus sociabilis plumbeus*) against Wood Storks (*Mycteria americana*), which require conflicting water levels. A multi-species or ecosystem approach could have helped to resolve the first pair of issues and did resolve the second.

Perhaps the most important recommendation provided by Clark and Harvey (2002) is that the most seriously imperiled species will likely best be served by including them in "both a multi-species plan, in which the threats they face are addressed in the context of other species and/or the ecosystem, and a single-species plan, in which more detailed information particular to recovery of that species can be presented." To illustrate that approach, they point to the Florida panther (*Puma concolor coryi*), which is included in its own recovery plan and in the South Florida Multi-species Recovery Plan.

As we noted in an above section, we also compiled all available recovery plans for endangered freshwater fishes through a concurrent but independent project. For those plans, that included a statement indicating commitments to adaptive management, online literature searches were completed to identify follow-up actions where adaptive management plans were being followed. We were unable to identify any single-species plan for freshwater fishes that demonstrated a long-term and meaningful commitment to adaptive management. At this time, we are inclined to agree with a recent comment received from a colleague stating, "Mentioning adaptive management in a Recovery Plan is only an expression of good intentions. Adaptive management has become a motherhood phrase, so increasingly the word gets slipped into planning documents, just as a gesture. A Recovery Plan is not binding on the agency. So it doesn't cost anything to say adaptive management in the plan."

Implementing Successful Adaptive Management Programs and Plans

Adaptive management approaches hold the promise of reducing uncertainties faced by natural resource managers. Yet, difficulties in effective implementation of adaptive management plans are diverse. Many examples exist where adaptive management planning lacks essential requirements for success. Gregory et al. (2006) suggests that explicit criteria dealing with spatial and temporal scale, dimensions of uncertainty, the evaluation of benefits and costs, and institutional and stakeholder support must be considered by managers and decision makers to determine the appropriate options for adaptive-management strategies in resolving ecological uncertainty in environmental management. These authors found that many of the issues facing adaptive management have less to do with the approach itself than how it is applied.

A number of key requirements have been defined that can increase the potential for success of adaptive management programs and plans (ESSA Technologies Ltd. 2008). First among these, the adaptive management plan and program should be consistent with the current practice of adaptive management, such as that provided by the DOI guide presented above.

Identifying and Involving the Stakeholders

At the head of the list of requirements for producing adaptive management success is to make sure all key stakeholders are participating in all critical steps of the program. Collaborative and consensual decisions are required on problem scoping and identification, program goals and objectives, selection and implementation of management measures, translating monitoring information into assessment conclusions and then into decision points to define any needed next steps, and commitment to adequate funding of the program. Equally important, the stakeholders must have a clear recognition and commitment to the process that will be followed when the actions implemented fail to produce the projected result.

Most programs involving the management of natural resources, their sustainability, conservation, or restoration, typically involve many stakeholders, including representatives of governmental agencies, land owners, resource users, environmental activists, political lobbyists, and potential investors, each having unique and often widely conflicting agendas. Obtaining consensus across this array of stakeholders requires open and honest communication of their individual goal(s) and the exclusion of hidden agendas (Stringer et al. 2006). Adaptive management requires stakeholder agreement on clear, formal goals and objectives within the plan supported by testable hypotheses about relations affecting natural resources, agreement on the processes through which attainment of goals and objectives are measured through stakeholder-defined monitoring programs; and how management plans and procedures may be modified to improve the potential for attaining the goals and objectives. Each stakeholder must have clear and mutually agreed-to delegation of roles and responsibilities. This is not easy, but the effort has the potential to produce an effective democratic process (Stringer et al. 2006).

Writing the Plan

Adaptive management plans must include clear statements of management goals and objectives that are easily understood, biologically meaningful, measurable, financially and scientifically feasible, consistent with the current understanding of the system and consistent with other regional natural resources goals and objectives (ESSA Technologies Ltd. 2008). The plans also must list all of the key uncertainties (management questions), describe how the alternative management actions used link to the listed uncertainties and define the geographic and time limits of the program. They need to present hypotheses to be tested and management methods to be assessed during at least the initial cycle of the program, with the models, sampling design, measurement parameters, monitoring methods, and data management and analysis involved in this assessment of program decision points clearly documented. They also need to explicitly define the process and decision steps that will be involved in using the information obtained in earlier steps of plan implementation to formulate decisions regarding next steps and future changes (where necessary) in management and improved monitoring practices to resolve whatever critical uncertainty remains. It is critical to include the role of the various stakeholders, including their scientists and managers, in designing, implementing, monitoring, assessing, and modifying the plan.

Monitoring

Too frequently, there has been a flawed tendency in some management documents to simply equate having a specified a monitoring program alone as providing "the adaptive management plan." Certainly, good project management is integrally linked to well-designed monitoring and evaluation systems; indeed, results from well defined monitoring programs evaluating changes in natural resources can supply much of the necessary information enabling adaptive management to operate and produce beneficial results (Stem et al. 2005). But in adaptive management "a necessary and appropriate monitoring program" must be developed to measure progress at all levels of the program's efforts, at the appropriate scale for each (Stem et al. 2005). The monitoring plan typically should include the quantitative conditions for biological, physical, and chemical variables, as well as how the assessment, interpretation, and programmatic changes produced through this process match the guidance and specifications defined in the adaptive management program's plan.

Each parameter monitored and the monitoring method and data assessment approach used should be specifically linked to the environmental relationships (hypotheses) being assessed. It makes little sense to expend limited resources collecting monitoring data without knowing why the data are being collected, how they will be assessed, or what program objective the information will help address. Data produced by monitoring should have a greater purpose then filling up computer databases: If a purpose for collecting data on the parameter cannot be specifically linked to the goals of the Program, if there is no benchmark available for assessing the implications of the parameter data relative to the Program goals, then serious consideration should be given to omitting that parameter from the monitoring plan.

In developing the monitoring plan, it is important to draw from the lessons available from the useful and practical monitoring and assessment approaches developed elsewhere (Stem et al. 2005). In doing that, however, it is important to recognize that monitoring and assessment approaches exist to address four broad aims: basic research, accounting and certification, status assessment, and effectiveness measurement (Stem et al. 2005). Adapting the monitoring approaches developed by others requires a consideration of which of the four aims those monitoring methods and plans were intended to address, since each has different approaches, can include language differences that impedes clear communication when used inappropriately leading to confusion when selecting among monitoring and assessment components included and hinders abilities to correctly interpret the results obtained.

Funding for the Long-term

Adaptive management and its monitoring requirements are not inexpensive. This is a result of the fact that, as implicit in its origins, adaptive management "assumes and embraces a high level of uncertainty" as integral to the process (Stem et al. 2005). Moreover, most natural resource responses to management changes may take several years before showing measureable change. Therefore, the stakeholders often must have a firm commitment to long-term monitoring and a long-term commitment to applying the information gained from the monitoring data collected to producing informed adaptive management decisions. Without such a commitment, the very nature and goals for any given adaptive management program can be, in effect, nullified. Therefore, the adaptive management program and plan must include the essential details of funding: how long will the program last, what the cost is projected to be, and who will pay for the continuing requirements.

Using Outside Review

While not an identified part of many guides for adaptive management planning, both public and expert peer review of the plan, program, and implementation of adaptive management commonly is of considerable value to benchmarking the progress and success of adaptive management programs. Public review helps to both inform and collect input from a wider public, beyond the immediate stakeholder group, regarding the general public understanding and appreciation of the planning process, its implementation, and how the adaptive management program might be modified to better involve a larger community of citizens and better address their concerns and needs. Adaptive management programs should not become “best kept secrets” from a public’s vantage point.

Many of the most successful adaptive management programs, as discussed for some of the case study summaries later in this report, include regular independent (outside) peer review involving, for example, experts in aquatic ecology, fisheries biology, hydrology, fluvial geomorphology, water management, environmental chemistry, ornithology, regulatory matters, public outreach, etc., as appropriate for the individual program goals and objectives. The reviews can include producing guidance on how to best address key program issues, and assessments on the consistency of the program in adhering to its plan and processes, and progressing toward attainment of its goals and objectives. Of particular importance to the Corps, both the monitoring and adaptive management plans should be reviewed by outside experts, as part of the established peer-review process for the Project Implementation Reports (PIRs) under Engineering Circular 1105-2-408 (USACE 2005, RECOVER 2010).

Recognizing Limitations Caused by Inherent Human and Institutional "Tendencies"

Allan and Curtis (2005) studied adaptive management programs in both Australia and North America. Their findings can directly lead those working with adaptive management programs to identify specific inherent stakeholder responses that can then be directly addressed. Although they found at least some level of implementation success with all of the adaptive management programs studied, they concluded that all of the projects were constrained by deeply entrenched social norms and institutional frameworks. They identified seven "imperatives" (i.e., natural tendencies that are inherently part of human and institutional "psyches") that guide the behavior of project stakeholders and that, if not overcome, tend to produce negative consequences for adaptive management. They suggest that recognizing the existence of such relationships can help overcome them. The following borrows liberally from Allan and Curtis (2005) with the hope it can aid the readers of this report in recognizing and rectifying potential effects produced by these imperatives during their work to successfully implement adaptive management. We encourage the reader to consult the original work of Allan and Curtis (2005) to obtain additional details beyond that overviewed in the following bullets.

1. *Got to keep moving* – Stakeholders often become concerned and exhibit frustration when they perceive "insufficient" project activity. They often view projects in terms of a journey that needs to be "pushed" along, the need to "drag people along" with them, and to "drive activities" in certain directions. For example, the common emphasis on attainment of "milestones" or "targets" implies a confidence in the results of the activity and the final destination. But, when the destination of the journey is "known" with confidence, there is little to no incentive to stop and reflect on what new things might be learned along the way. Thus, there is a real tension inherent in the idea of ''learning from doing,'' as the act of learning, when looking back may be viewed as slowing or even stopping the act of doing.

2. *Got to have control* – Order and control are inherent in ideas of inside and outside. Control maintained through hierarchies and "gate-keeping" encourages a narrow focus, a demarcation of activities, and compartmentalization, leading to "silo" or "fortress" mentalities. It encourages reductionism and thwarts the

opportunity for the collaborative and holistic thinking required for adaptive management. This also makes it easy, possibly even desirable, to give management responsibilities to separate organizations, rather than to the collection of stakeholders responsible for the ultimate success of the adaptive management program.

3. *Got to be clear* – Often there is an "urgent desire for clarity" by the stakeholders. This can particularly relate to details of physical or biological processes and of project management. This can tend to reduce perceptions, but not the reality, of the complexity related to the target problem. Taken to the extreme, this can produce "spurious certitude." The desire for clarity also tends to create disincentives to learning by doing, because new information often makes things somehow less clear, adding to management complexity.

4. *Got to sell* – Communication of ideas and information is vital to successful project implementation that is needed to persuade stakeholders to adopt recommended management practices to achieve needed changes. The confidence required to "sell" an idea or project can tend to inhibit the questioning (i.e., reduce the level of actual uncertainty) associated with that idea or project. As such, "the imperative to sell ideas" works against the culture of questioning and reflection that is at the heart of adaptive management. Equally damaging to adaptive management, it also "tends to promote the demarcation and privileging of certain types of information."

5. *Got to compete* – Adaptive management stakeholders frequently referred to "winning" or "losing" various political and environmental "games." When natural resource management and politics are considered to be games, stakeholders necessarily feel that "they need to be playing the right game, and that they should be playing to win." Organizations thus "compete" with each other for recognition and funding. This competitive inclination tends to inhibit the holistic, collaborative learning-by-doing dimensions of adaptive management.

6. *Got to maintain institutions* – Formal organizations and less formal social habits both require input of "institutional" time, money, or other resources to maintain

their existence and participation in the process. Adaptive management stakeholders not uncommonly see participant involvement in machine-like terms: agencies having a variety of policy “tools” to use, stakeholders characterized as “cogs,” and conversations referred to as “engagements.” Maintaining a “smoothly” operating, efficient organizational machine can dominate thinking, especially within government agencies. In turn, this can impact problem definition and learning from implementation.

7. *Got to be comfortable* **–** Most everyone likes to be “comfortable,” and avoid pain and distress. Allan and Curtis (2005) found that individuals and groups maintained their comfort by denying that they had learned. Deception was apparent in the submissions and reports to funding bodies. To ensure future funding, projects tended to be presented in “a good light.” A “necessary spin” was applied to anomalies so that they conformed to the expected outcomes, thus maintaining the comfort of future funding. “Self-deception” was perhaps even more common, “with an almost reckless use of metaphor by participating stakeholders, particularly when new ideas or difficult concepts are under discussion.” Understanding a difficult or threatening idea by transforming it into a more familiar and safe one helps to avoid admitting the need to learn or to change a behavior because of that learning. When Allan and Curtis (2005) discussed how best to conduct adaptive management during public meetings, they found that people often responded, with obvious indignation, that they are already managing adaptively. This lead Allan and Curtis (2005) to suggest that, “[p]erhaps rather than admit to tacit accusations of stupidity, it is better to cling to the comforting notion that humans always learn from experience.”

EXAMPLE LARGE-SCALE ADPATIVE MANAGEMENT PROGRAMS

This section provides a series of brief introductions to eight ongoing adaptive management programs. The primary intent of these summaries are to provide snapshot examples of what works and what does not for each, which requires additional background summary information on each, including their objectives, strategies, implementation status, and budgets, where possible. The first program is commonly described as the only successfully implemented adaptive management program for natural resources management. The regulation of North American waterfowl is likely characterized as such, because it has been perhaps the longest running of such efforts, completing annually a full cycle of management steps, its results appear to benefit the resource and are generally accepted by stakeholders, and becasue most other adaptive management programs are still in the startup or very early phases of definition and implementation, with their potentials for actually reaching their goals and objectives still greatly uncertain. Most of the case studies then focus on aquatic habitat restoration programs, with a concluding introduction to the adaptive management plan and program developing for the Middle Rio Grande

Adaptive Regulation of North American Waterfowl

A successful example of adaptive management applied to natural resources comes from the regulation of hunting of waterfowl in North America. A series of papers have detailed the general theory, development, and use of Adaptive Harvest Management (AHM) for waterfowl in, primarily, the midcontinent and eastern flyways of North America (e.g., Nichols et al. 1995, Johnson and Williams 1999, Johnson and Case 2000, and Johnson et al. 2002). Most of the "harvest," not surprisingly, takes place in the United States. In short, AHM is a statistical (Bayesian) approach starting with assumptions and relationships known or assumed to be correct to probabilistically factor in the uncertainties in the dual pursuits of conservation benefits (in terms of waterfowl harvest) and a deeper understanding of complex population dynamics and ecosystem interactions. Iterative feedback to the management models can then be parsed by either an active or passive information supply. Active and passive management is distinguished in this process by the specific use of management actions to acquire useful information. Active pursuit of information is an objective of the decision making process, passive, on the other hand, allows less resolved information (e.g. sufficiently randomized point counts) to augment more intensive efforts (e.g. in-depth studies on survival and mortality) and allows the resulting probabilistic distributions to inform the predictive models. After several years of evaluation and experience with AHM, Johnson et al. (2002) concluded that a passive approach performed nearly as well as an active. This, in turn, may allow for a significantly greater degree of flexibility in the allotment of monitoring budgets under a passive approach. This also suggests that other adaptive management programs may find similar efficiencies in following similar approaches that require less intensive and less expensive monitoring and data inputs.

AHM has achieved good success. Regardless of certain nuances and variations in its implementation over the years, the management approach consistently includes (1) objectives that describe the preferred outcome of decision making and that provide common metrics by which alternative decisions can be evaluated; (2) a set of plausible alternatives that allow certain recourse in past decisions when data suggest an undesirable outcome; and (3) models that can in fact predict outcomes of the alternatives relative to the stated objectives.

The success that AHM appears to stem from a clear vision of objectives, a thoughtful selection of metrics to assess the objectives, an established protocol to measure the metrics, a set of aptly parameterized (but not overly so) models capable of predicting the outcome of management decisions, and a commitment by all stakeholders to implement the "adaptive" part of adaptive management. All stakeholders have faith, to some degree, in the elements of the approach and fully recognize the uncertainty involved in predicting the results of perturbations on this complex and often chaotic system. Again, uncertainty in the AHM model is addressed, in part, by the Bayesian statistical theory itself and also by alternate forms of predictive models; a type of sensitivity analysis where not only system behavior is evaluated but also a differential assessment on what parameters appear to drive the system. Thus, feedback from the predictive process allows management to potentially choose where limited resources should be focused in the future. In this sense, not only is "adaptive" management focused on the system, restoration project, or species, but also on the process by which it is managed.

Red Wolf Recovery in Coastal North Carolina

Another series of papers documents the history and the progressing success of adaptive management related to the red wolf (*Canus rufus*) recovery program in coastal North Carolina (Parker et al. 1990, Lancia et al. 1996, Kelly et al. 1999, and Stoskopf et al. 2005). The major challenge that this program faced was the introgression of coyote (*Canis latrans*) and feral dog genes and a subsequent hybridization of reintroduced red wolf populations. Due to an even greater threat of hybridization and a myriad of social and political issues, areas within the Great Smoky Mountains National Park were deemed unsustainable and thus excluded from this plan.

After clear evidence that hybridization in the North Carolina population had in fact occurred, the USFWS decided to reevaluate the program. A key step in the review process involved a Population and Habitat Viability Assessment (PHVA) organized by the USFWS and facilitated by the World Conservation Union, Species Survival Commission (IUCN). After productive debate (Lancia *et al*. 1996), a consensus was developed that included:

> "…our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive breeding component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal." (Kelly et al. 1999, page 6)

The outcome of the PHVA resulted in an adaptive management plan designed to reduce the threat of hybridization. The elements of the adaptive management plan that fostered its overall success are (1) clear identification of the problem(s); (2) metrics to measure the management program's success; and (3) a long-term commitment by the stakeholders (primarily, in this case, being the USFWS) to appropriate intervention based on genetic monitoring, the metrics established in element 2 above.

An additional element of the red wolf recovery program's success was the creation of an independent, multi-disciplinary recovery implementation team (Red Wolf Recovery Implementation Team, RWRIT). Germane to the success of the RWRIT, and the overall program, was a thoughtful and careful selection of its members. Factored into the selection of RWRIT personnel were expertise, a commitment to objective science, a commitment to active research by the RWRIT, group dynamics, and a willingness to participate over a long-term effort. Expertise of the RWRIT includes genetic/molecular scientists, epidemiologists, canid ecologists, and a conservation economist. The RWRIT continues to work cohesively with the USFWS personnel directly responsible for both the management and day-to-day operations of the program. To date, the red wolf recovery effort has established over 100 breeding pairs that show no evidence of foreign gene introgression.

North Platte River Recovery Implementation Program

Background

In 1997, the states of Colorado, Wyoming, Nebraska and the Department of Interior formed a unique partnership with the goal of developing a shared approach for managing the Platte River (Freeman 2010). Water users from the three states and local and national conservation groups joined the effort. Together, these stakeholders developed an innovative approach for improving the management of the Platte — for the health of the ecosystem and the people that depend on it. The Platte River Recovery Implementation Program is the result of that planning effort. The Program is focused on implementing a shared vision for creating and maintaining habitats on the Platte.

(1) Platte River Habitat Recovery Program

- (a) Endangered Species
    1. Whooping Crane
    2. Piping Plover
    3. Least Tern
    4. Pallid Sturgeon

- (b) Habitat
    1. Backwaters
    2. Oxbows
    3. Bare Sand habitat

- (b) Stakeholders
    1. Colorado
    2. Wyoming
    3. Nebraska
    4. United States Department of the Interior
    5. The environmental community

Historically, Platte River backwaters and oxbows in a meandering pattern have been critical to the breeding and feeding of migrating waterfowl – such as the sandhill and whooping cranes and several shore birds including the least tern and the piping plover. Platte River Basin flows have been altered by 15 major dams and many smaller water diversions and storage projects. On the South Platte alone, 106 storage facilities hold an average of 2.8 million acre feet of water (Eisel and Aiken 1997). Given that fast moving clear water released through dams picks up sediment, transporting large quantities of sediment is a major source of erosion of the river bed that destroys the meandering characteristics of the river by carving deeper narrower channels that limit critical habitat.

Adaptive Management is central to the Platte River Recovery Implementation Program (PRRIP or Program). The process of Adaptive Management is utilized where it is uncertain how actions taken will affect the outcome, but decisions regarding management actions must be made despite the unknowns. Monitoring and directed research are designed to reduce uncertainties and move decisions forward. It is a process of using the best available science to test hypotheses, implement management experiments or actions, learning from the results, and revising actions as required.

The Program's Adaptive Management Plan (AMP) is built around an Applied Science Strategy based on numerous priority hypotheses that represent different concepts about how the Platte River system functions and how the system may respond to Program management actions. For example, one priority hypothesis states: "Additional bare sand habitat will increase the number of adult least terns". Adaptive Management is applied to test this hypothesis by:

- Assessing the problem: How much sand is available? What river processes are important?
- Designing and Implementing experiments to create bare sand habitat
- Monitoring the affected species and the defined habitat
- Evaluating the results of the experiment – this includes analyzing data on tern nesting success, number of terns nesting on bare sand, availability of bare sand, etc.
- Adjusting management actions based on the results and then beginning the process over to learn more about the river system and improve future management decisions.

Management Objectives

There are four main AMP management objectives:

1. Improve production of interior least terns and piping plovers from the central Platte River
2. Improve survival of whooping cranes during migration
3. Avoid adverse impacts from Program actions on Pallid Sturgeon populations

4. Provide benefits to other species that use the Platte River and reduce the likelihood of listing those species.

Applied Science Strategy

Program science is applied in an adaptive management framework through an Applied Science Strategy that incorporates the following elements:

- Conceptual Ecological Models – represent broad ideas about how river processes work
- Priority Hypotheses – more detailed representations of species/river relationships and how the system will respond to management actions
- Management Strategies – two different sets of management actions that the Program will apply on the ground to test Priority Hypotheses
- Performance Measures – data points that are used to help decision making (number of terns/plovers, width-to-depth ratio, water flow, sediment, etc.)
- Integrated Monitoring Research Plan (IMRP) – monitoring and research conducted to collect, compile, and analyze data on performance measures.

A key part of the Applied Science Strategy is using data collected through the IMRP to assess progress toward Program management objectives and Priority Hypotheses. The knowledge gained can then be used to guide future management actions to more effectively and efficiently benefit the species.

Management Strategies and Actions

The Program will implement two management strategies that will be used to test hypotheses:

Flow-Sediment-Mechanical (FSM)

This strategy will attempt to use water and other measures to rehabilitate the Platte toward a braided river (broad and shallow with exposed bare sand bars) as the underpinning for maintaining restored habitat. Key actions include:

- Flow consolidation
- Channel widening and vegetation clearing
- Short duration high flows
- Sediment augmentation

Mechanical Creation and Maintenance (MCM)

This strategy will attempt to use mechanical means to achieve similar habitat objectives. Key actions include:

- Channel widening and vegetation clearing
- Off-channel sand and water
- Wetlands and uplands

Design and Implementation

The Program's Adaptive Management Working Group and Executive Director's Office are using several tools to design adaptive management experiments. Special attention is being paid to experimental design to ensure Program resources are used efficiently and effectively, and that responses to Program actions can be determined in a robust and meaningful manner. It is important that through these experimental efforts we learn more about how to effectively manage our water and land resources for the benefit of the species and the Platte River system.

Program Budget

For the first thirteen year increment of the Platte River Habitat Recovery Program, cash and cash-equivalent contributions will be provided by the U.S. Department of the Interior (DOI) and the three states, as summarized in the table below. Dollars are valued in millions as of 2005. They will be adjusted annually for inflation.

Contributions	*Total*	*DOI*	*States*	*Description*
Cash	*187.14*	*157.14*	*30.00*	*Colorado-24 Wyoming-6*
Cash Equivalents-Land	*10.00*		*10.00*	
Cash Equivalents-Water	*120.19*		*120.19*	
Total	*317.33*	*157.14*	*160.19*	

Glen Canyon Dam and the Colorado River Eco-System Adaptive Management Plan

Background

Glen Canyon Dam, authorized by the Colorado River Storage Act of 1956 and completed by the Bureau of Reclamation (Reclamation) in 1963, spans the Colorado River just south of the

Arizona- Utah border. Behind the dam, the waters of Lake Powell extend upstream for 186 miles. Downstream, the Colorado River passes through a 15-mile stretch of Glen Canyon and into Marble Canyon at Lee's Ferry, where it enters the Grand Canyon. The river then flows 278 miles through Grand Canyon National Park before reaching Lake Mead, which is impounded by Hoover Dam. Flows through Glen Canyon Dam hydroelectric turbines generate power for a multi-state grid served by the Western Area Power Administration. Glen Canyon Dam and its operations have altered hydrologic and temperature regimes in ways that have drastically changed the Colorado River ecosystem. Because of the importance of the Colorado River to the southwest United States, there are always issues raised over how to share and manage this resource. In order to address the impacts to the downstream ecosystem resulting from the operation of Glen Canyon Dam, the Glen Canyon Dam Adaptive Management Program (AMP) was established in 1997. The AMP provides a process through which the effects of Glen Canyon Dam operations on downstream resources are monitored and assessed. Operational adjustments can be recommended to the Secretary of the Interior and implemented based on the scientific assessments. One of the most significant lessons learned from the years of scientific research and analysis that led to the Glen Canyon Dam Environmental Impact Statement (EIS) was that there was no clear and concise understanding of the riverine resources of the Grand Canyon. Over 14 years of work went into completing the EIS, selecting a preferred alternative, and signing a Record of Decision (ROD). Throughout this process, it became clear that no matter how much scientific research was done on alternative ways of operating Glen Canyon Dam, there will always be uncertainties and data gaps until various operating alternatives could be tested over time. The implementation of the Glen Canyon Dam Adaptive Management Plan (GCDAMP) provides for flexibility in adapting the dam's operations in order to facilitate continued scientific research and monitoring while the project purposes for which the dam was constructed continue. As environmental experiments and studies continue to take place, it is important to recognize that the dam must continue to be operated to meet the purposes of the dam as established by law.

Management Objectives

Initially, the AMP struggled with the requirements necessary for effective adaptive management, and it is not without most of the problems that plague many adaptive management programs. Below is a list of problems that initially reduced the effectiveness of the program

- Identifying correct stakeholder representatives
- Involving stakeholders
- Lack of independent review of potential management measures
- No coordinated "vision" for the future state of the Colorado River ecosystem
- Lack of a clear set of management objectives

Since the inception of the program, significant improvements in the degree of stakeholder buy-in and cooperation has taken place. Stakeholders with differing values and perspectives have been able to overcome differences and have achieved success in working together to undertake large-scale ecosystem level experiments. However, there continues to be a recognized need to improve the definitions of the roles and responsibilities of the stakeholder and program members, particularly between scientists and managers.

The principal twelve management objectives developed by the AMP (and stakeholders) are listed below.

- Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.
- Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent further adverse modification to their critical habitat.
- Restore populations of extirpated species, as feasible and advisable.
- Maintain a naturally reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.
- Maintain or attain viable populations of Kanab ambersnail.
- Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.
- Establish water temperature, quality, and flow dynamics to achieve AMP ecosystem goals.
- Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the AMP ecosystem goals.
- Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem.
- Maintain power production capacity and energy generation, and increase where feasible and advisable, with the framework of the AMP goals.
- Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.
- Maintain a high quality monitoring, research, and adaptive management program.

Because management strategies to achieve an objective may benefit one resource or value and adversely affect another, those action alternatives that benefit all resources and values will be pursued first. When this is not possible, actions that have a neutral impact, or as a last resort, actions that minimize negative impacts on other resources, will be pursued consistent with the Glen Canyon Dam Environmental Impact Statement and Record of Decision.

Management Strategies

Once the scientific understanding of the impacts of the construction and operation of Glen Canyon Dam has progressed further, specific strategies to meet the management objectives include addressing the effect on dam release temperatures, control of non-native vegetation, timing, duration, protection and recovery of threatened and endangered species, and magnitude, timing and duration of reservoir releases. Adoption of long-term experimental plans will assist scientists, policy makers, and resource managers to better understand resource management options, trade-offs and consequences and assist in the long-term operation of Glen Canyon Dam.

Program Budget

One common problem that, to date, the Glen Canyon Adaptive Management Group does not seem to be experiencing is a lack of adequate and dependable funding. The annual budget of the program has consistently been approximately $8.5 million which is paid for primarily out of hydropower revenues generated by Glen Canyon Dam. With a solid understanding of the adaptive management processes and requirements, along with the commitment of the stakeholders, the scientific community, resource managers, and a consistent funding source, the Glen Canyon Dam Adaptive Management Plan's potential for success is encouraging.

Klamath River Basin

Background

In the spring of 2001, drought and implementation of the Endangered Species Act (ESA) requirements prompted the Bureau of Reclamation (Bureau) to discontinue supplying project irrigation water to over 1,300 farms and ranches in the Klamath Basin in order to restore the populations of two species, the sucker fish and the coho salmon. Both were listed as Federally endangered species with the recovery of the sucker fish being monitored by the U.S. Fish and Wildlife Service (USFWS). The recovery of the coho salmon is monitored by the National

Marine Fisheries Service. Following the closure of the irrigation gates and the resulting public outcry, the Secretaries of Commerce and the Interior asked the National Research Council (NRC) to conduct an independent scientific review of the agencies recommendations. The review found that there was no scientific basis for the USFWS and the NMFS assumptions on the effects of lake levels and river flows on the fish. Also included in the review was a recommendation that the agencies undertake eco-system management using adaptive management on a watershed basis, including monitoring and coordination with all potential stakeholders.

The number, variety and diversity of stakeholders makes the development of comprehensive adaptive management plans extremely problematic. In the past, the lack of productive communication and trust led to many lawsuits between basin stakeholders. Collaboration among federal, state, and local agencies, tribes, organizations and individuals can hopefully lead to solutions rather than further litigation. The plan establishes the Klamath Basin Coordinating Committee (KBCC) to facilitate coordination, cooperation, collaboration, and accountability by the stakeholders to ensure that the plan is carried out effectively. Also included in the plan is a process to resolve issues among stakeholders that will be adhered to so that litigation will be a last resort, made only after careful consideration to any potential collateral consequences that would affect the plan.

While most stakeholders in the Klamath Basin are supportive of implementing solutions within an adaptive management framework, getting there in terms of practical implementation is considerably more of a challenge. Establishing trust between stakeholders who have extremely diverse agendas and cultural biases is a complicated, expensive, and intensive endeavor. In the Klamath Basin, an agreement addressing how to accomplish this took about 9 years to be developed and presented to the public in draft form. This is an ongoing case study. While the basin appears to be headed in the right direction from an adaptive management point of view, its success or failure is yet to be determined. J.D. Ruhl, an attorney who studied the adaptive management program for the Klamath Basin and its relationship with the Endangered Species Act (ESA), summarized the overall status of adaptive management in relation to the ESA, "The funding and political will to build a comprehensive monitoring – adjustment loop between the information and planning programs and the regulatory programs seem unlikely to appear except in isolated crisis situations. We are, in other words, trying to make the ESA adaptive through a decidedly non adaptive approach—one crisis at a time."

Management Objectives

Following the shutdown of the irrigation water, the Natural Resources Conservation Service began providing technical and financial assistance to over 1,300 farms and ranches in the Klamath Basin in order to minimize drought impacts. In order to meet these general objectives, the Klamath Basin Stakeholders have developed a draft Klamath Basin Restoration Agreement. The stakeholders include but are not limited:

- Local Farmers, Ranchers, and Dairy Producers
- Local Irrigation Districts
- Klamath Water Users Association
- Cooperative Extension Service
- California Department of Water Resources
- Oregon Department of Environmental Quality
- The Nature Conservancy
- Klamath Basin Tribes
- Yurok, Karuk, and Hoopa Valley Tribes
- US Bureau of Land Management
- US Fish and Wildlife Service
- US Forest Service
- US Bureau of Reclamation

The Klamath River Basin stakeholders developed a Public Review Draft of the Klamath Basin Restoration Agreement. The agreement is intended to result in effective and durable solutions which will: (1) restore and sustain natural fish production and provide for full participation in ocean and river harvest opportunities of fish species throughout the Klamath Basin; (2) establish reliable water supplies which will sustain agricultural uses, communities, and National Wildlife Refuges; and (3) contribute to the public welfare and sustainability of all Klamath Basin communities.

Management Strategies

To implement the three general objectives listed above, the following general management strategies have been developed and approved by the stakeholders.

(1) Rebuilding Fisheries

The Fisheries Program includes the following management strategies;

- Reintroduction of anadromous species within the basin
- Establish conditions that, when combined with effective implementation of a new Water Resources Program and the Hydroelectric Settlement, will contribute to the natural sustainability of fisheries and the full participation in harvest opportunities, as well as the overall ecosystem health of the Klamath River Basin.
- Develop a fish monitoring plan to assess status and trends of fisheries and their habitats.
- Assess the effectiveness of these actions and provide for adaptive management.

(2) Sustainable Water Supply Reliability – the plan contains a number of measures to provide water supply reliability. Major strategies are listed below;

- Established a permanent limitation on the amount of water that will be diverted from Upper Klamath Lake and the Klamath River for the US Bureau of Reclamation's Klamath River Project.
- Maintain wetlands and other wildlife and agricultural Partnerships
- Develop a Drought Plan
- Add fish and wildlife and national wildlife refuges as authorized purposes of the Klamath River Project.

(3) Contribute to the public welfare and sustainability of all Klamath Basin communities.

- Support the goals of each tribe to achieve the revitalization of tribal subsistence and related economies.
- Develop programs to address economic impacts associated with the implementation of the program.
- Ensure affordable electricity for eligible irrigators to maintain sustainable agricultural communities.
- Determine how long-term climate change may affect the fisheries and communities of the Klamath basin.

Program Budget

The cost for implementing and adapting the management strategies requires authorization and funding from both Federal and state governments. The estimate for implementing the agreed to management strategies in the first year is $47 million, and the long-term cost of implementation is estimated at $97 million per year. Over 90 percent of the estimate is budgeted for fisheries restoration and actions to enhance the amount of water for fish.

Kissimmee River Restoration Project - Central Florida, USA

Background

The Kissimmee River in central Florida is the focus of one of the largest and most ambitious restoration projects in the world. The goal of this effort is to restore the ecological structure and function for much of the Kissimmee River and its floodplain by reinstating the natural flow regime and rerouting flows back into the historic channel (SFWMD 2006).

The Kissimmee River flows from Lake Kissimmee in the north to Lake Okeechobee in the south. Anthropogenic modifications to the system began as early as the 1830s with the construction of Fort Gardiner and essentially culminated in the 1960-70s with the construction of the main flood control canal (C-38) and various check dams. Collectively referred to as the Central and Southern Florida Flood Control Project, the conveyance and flood control structures were authorized by Congress in 1948 in response to severe droughts and hurricane-related flooding within the Kissimmee Basin.

The canal, C-38, radically changed the river from a highly sinuous freshwater system, with extensive floodplain habitats, to a uniformly excavated channel (approximately 90 km long x 10 m deep x 30-90 m wide) with effectively no direct floodplain connection. In addition, the annual hydrograph was essentially reversed to allow for greater storage capacity in the headwater lakes during the rainy season (June-November). This was seen as a flood control measure as well as a buffer against drought and the heavy agricultural demand within the basin. This type of hydrographic reversal is, in general, emblematic of the changes brought about by flood control and water supply alterations of freshwater systems (Poff et al. 1997, Poff et al. 2007, Tockner and Stanford 2002). Further, as a result of artificial regulation, the inter-annual variation flow was substantively altered, and the coefficient of variation of this flow was greater in the post Central and Southern Florida Flood Control Project era relative to historic conditions (1933-1960).

Management Objectives

The U.S. Army Corps of Engineers completed two restoration feasibility studies (USACE 1985 and 1991) with the latter recommending the backfilling of C-38 and the diversion of flows back to the historic channel. The construction of C-38 opened up vast areas of land for agricultural use and further development and the altered land-use was the initial impediment to large-scale restoration efforts. Real estate acquisition therefore began in 1991 and represented a substantial project cost. This was explicitly anticipated and budgeted for throughout the feasibility and planning phases, a hallmark to the success of this project (Panel on Adaptive Management for Resource Stewardship 2004). While restoring the system's ecological integrity is the primary goal, restoration could not compromise the level of flood control provided by the channelized system. This clearly presented a number of engineering challenges but the control structures in the headwater lakes were seen as a sufficient safeguard.

Prior to the array of anthropogenic changes in the basin, flows in the Kissimmee River were more stable with far less long-term variation, showed a greater mean monthly flow distribution, and had a substantially different hydrograph of high- and low-flow periods with roughly double the peak flow magnitudes. The subsequent physical alterations resulted in a pronounced degradation of the ecosystem and virtually every key component and community showed marked degradations in structure and function. As a result, the following management objectives were adopted in the Kissimmee River restoration effort:

- Reestablish a sustainable population of breeding wading birds and wintering waterfowl,
- Reestablish native fish populations both in the main channel and those adapted to floodplain habitats,
- Increase aerial coverage of wet prairies, broadleaf marshes, and floodplain wetlands,
- Increase the abundance and diversity of aquatic macroinvertebrates,
- Provide a sustainable ecosystem that supports native plant communities,
- Decrease the spread of exotic species,
- Decrease the abundance of floating and submerged macrophytes that have led to drastic decreases in aquatic primary productivity and a detrimental increase in detrital loads, and

- With a decrease in the abundance of aquatic macrophytes, declines in dissolved oxygen concentrations (from the decomposition of detrital material) should no longer plague the system.

Management Strategies

The contemporary Kissimmee River Restoration Project (KRRP) was initially conceived as two complementary components: 1) the Headwaters Revitalization Project (HRP) and 2) the Kissimmee River Restoration Project. These were combined through a 1994 cost-share agreement between the South Florida Water Management District (SFWMD) and the U.S. Army Corps of Engineers (USACE). The HRP's charter (headed by the SFWMD) was to solve the issues of adequate flood control storage while attempting to produce releases that more approximate the natural flow regime. The precursor KRRP (USACE) sought to find an equitable means of restoring the river channel while, again, not compromising the flood control conveyance characteristics. After a time, it became logical and pragmatic to combine these efforts into a unified process that evaluated the biotic and abiotic system as a whole.

Although there is much more detail to the feasibility, planning, and phased construction of the KRRP, the key elements that have made the project a success to date are:

- Clear and stated goals for the project.
- Agreement among stakeholders on the goals and process to reach project objectives.
- An understanding and delegation of stakeholder roles and responsibilities.
- The contributions and programmatic guidance of an independent panel of experts (aquatic ecologist, fisheries biologist, hydrologist, environmental chemist, ornithologist, etc. – see dedicated issue of Restoration Ecology, 1995 3[3]).
- A thoughtful consideration of ecosystem and community metrics and a comprehensive effort to measure the baseline conditions – not an exhaustive suite of metrics that, collectively, are unrealistic or overly expensive to measure but a simplified number of elements that indicate a healthy ecosystem's structure and function (SFWMD 2005a).

- A thorough consideration of the expected outcomes of the restoration relative to the baseline conditions and the use of objective science to measure ecosystem responses (SFWMD 2005b).
- An appropriate integration and synthesis of the biotic and abiotic processes (see dedicated issue of Restoration Ecology, 1995 3(3).
- An early commitment from the very beginning to monitoring and its inclusion in the budgetary process – not using such funding for overruns in other areas of project.
- An early commitment to adaptively manage the project when expected outcomes are not observed.
- Programmatic and budgetary allocation for future adaptive management – fully understanding that, if the project is to be viewed as successful and lessons from the process can be used for other restoration projects, the adaptive management loop is as important as the initial stages of construction.

Lastly, the KRRP utilizes the Before-After-Control-Impact Pair (BACIP) sampling design (Stewart-Oaten et al. 1986, Stewart-Oaten et al. 1992, Schroeter et al. 1993). The BACIP approach focuses on addressing a central problem in ecology: how ecological responses of human environmental perturbations can be separated from the considerable temporal variations exhibited by most ecosystems and communities. The case is further confounded in that most human perturbations are generally unique and not replicated. This raises the question, then, of whether measured responses are the result of human intervention or the outcome of natural variation that occurs at separate but structurally and functionally comparable sites. The BACIP successfully addresses this by sampling impact and control sites simultaneously, before and after the treatment (in this case, after channel and hydrograph restoration). Thus, through the comparison of Before-After and Control-Impact pairings, the effects of restoration can be effectively disarticulated from natural variation or system noise. In this way, managers and decision makers can be relatively assured that the ecosystem responses presented are those that result from the restoration efforts themselves and not an artifact of natural variation. There is no perfect solution but the BACIP approach, combined with the baseline data, provides more accurate and reliable measures of success, and is precisely the information needed to fuel the adaptive management process.

Program Budget

With an estimated budget of $578 million, the project is expected to take roughly 15 years to complete and will restore approximately 104 km^2 of floodplain wetlands and over 69 km of river channel.

Healthy Waterways Partnership - Southeast Queensland, Australia

Background

The Healthy Waterways Partnership (HWP) was initially established as the Moreton Bay Waterways and Catchments Partnership (MBWCP) in July 2001. The HWP is a rare and effective collaboration between government, industry, the research community, and the general public. The partners work closely to improve watershed management and waterway health (including tidal, estuary, marine, and freshwater wetlands) in Southeast Queensland (SEQ), Australia (Figure. 2; SEQ Healthy Waterways Partnership Strategy Overview 2007).

The HWP is guided by the Chief Executive Officer's Standing Committee, a Scientific Expert Panel (SEP) and a number of sub-regional groups. HWP oversight is through the SEQ Regional Coordination Committee[1]. The cooperative efforts of the HWP are fostered and coordinated by a dedicated HWP office staff and other partnership members.

SEQ is comprised of 19 major catchments totaling approximately 22,000 km2 (8,494 mi2). The region is among the fastest growing populations in Australia with over 2.5 million people living within its boundaries and a diverse social background (SEQ Healthy Waterways Partnership Strategy Overview 2007). SEQ is a rich source of biodiversity; however, with the expanding human population there has been an increasing stress on the region's water resources. Among the issues facing the SEQ are water quantity, quality, declining ecosystem services, nutrient

[1] The SEQ Regional Coordination Committee advises the Queensland government on the implementation of the SEQ Regional Plan, a statutory regional land-use plan for SEQ under Queensland's Integrated Planning Act. The Committees membership includes Queensland Ministers and SEQ Local Government Mayors.

loading, decreased in-stream productivity, riparian degradation, and toxic algal blooms. In short, many factors have contributed to the problems facing managers.

To address these complex issues, the HWP has designed and implemented an ecosystem approach that considers the entire water cycle, engages all committed stakeholders in a productive decision making process, identifies specific metrics through which success or failure can be measured, employs an adaptive management/learning procedure, and is highly effective in communicating the evolving issues the HWP faces and the incremental progress (or in some cases resource condition regress) over time. The HWP philosophy is summarized as (SEQ Healthy Waterways Partnership Strategy Overview 2007):

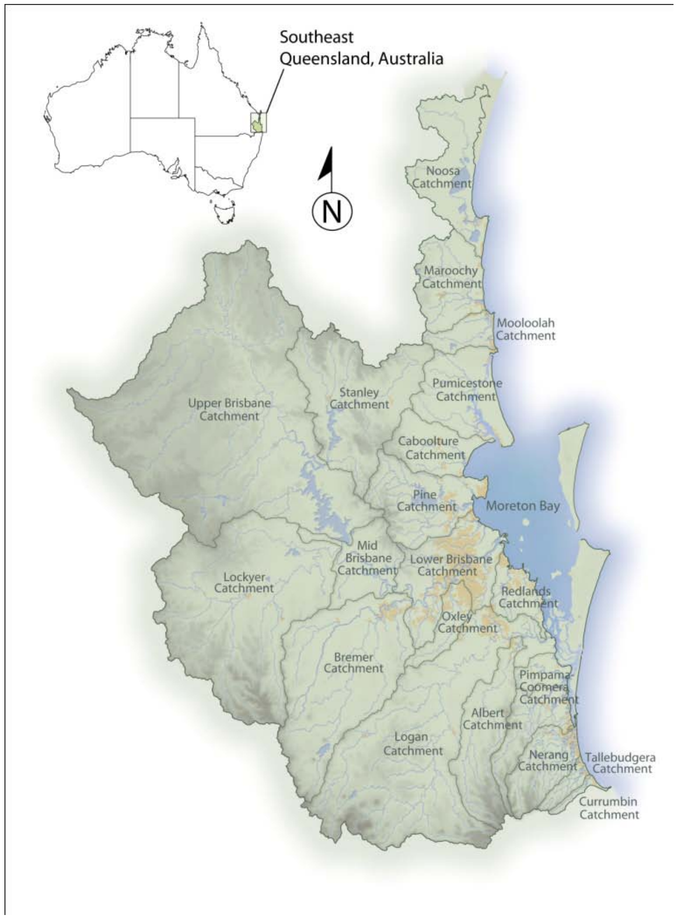

Figure 2. Map of SEQ Healthy Waterways Partnership; adapted by permission from SEQ HWP.

- Commitment to working in a coordinated partnership structure in which all partners can be heard, contribute to decision-making, and implement agreed actions within their own spheres of responsibility.
- Formulation of management strategies on the basis of sound science, rigorous monitoring of the waterways environment, and adaptive learning.

Management Strategy

Vision Statement

Central to the success of the HWP was the initial formulation of a *shared* vision. In its purest sense, a vision serves to frame the goal(s) of the effort such that all involved have a common purpose and reference system to guide their actions. Further, a defined vision can serve to better unify more disparate points of view and hopefully diffuse future misunderstandings and conflict. The HWP vision is (SEQ Healthy Waterways Partnership Strategy Overview 2007):

> *By 2026, our waterways and catchments will be healthy ecosystems supporting the livelihoods and lifestyles of people in South East Queensland, and will be managed through collaboration between community, government and industry.*

Word choice is purposeful and clearly identifies desired targets. For example, the HWP vision statement provides targets for both a resource condition ("healthy ecosystems") and the human community in which they reside. "Ecosystem" also identifies the level at which efforts are focused and thus may assist in defining how best to approach undesirable conditions, how to measure their state over time, and how more resolved metrics fit into the larger picture; in essence, a strategy and action plan on how to proceed and who is taking ownership of the process. Care, however, should be exercised to ensure that the targets indentified in a vision can in fact be achieved and are not diametrically opposed to the extent that irreconcilable conflict is inevitable.

Strategy, Action Plans, and Adaptive Management

A strategy provides a formalized linkage between the vision and plans for action. There is far more to be said about the complexities of a given planning and strategy formulation process, but suffice to say that a strategy is an integrated set of activities (action plans) aimed at achieving the objectives of the vision statement; it codifies and organizes the action plans in specific relation to the expressed goals captured in the vision.

HWP has a nested approach whereby the action plans have been divided into *Issue-based* and *Area-based* initiatives. In addition, a set of *Enabling Action Plans* that supports and facilitates the implementation, measures of success, adaptive management, and stakeholder involvement of the Issue- and Area-based Action Plans is also integrated into the overall strategy (Figure. 3).

Each Action Plan has a target that supports the vision statement's objectives, and yet is clearly an endeavor unto itself. The key element to this approach is the Enabling Action Plans as they are the mechanisms that allow for the measurement of success and thus the necessary feedback on the adaptive management process. Without consistent and defensible monitoring, adaptive management becomes little more than a trial and error exercise, which can be both environmentally and financially costly. Again, there is certainly more detail to the process, for example the particulars of what and how to measure a given parameter, but the focus here is the overall process and the benefits it conveys to a resource management or restoration program. Nonetheless, it should be mentioned that the HWP has enlisted the assistance of an independent panel of scientific experts that programmatically advise the HWP and carry out many of the monitoring activities (the SEP mentioned previously). While perhaps more difficult to orchestrate and/or fund in the beginning, the SEP provides an inherent level of scientific objectivity and a defensible platform from which to base adaptive management decisions thereby increasing the chances of success and attaining a stated goal(s).

Figure 3. Issue-based, Enabling, and Area-based Action Plans; adapted by permission from SEQ HWP.

The Ecosystem Health Monitoring Program (EHMP) is the means by which the HWP directly assesses their efforts in relation to the overall goals of the vision statement, individual action plans, and the adaptive management process. It is one of most comprehensive monitoring programs in Australia and clearly a model worthy of consideration for wider use (as are other aspects of HWP). The monitoring activities result in an annual report card that assigns grades (A through F) which reflect the degree to which a catchment/estuarine/marine system meets the established ecosystem health criteria (Figure 4) and succinct summaries convey the key points of the annual report card and suggest future directions of the EHMP (Figure. 5). This framework allows a simple, straightforward interpretation of performance over time that is easily understood by the general public. Yet, with supplemental information provided in the annual reports and monitoring methods addendums, a more in-depth understanding of the metrics and ecosystem processes they describe is readily afforded across disciplines, resource managers, and those with a desire to learn more about the system. An array of graphics, both geospatially explicit and conceptual, further details the mechanisms of the local water cycle and how it fits into the larger framework of the HWP and their objectives. For example, a rating system for management decisions and the need to monitor system drivers and pressures, such as climate variability/change and population growth, are outlined for the future activities.

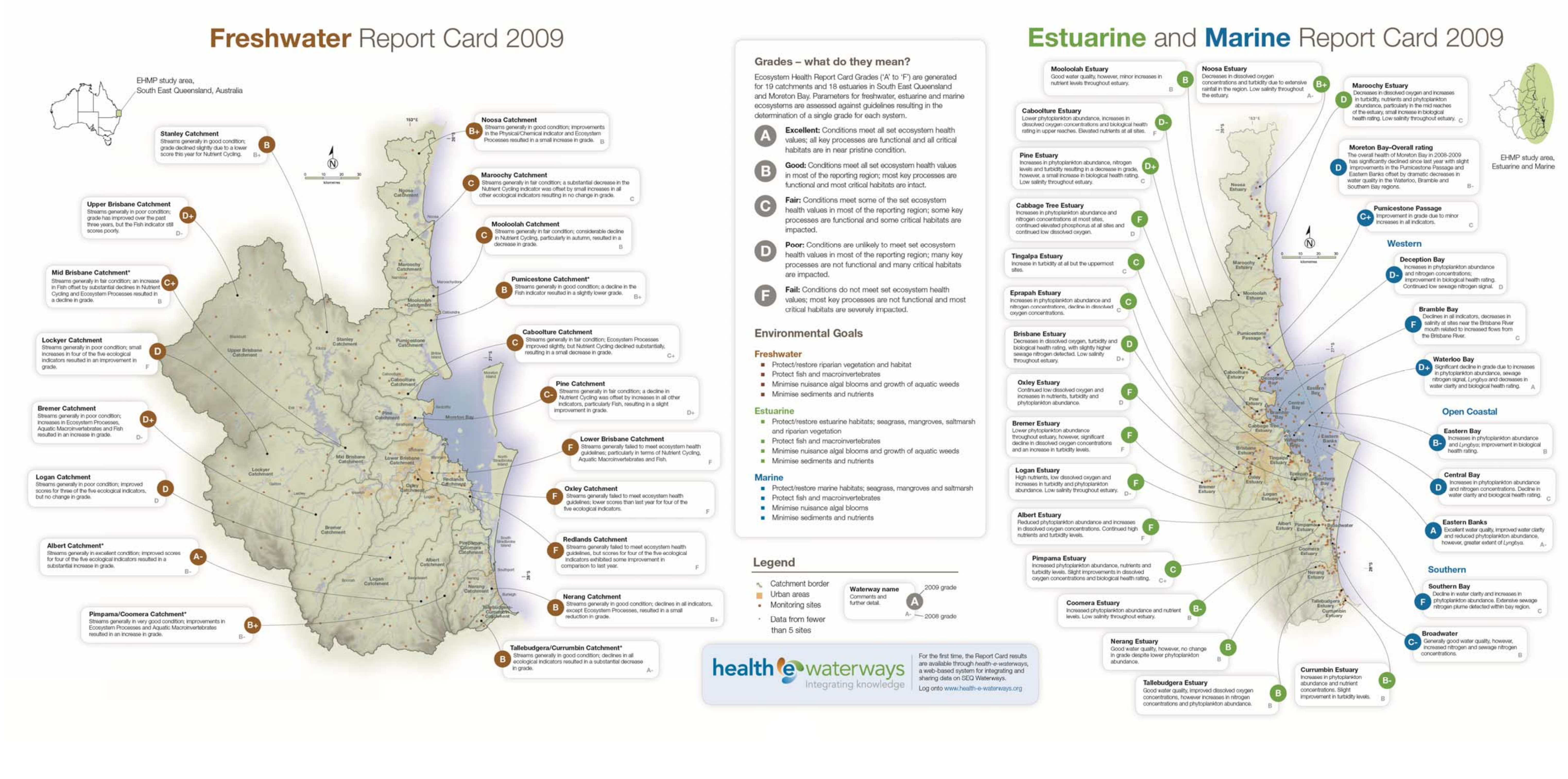

Figure 4. 2009 HWP Annual Report Card; adapted by permission from SEQ HWP.

Partial recovery of **South East Queensland's** waterways and **Moreton Bay**

Key messages of the 2010 Report Card

The 2010 Report Card results provide insight into how, and if, our waterways are recovering following the major rainfall that occurred in early 2009. This rainfall moved a significant load of sediment and nutrients (diffuse source pollution) from the catchments into our waterways. While there was some intense summer rainfall in 2010, the total rainfall throughout the region was below the long-term average (Figure 1), resulting in less diffuse source pollution entering Moreton Bay.

Total annual rainfall

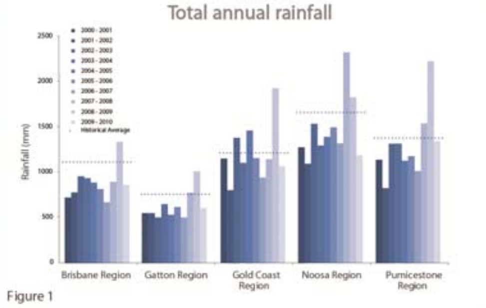

Figure 1

In 2009, Moreton Bay recorded the lowest ecosystem health grade (D) in a decade. The 2010 grade (C) for Moreton Bay, although an improvement from last year, is only a partial recovery and Moreton Bay is still falling short of its ten year average of a B grade (Figure 2).

Trends in the ecosystem health of Moreton Bay

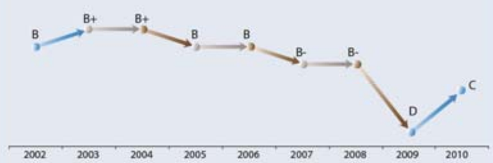

Figure 2

In 2010, the health of South East Queensland's (SEQ) freshwater streams and estuaries demonstrated some increases and some declines. Most of the changes that occurred in freshwater ecosystem health appeared to be driven by localised rainfall variability, rather than direct responses to land use change or management actions.

Moreton Bay

Over half of the zones that were monitored in Moreton Bay improved in ecosystem health, due mainly to a reduction in nitrogen and improvements in water clarity. Eastern Banks continued to receive the highest ecosystem health grade (A), while Southern Moreton Bay retained an F grade. The greatest improvement in ecosystem health occurred in Waterloo Bay (D+ to B) with Pumicestone Passage the only region to drop a grade (C+ to D+).

Estuaries

There were improvements in ecosystem health grades for some estuaries (Maroochy, Caboolture, Pine, Cabbage Tree and Tingalpa) with the greatest improvement occurring in the Maroochy estuary (D to C). The Noosa Estuary continued to receive the highest ecosystem health grade (B+). There were declines in southern catchment estuaries (Gold Coast and Logan), and the Albert, Bremer, Logan and Oxley estuaries all retained an F grade.

Freshwater

There was no significant change in the overall health of SEQ's freshwater streams from 2009 to 2010. While biological indicators (fish and macroinvertebrates) increased in some streams, increased algal growth has offset any major improvements. Mooloolah showed the greatest improvement (C to B-), whereas Pumicestone (B to C-) and Albert (A- to B-) showed the greatest declines. Although Lower Brisbane and Oxley showed some improvements, these waterways (along with Redlands) failed to meet ecosystem health guidelines.

How long will it take our waterways and Moreton Bay to fully recover from extreme rainfall events?

To answer this question, more information is required to fully understand:

- The effects of additional sediment and nutrient loads on Moreton Bay.
- The ability of waterways to cope with significant pressures, such as rapid population growth and climate variability.

Unless diffuse source pollution from rural and urban catchments is addressed, ongoing runoff from the catchments will continue to deposit sediment and nutrients throughout Moreton Bay (Figure 3).

To determine the level of management investment required, it is necessary to understand the recovery of our waterways following extreme rainfall events and their resilience to these events.

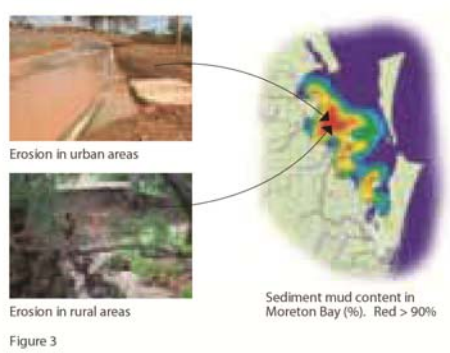

Figure 3

Figure 5. 2010 Annual Report Card summary; adapted by permission from SEQ HWP.

Summary

The HWP is a broad-based, collaborative restoration and monitoring initiative where an adaptive management cycle or process is truly an applied element within the larger context of the program. There are no revolutionary aspects on how they employ adaptive management (Figure 6) other than the fact they actually use the concept as it has been generally conceived.

The HWP appears to have found a solution to the array of problems and complexities encountered when applying adaptive management to large-scale management programs. Perhaps the most impressive aspect of the HWP is their effective communication. The annual report cards and status reports speak to a wide range of partnership members and have fostered a growing participation among the public; the citizens of SEQ hold a sincere ownership of the region's waterways and thus greatly increase the likelihood of achieving the HWP objectives.

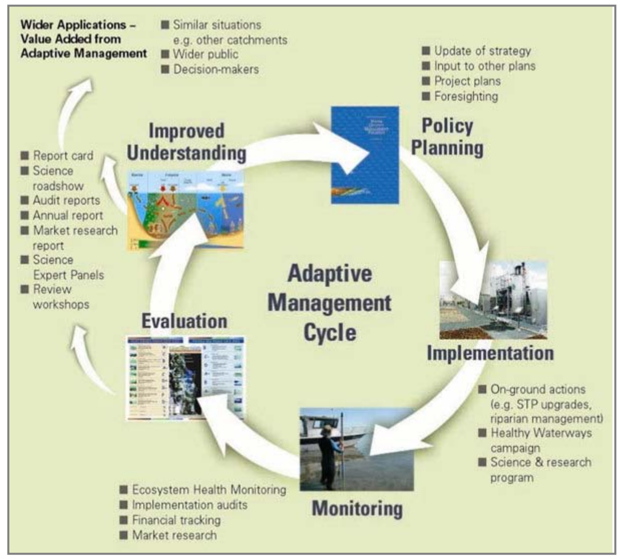

Figure 6 – Adaptive management as used by the HWP; adapted by permission from SEQ

The Middle Rio Grande Endangered Species Collaborative Program

Background

The MRG Program was initiated 10 years ago to address broad threats to two endangered species, the Rio Grande silvery minnow and the Southwestern willow flycatcher, as defined in both species' recovery plans and in a series of Biological Opinions that have be issued by the FWS regarding water operation along the Middle Rio Grande. The group formed because, at least in part, of a District Court ruling directing, in effect, that the combating water users, water managers, water regulators, and environmental groups themselves develop solutions to address threats to these species or the Court would define the solutions for them. Because these Biological Opinions have provided coverage on take to an array of water operations and users, and because of environmental and endangered species concerns, the MRG Programs include more than 20 stakeholders, including over time federal and state agency water and natural resource managers, city and county water suppliers, Native American pueblos and their federal trust agencies, an irrigation district, a group of irrigators, universities, and environmental groups. A diversity of deeply conflicting goals held by the individual stakeholder groups, long-held mistrust between several of the groups, which include various lawsuits, and deeply divided scientific uncertainties on the biological requirement and habitat relationships for the listed species, particularly the minnow, has limited progress by the group in achieving consensus and solutions over its decade of existence.

Development of a Draft Plan

While the MRG Program has included in documented statements and in contracts requirements intents to operate using adaptive management principals, it has not developed an adaptive management plan or, until relatively recently, committed necessary resources to producing such a plan. Starting in 2010, it contracted with consulting experts in adaptive management to guide the Program in developing and drafting an adaptive management plan (Murray et al. 2011).

Development of the draft plan is involving MRG Program stakeholders and has begun to integrate background information from the MRG Program, including its goals and extensive discussions on what the final plan should contain (Murray et al. 2011). As the final plan progresses, it will require clear definitions of the research and management questions for the Program and its stakeholder managers, including what is known, what is unknown, and what is in need of learning related to the goals of the Program. The draft plan defines the steps on how best to answer those questions to help specifically direct management actions, monitoring, and research activities, emphasizing “need to know” priorities versus “nice to know” topics. The draft plan points out that properly assessing and bounding the MRG Program problems and goals will help to ensure that Program management and science activities on the Middle Rio Grande directly relate to priority decision needs, including decisions that need to be made by the MRG Program as a whole and those to be made by each of the stakeholders involved in the Program, given their respective mandates.

Developing Program Objectives

A particularly important benefit coming from the development of the draft plan is a compilation of nearly nine pages of “critical uncertainties” and hypotheses related to the MRG Program’s goals submitted by its participants. These included nearly seven and half pages of uncertainties on silvery minnow biological and ecological relationship. Approximately a half a page of uncertainties is presented on Southwestern Willow Flycatcher concerns, with the final page related to physical environment and related uncertainties, including hydrologic and geomorphologic relationships. This list will be refined through finalization of the plan and should become a key resource for advancing planning and implementing actions, especially defining specific program objectives, through the final plan.

The extensive list of uncertainty related to silvery minnows, as indicated above, which remain after more than a decade and half of funding support by federal and state agencies related to monitoring and research on this species, points to how implementing an adaptive management program earlier might have potentially helped to better guide and focus the expenditure of these dollars. A structured, iterative assessment program over this period would have likely resulted in a substantially shorter list of uncertainties related to this species. Without finalizing and implementing the developing plan for the MRG Program, this situation may not improve. For example, the 2010 USFWS updated Recovery Plan for the silvery minnow includes, under recovery action #4, the requirement to develop and implement an adaptive management program; but as Murray et al. (2011) noted, the actions listed in the recovery plan focus predominately on monitoring and data management (step 4 in the draft adaptive management cycle for the MRG Program), but lacks any other steps to produce a fully implementable adaptive management plan. Murray et al. (2011) suggests that the updated recovery plan equates adaptive management with effectiveness monitoring and then making adjustments based on only new knowledge; it lacks other adaptive management elements, including explicit recognition of uncertainty and identification and operational testing of hypotheses. Murray et al. (2011) additionally reports that the recovery plan for the flycatcher (USFWS, 2002) conveys a similar view of adaptive management, and it too focuses recovery efforts on the monitoring and adjustment aspects of research activities, without including other necessary adaptive management steps.

Establish the Opportunity to Build from the Past

With the implementation of an adaptive management plan, the Program can start to benefit from many of its previous projects, which were variously required under their individual contracts to include information on how the resulting work products could be linked into adaptive management for the Program. Apparently, these requirements were included within project requirements in anticipation of the Program developing an adaptive management plan. Among the Program products having such requirements are the reach-specific habitat restoration assessment and recommendation reports completed for the San Acacia, Isleta, Albuquerque, and Velarde Reaches of the Middle Rio Grande. Since an overall, integrated adaptive management plan for the MRG Program did not exist at the time for completing these requirements, the discussions within these documents are incomplete, but can still be very valuable. For example, in an outside peer review of the *Restoration Analysis and Recommendations for the San Acacia Reach of the Middle Rio Grande, NM* (Parametrix 2008), Noon et al. (2009) commented on the report's chapter 6 discussion on adaptive management, monitoring criteria, and information gaps. These reviewers found the description of adaptive management to be generally consistent with current thinking, but that the connection to actual decision making was not clearly made to take the advantage of iterated decision making. While outside the formal scope of their review, the reviewers contributed, from their experiences working with adaptive management, tips for successful implementation of the information in these documents, including a description of how scientific results (including possible research results) can be used to address both management risks and resource sustainability; decisions should be made through discussions involving both scientists and decision-makers.

This adaptive management development project is ambitious and the resulting plan should be highly beneficial to the MRG Program, but it will require that the MRG Program manager and stakeholders adhere to the terms established by the plan. When completed, the MRG Program's final adaptive management plan has the potential to help the Program better identify where it is headed, and to produce a set of hierarchal goals and specific management objectives that clearly point to relationships between those goals and objectives, as well as between objectives, hypotheses, and performance measures. Implementation of the final adaptive management by the MRG Program also has the potential to begin to remediate the deficiencies noted above in the two recovery plans, and provide a systematic approach to address the multitude of uncertainties surrounding the key management needs for both species along the Middle Rio Grande. The continuing difficulty in implementing the final plan will be the same problem that has faced this program since its start, i.e., conflicting goals and inherent long-held mistrust among the stakeholder, scientific uncertainties involving the species' habitat needs, and limits on funds available to address the solutions. These are the same issues that typically have plagued most adaptive management groups, many of which have found success in working sequentially through the adaptive management process to come to functional solutions unique to the problems each have faced.

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Appendix A

List and Categories of Compiled Adaptive Management Reports

(reports summaries and copies of reports contained on CD)

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
1	Puget Sound Chinook Salmon Recovery Plan: Monitoring and Adaptive Management Plan	2007 MAMA Team	Species-specific	Fishes	AMP	Oct-07
2	Michigan Wolf Management Plan	Michigan Dept. of Natural Resources	Species-specific	Mammals	AMP	Jul-08
3	Bald Eagle Management Plan	Florida Fish and Wildlife Conservation Commission	Species-specific	Birds	AMP	Apr-08
4	Status Report for the Bald Eagle - Washington	Washington Department of Fish and Wildlife	Species-specific	Birds	Status Report	Oct-07
4a	Post-delisting Monitoring Plan for the Bald Eagle in the Contiguous 48 States	USFWS	Species-specific	Birds	Monitoring Plan	Mar-09
5	An Adaptive Plan for Managing Alewife in the St. Croix River Watershed, Maine and New Brunswick	St. Croix Fisheries Steering Committee	Species-specific	Fish	AMP	Apr-10
6	Oregon Cougar Management Plan - 2006	Oregon Dept. of Fish and Wildlife	Species-specific	Mammals	AMP	Apr-06
7	Macquarie Marshes Adaptive Management Plan	Dept. of Environment, Climate Change and Water NSW (Australia)	Place-based	Wetlands	AMP	Jun-10
8	Gwydir Wetlands Adaptive Environmental Management Plan	Dept. of Environment, Climate Change and Water NSW (Australia)	Place-based	Wetlands	AMP	Apr-10
9	Red Wolf Recovery/Species Survival Plan	USFWS et al.	Species-specific	Mammals	Management Plan	Oct-90

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
9a	From the Field: Implementing Recovery of the Red Wolf - Integrating Research Scientists and Managers	Michael Stoskopf et al.	Species-specific	Mammals	Review	2005
10	Russian River Watershed Adaptive Management Plan - Final Draft - SOW	Russian River Watershed Council Review Panel	Place-based	Watershed / Basin	AMP SOW	Unknown
10a	Russian River Baseline Watershed Assessment Synthesis Report	Smith, R. Daniel	Place-based	Watershed / Basin	Project Report	2008
11	Federal Columbia River Power System Adaptive Management Implementation Plan	Unknown	Place-based	Watershed / Basin	AM Implementation Plan	Sep-99
12	South Bay Salt Pond Restoration Project Adaptive Management Plan	L. Trulio et al.	Place-based	Watershed / Basin	AMP	Dec-07
13	An Adaptive Management Plan for the Burrowing Owl Poplulation at Naval Air Station Lemoore	The Institute for Bird Populations; OR Cooperative Fish and Wildlife Research Unit	Species-specific	Birds	AMP	Aug-98
14	Dutch Slough Adaptive Management Plan	Cain, John	Place-based	Esturary	AMP	Jan-08
15	Leech Lake Management Plan - Draft	Schultz, Doug	Place-based	Lake	Habitat Management Plan	Jun-10
16	Papahanaumokuakea Marine National Monument Management Plan	P. Marine National Monument	Place-based	Esturary	AMP	Dec-08
17	National Management Plan for the Genus Caulerpa	*Caulerpa* Working Group	Species-specific	Birds	Management Plan	Oct-05
18	North American Waterfowl Management Plan	USFWS & Canadian Wildlife Service	Species-specific	Birds	Management Plan	May-86

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
19	North American Waterfowl Management Plan - 1998 Update	USFWS & Canadian Wildlife Service	Species-specific	Birds	Management Plan	1998
20	North American Waterfowl Management Plan - 2004 Strategic Guidance	USFWS & Canadian Wildlife Service	Species-specific	Birds	Management Plan	2004
21	North American Waterfowl Management Plan - 2004 Implementation Framework	USFWS & Canadian Wildlife Service	Species-specific	Birds	Management Plan	2004
22	North American Waterfowl Management Plan - Continental Progress Assessment - 2007	Assessment Steering Committee	Species-specific	Birds	Management Plan Assessment	2007
22a	Evaluation of Waterfowl Conservation Under the North American Waterfowl Management Plan	Byron K. Williams et al.	Species-specific	Birds	Management Plan Review	Apr-99
23	Managing North American Waterfowl in the Face of Uncertainty	James D. Nichols et al.	Species-specific	Birds	Paper	1995
24	Adaptive Regulation of Waterfowl Harvests: Lessons Learned and Prospects for the Future	Johnson, F. A.; Case, D. J.	Species-specific	Birds	Paper	Unknown
25	Conditions and limitations on learning in the adaptive management of mallard harvests	Fred A. Johnson et al.	Species-specific	Birds	Paper	2002
25a	Protocol and Practice in the Adaptive Management of Waterfowl Harvests	Johnson, F.; Williams, K.	Species-specific	Birds	Paper	1999
25b	Black Duck Joint Venture Strategic Plan 2008-2013	Black Duck Joint Venture	Species-specific	Birds	Implementation Plan	Mar-08

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
26	Clark County Multiple Species Habitat Conservation Plan	A Multiple Agency Collaboration	Place-based	Multiple Species	AMP	Sep-00
27	Adaptive Management Report for the Clark County, Nevada Multiple Species Habitat Conservation Plan	Clark County Desert Conservation Program	Place-based	Multiple Species	HCP AMP	Oct-08
28	Comprehensive Everglades Restoration Plan Adaptive Management Strategy	CERP AM Steering Committee and Writing Team	Place-based	Multiple Species	AMP	Apr-06
29	The Central and Southern Florida (incl. Everglades) Comprehensive Review Study	Central and Southern Florida Project	Place-based	Multiple Species / Wetland	AM Theory Management Plan Review	Apr-99
30	Experimental Policies for Water Management in the Everglades	Walters, C.; Gunderson, L.; Holling C. S.	Place-based	Multiple Species / Wetland	AM Theory Paper	May-92
31	San Juan River Basin Recovery Implementation Program - 1995	USFWS	Place-based	Multiple Species / Basin	RIP	1995
32	San Juan River Basin Recovery Implementation Program - 2006	USFWS	Place-based	Multiple Species / Basin	RIP	2006
33	San Juan River Basin Recovery Implementation Program - 2006 - Monitoring Plan and Protocols	USFWS	Place-based	Multiple Species / Basin	Monitoring Plan	2006
34	Vernalis Adaptive Management Program Report of the 2010 Review Panel	VAMP Review Panel	Place-based	Chinook salmon	AMP Review	May-10
35	Vernalis Adaptive Management Plan Technical Report - 2000	San Joaquin River Group Authority	Place-based	Chinook salmon	Technical Report	2000
36	Vernalis Adaptive Management Plan Technical Report - 2003	San Joaquin River Group Authority	Place-based	Chinook salmon	Technical Report	2003

Adaptive Management Documents

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37	Vernalis Adaptive Management Plan Technical Report - 2008	San Joaquin River Group Authority	Place-based	Chinook salmon	Technical Report	2008
38	Interagency Bison Management Plan	Unknown	Species-specific	Mammals	Management Plan	Unknown
39	Interagency Bison Management Plan: A Status Review of Adaptive Management Elements, 2000-2005	IBMP Status Review Team	Species-specific	Mammals	AMP Review	Sep-05
40	Interagency Bison Management Plan - Adaptive Management Plan	5 agencies	Species-specific	Mammals	AMP	Dec-08
41	Work Plan for Adaptive Management - Klamath River Basin, OR & CA	Natural Resources Conservation Service	Place-based	Watershed / Basin	AMP	May-04
42	Draft Monitoring and Adaptive Management Plan for the Hamilton Wetland Restoration Project	Unknown	Place-based	Wetlands	AMP	Oct-02
43	Finney Adaptive Management Area Plan	US Forrest Service	Place-based	Forest	AMP	Unknown
44	Learning How to Apply Adaptive Management in the Sierra Nevada Forest Plan Amendment - Revision	University of California Science Team	Place-based	Forest	AMP	Jan-07
45	Secret Ravine Adaptive Management Plan - From Website	Unknown	Place-based	River / riparian / fish	AMP	Unknown
46	Napa River Flood Protection Project Performance-Based O&M for the Enhanced Minimum Plan (AMP)	City of St. Helena	Place-based	Floodplain / River / riparian / fish	AMP	Dec-03
47	Review of the Diavik and EKATI Adaptive Management Plans	ESSA Technologies Ltd.	Place-based	Aquatic Habitat	AMP Theory & Review	May-08

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
48	Bay Delta Conservation Plan Independent Science Advisors' Report on Adaptive Management	An Independent Science Advisor Panel	Place-based	Esturary	AMP Theory & Review	Feb-09
49	Adaptive Management - Concepts and Applications to Plum Creek's Native Fish Habitat Conservation Plan	Plum Creek Timber Co.	Place-based	Fish Habitat	AMP Theory & Review	Mar-99
50	Regional Scale Adaptive Management: Lessons From the North East Salinity Strategy	Allan, Catherine; Curtis, Allan	Place-based	Salinity	AMP Theory & Review	2002
51	Adaptive Management of the Water Cycle on the Urban Fringe - Three Australian Case Studies	Alistair Gilmour et al.	Place-based	Water supply, water quality, and recreation use	AMP Theory & Review	1999
52	Large-Scale Management Experiments and Learning By Doing	Walters, C.; Holling C. S.	AM Concepts	ecosystem	AMP Theory & Review	1990
53	Valuation of Experimental Management Options for Ecological Systems	Walters, C.; Green, R.	AM Concepts	ecosystem	AMP Theory & Review	Oct-97
54	Adaptive Management in Habitat Conservation Plans	George F. Wilhere	AM Concepts	Habitat Conservation Plans	AMP Theory & Review	Mar-01
55	Active Adaptive Conservation of Threatened Species in the Face of Uncertainty	Eve McDonald-Madden et al.	Species-specific	Tasmanian devil	AMP Theory & Review	2010
56	Regime Shifts, Resilience, and Biodiversity in Ecosystem Management	Carl Folke et al.	AM Concepts	ecosystem resilience	AMP Theory & Review	Aug-04

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
57	Challenges in Adaptive Management of Riparian and Coastal Ecosystems	Carl Walters	AM Concepts	Riparian and Coastal Ecosystems	AMP Theory & Review	1997
57a	Managing Science-Management Partnerships - A Challenge of Adaptive Management	Kevin Rogers	Site-specific	River flows	AMP Theory & Review	1998
58	Deconstructing Adaptive Management: Critieria for Applications to Environmental Management	R. Gregory et al.	AM Concepts	ecosystem	AMP Theory & Review	Apr-06
59	Using Adaptive Management to Meet Conservation Goals	Thomas M. Franklin et al.	AM Concepts	fish and wildlife habitat	Case Study Review	Sep-07
60	Adaptive Management: A Spoonful of Rigour Helps the Uncertainty Go Down	Murray, C.; Marmorek, D.	AM Concepts	ecosystem	Case Study Review	Aug-04
61	Assessing Multi-species Recovery Plans Under the Endangered Species Act	Clark, J. Alan; Harvey, Erik	AM Concepts	Multi-species Recovery Plans	Case Study Review	2002
62	Unpacking "Participation" in Adaptive Management of Social-ecological Systems: A Critical Review	Lindsay C. Stringer et al.	AM Concepts	Stakeholder interaction	Case Study Review	2006
63	Appraising Adaptive Management	Kai N. Lee	AM Concepts	Ecoregions	AMP Theory & Review	1999
64	Monitoring and Evaluation in Conservation: a Review of Trends and Approaches	Caroline Stem et al.	AM Concepts	Assessment approaches	AMP Theory & Review	Apr-05
65	Adaptive Management of Natural Resources - Theory, Concepts, and Management Institutions	US Forrest Service	AM Concepts	Northwest Forest Plan	AMP Theory & Review	Aug-05

Adaptive Management Documents

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66	Using Expert Judgment and Stakeholder Values to Evaluate Adaptive Management Options	Lee Failing et al.	AM Concepts	response of salmonids to a hydroelectric facility in British Columbia	Case Study Review	2004
67	Adaptive Management and Ecological Restoration	Murray, C.; Marmorek, D.	AM Concepts	Assessment approaches; SW Ponderosa Pine Forests	AMP Theory & Review	2003
68	Adaptive Management of Natural Resources	Catherine Allan	AM Concepts	Water management planning	AMP Theory & Review	2007
69	Using Science in Habitat Conservation Plans	National Ceneter for Ecological Analysis and Synthesis; American Institute of Biological Sciences	AM Concepts	Habitat Conservation Plans	Case Study Review	Unknown
70	The Role of Adaptive Management as an Operational Approach for Resource Management	Barry L. Johnson	AM Concepts	Agency Management of Complex Environmental Problems	AMP Theory & Review	1999
71	Improving the Practice of Conservation: a Conceptual Framework and Research Agenda for Conservation Science	Nick Salafsky et al.	AM Concepts	Conservation Practice	AMP Theory & Review	Dec-02
72	Adaptive Management - What does it mean and how can it be used in fire management	Whelan, R. J.	AM Concepts	Fire Management in enviornmental management	AMP Theory & Review	Oct-02

Adaptive Management Documents

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73	Enabling Adaptive Forest Management - NCSSF Project D1	ESSA Technologies Ltd.	AM Concepts	Adaptive Forest Management	AMP Theory & Review	May-06
74	Nipped in the Bud: Why Regional Scale Adaptive Management is Not Blooming	Allan, Catherine; Curtis, Allan	AM Concepts	Regional-scale AM	AMP Theory & Review	Aug-05
75	Adaptive Management: The US Department of the Interior Technical Guide	B. K. Williams et al.	AM Concepts	DOI Guidance	AMP Theory & Review	2009
76	Grand Canyon Monitoring and Research Center – Website	USGS	Place-based	River management	Website	N/A
77	Environmental Protection: Using Adaptive Management at Glen Canyon Dam	Dennis M. Kubly	Place-based	River management	Project Report	Oct-11
78	Adaptive Ecosystem Management in the Pacific Northwest	US Forrest Service	Place-based	regional, provincial, and watershed scales	AMP Theory & Review	Sep-94
79	South East Queensland Healthy Waterways Strategy, 2007-2012 - Management Strategy Evaluation Action Plan	South East Queensland Healthy Waterways Partnership	Place-based	River management	Project Report	Dec-07
80	Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act	J.B. Ruhl	AM Concepts	ESA Species Management	Law Review Article	2004
81	South East Queensland Healthy Waterways Strategy, 2007-2012 - Strategy Overview	South East Queensland Healthy Waterways Partnership	Place-based	River Management	Project Report	Dec-07

Adaptive Management Documents

Doc. #	Title	Author(s)	Category	Target	Document Type	Date
82	Adaptive Impact Management: An Integrative Approach to Wildlife Management	S.J. Riley et al.	Management Methods	Wildlife Management	Journal Article	2003
83	Preserving the biodiversity and ecological services of rivers: new challenges and research opportunities	A.H. Arthington et al.	Management Methods	River Management	Journal Article	2010
84	Adaptive management of an environmental watering event to enhance native fish spawning and recruitment	A.J. King et al.	Management Methods	River Management	Journal Article	2010
85	Ecosystem effects of environmental flows: modeling and experimental floods in a dryland river	P.B Shafroth et al.	Management Methods	River Management	Journal Article	2010
86	Incorporating thermal regimes into environmental flows assessments: modifying dam operations to restore freshwater ecosystem integrity	Julian D. Olden and Robert J. Naiman	Management Methods	River Management	Journal Article	2010
87	Decision Point, Issue 22	David Salt (Applied Environmental Decision Analysis (AEDA) research hub)		River Management	Decision Document	Aug-10
88	Detecting ecological responses to flow variation using Bayesian hierarchical models	J. Angus Webb et al.	Management Methods	River Management	Journal Article	2010
89	Kissimmee River Restoration Studies - Executive Summary	South Florida Water Management District	Place-based	River Management	Project Report	Sep-06

Adaptive Management Documents

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90	Kissimmee River Restoration Studies - Volume I	South Florida Water Management District	Place-based	River Management	Project Report	Nov-05
91	Kissimmee River Restoration Studies - Volume II	South Florida Water Management District	Place-based	River Management	Project Report	Nov-05
92	Proceedings of the Colorado River Basin Science and Resource Management Symposium	USGS	Place-based	River Management	Symposium proceedings	Nov-08
93	Adaptive Management for Water Resources Project Planning - Executive Summary	Panel on Adaptive Management for Resource Stewardship, Committee to Assess the U.S. Army Corps of Engineers Methods of Analysis and Peer Review for Water Resources Project Planning, National Research Council	AM Concepts	Water Resource Management	Regulatory Guidance	2004
94	ER 1105-2-100, Amendment #1 - Appendix H - Policy Compliance Review and Approval of Decision Documents	USACE	Regulartory Guidance	Corps Planning	Regulatory Guidance	Nov-07

Adaptive Management Documents

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95	Memorandum: Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 - Monitoring Ecosystem Restoration	Theodore Brown, USACE	Regulartory Guidance	Corps Planning	Regulatory Guidance	Aug-09