Appendix C
Adaptive Management and the Delta Plan

The Sacramento-San Joaquin Delta Reform Act of 2009 seeks to provide a strong science foundation to inform decisions of the Delta Stewardship Council, seen in both provisions for a science program and an independent science board (Water Code section 85280):

> *85280 (a) The Delta Independent Science Board is hereby established in state government*
>
> *85280 (a)(3) The Delta Independent Science Board shall provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs that shall be scheduled to ensure that all Delta scientific research, monitoring, and assessment programs are reviewed at least once every four years.*
>
> *85280 (b)(4) The mission of the Delta Science Program shall be to provide the best possible unbiased scientific information to inform water and environmental decisionmaking in the Delta. That mission shall be carried out through funding research, synthesizing and communicating scientific information to policymakers and decisionmakers, promoting independent scientific peer review, and coordinating with Delta agencies to promote science-based adaptive management. The Delta Science Program shall assist with development and periodic updates of the Delta Plan's adaptive management program.*

The Delta Reform Act requires the inclusion of science-based adaptive management in the Delta Plan as defined and stated in Water Code sections 85308(f) and 85052:

> *85308(f) Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.*
>
> *85052 "Adaptive management" means a framework and flexible decisionmaking process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives.*

The Delta Reform Act also requires that the Delta Plan is based upon and implemented using the best available science:

> *85308 The Delta Plan shall meet all of the following requirements:*
>
> > *(a) Be based on the best available scientific information and the independent science advice provided by the Delta Independent Science Board.*
> >
> > *(e) Where appropriate, recommend integration of scientific and monitoring results into ongoing Delta water management.*
>
> *85302(g) In carrying out this section, the council shall make use of the best available science.*

Appendix C Adaptive Management and the Delta Plan

The Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act) requires a strong science foundation to inform Delta Stewardship Council (Council) decisions. This includes providing scientific expertise to support the Council and other agencies through the Delta Science Program and Delta Independent Science Board (Water Code section 85280). The Delta Reform Act also requires that the Delta Plan be based on and implemented using the best available science (Water Code sections 85308(a) and (e) and 85302(g)), and requires the use of science-based, transparent, and formal adaptive management strategies for ongoing ecosystem restoration and water management decisions (Water Code section 85308(f)).

Best Available Science

The Delta Reform Act requires the Council to make use of the best available science in implementing the Delta Plan. Best available science is specific to the decision being made and the timeframe available for making that decision. Best available science is developed and presented in a transparent manner consistent with the scientific process (Sullivan et al. 2006), including clear statements of assumptions, the use of conceptual models, description of methods used, and presentation of summary conclusions. Sources of data used are cited, and analytical tools used in analyses and syntheses are identified. Best available science changes over time, and decisions may need to be revisited as new scientific information becomes available. Ultimately, best available science requires scientists to use the best information and data to assist management and policy decisions. The processes and information used should be clearly documented and effectively communicated to foster improved understanding and decision making.

Steps for Achieving the Best Science

Science consistent with the scientific process includes the following elements:

- Well-stated objectives
- A clear conceptual or mathematical model
- A good experimental design with standardized methods for data collection
- Statistical rigor and sound logic for analysis and interpretation
- Clear documentation of methods, results, and conclusions

The best science is understandable; it clearly outlines assumptions and limitations. The best science is also reputable; it has undergone peer review conducted by active experts in the applicable field(s) of study. Scientific peer review addresses the validity of the methods used, the adequacy of the methods and study design in addressing study objectives, the adequacy of the interpretation of results, whether the conclusions are supported by the results, and whether the findings advance scientific knowledge (Sullivan et al. 2006).

There are several sources of scientific information and tradeoffs associated with each (Sullivan et al. 2006, Ryder et al. 2010). The primary sources of scientific information, in a generalized ranking of most to least scientific credibility for informing management decisions, include the following:

- Independently peer-reviewed publications including scientific journal publications and books (most desirable)
- Other scientific reports and publications
- Science expert opinion
- Traditional knowledge

Each of these sources of scientific information may be the best available at a given time and contain varying levels of understanding and uncertainty. These limitations should be clearly documented when scientific information is used as the basis for decisions.

Guidelines and Criteria

There have been several efforts to develop criteria for defining and assessing best available science. In 2004, the National Research Council Committee on Defining the Best Scientific Information Available for Fisheries Management prepared a report (National Research Council Report) that concluded guidelines and criteria must be defined in order to apply best available science in natural resource management (NRC 2004). Major findings and recommendations included establishing procedural and implementation guidelines to govern the production and use of scientific information. The guidelines were based on six broad criteria: relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review.

Best available science for proposed covered actions and for use in the Delta Plan should be consistent with the guidelines and criteria in Table C-1. These criteria were adapted from criteria developed by the National Research Council. Proponents of covered actions should document their scientific rationale for applying the criteria in Table C-1 (i.e., the format used in a scientific grant proposal).

Table C-1
Criteria for Best Available Science

Criteria	Description
Relevance	Scientific information used should be germane to the Sacramento-San Joaquin Delta (Delta) ecosystem and/or biological and physical components (and/or process) affected by the proposed decisions. Analogous information from a different region but applicable to the Delta ecosystem and/or biological and physical components may be the most relevant when Delta-specific scientific information is nonexistent or insufficient. The quality and relevance of the data and information used shall be clearly addressed.
Inclusiveness	Scientific information used shall incorporate a thorough review of relevant information and analyses across relevant disciplines. Many analysis tools are available to the scientific community (e.g., search engines and citation indices).[a]
Objectivity	Data collection and analyses considered shall meet the standards of the scientific method and be void of nonscientific influences and considerations.[b]
Transparency and openness	The sources and methods used for analyzing the science (including scientific and engineering models) used shall be clearly identified. The opportunity for public comment on the use of science in proposed covered actions is recommended. Limitations of research used shall be clearly identified and explained. If a range of uncertainty is associated with the data and information used, a mechanism for communicating uncertainty shall be employed.

Table C-1
Criteria for Best Available Science

Criteria	Description
Timeliness	Timeliness has two main elements: (1) data collection shall occur in a manner sufficient for adequate analyses before a management decision is needed, and (2) scientific information used shall be applicable to current situations. Timeliness also means that results from scientific studies and monitoring may be brought forward before the study is complete to address management needs.[c] In these instances, it is necessary that the uncertainties, limitations, and risks associated with preliminary results are clearly documented.
Peer review	The quality of the science used will be measured by the extent and quality of the review process. Independent external scientific review of the science is most important because it ensures scientific objectivity and validity.[d] The following criteria represent a desirable peer review process.[e] Coordination of Peer Review. Independent peer review shall be coordinated by entities and/or individuals that (1) are not a member of the independent external review team/panel and (2) have had no direct involvement in the particular actions under review. Independent External Reviewers. A qualified independent external reviewer embodies the following qualities: (1) has no conflict of interest with the outcome of the decision being made, (2) can perform the review free of persuasion by others, (3) has demonstrable competence in the subject as evidenced by formal training or experience, (4) is willing to utilize his or her scientific expertise to reach objective conclusions that may be incongruent with his or her personal biases, and (5) is willing to identify the costs and benefits of ecological and social alternative decisions. When to Conduct Peer Review. Independent scientific peer review shall be applied formally to proposed projects and initial draft plans, in writing after official draft plans or policies are released to the public, and to final released plans. Formal peer review should also be applied to outcomes and products of projects as appropriate.

a. McGarvey 2007
b. National Research Council 2004, Sullivan et al. 2006
c. National Research Council 2004
d. Meffe et al. 1998
e. Adapted from Meffe et al. 1998

It is recognized that differences exist among the accepted standards of peer review for various fields of study and professional communities. When applying the criteria for best available science in Table C-1, the Council recognizes that the level of peer review for supporting materials and technical information (such as scientific studies, model results, and documents) included in the documentation for a proposed covered action is variable and relative to the scale, scope, and nature of the proposed covered action. The Council understands that varying levels of peer review may be commonly accepted in various fields of study and professional communities.

Adaptive Management

Adaptive management is defined in the Delta Reform Act as "a framework and flexible decisionmaking process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives" (Water Code section 85052). Adaptive management can be applied at a program, plan or project level.

Adaptive management is a strategy that provides for making management decisions under uncertain conditions using the best available science rather than repeatedly delaying action until more information is available. Adaptive management allows for continuous learning resulting in management decisions based on what was learned, rather than adopting a management strategy and implementing it without regard for scientific feedback or monitoring. Adaptive management is an approach to resources management that increases the likelihood of success in obtaining goals in a manner that is both economical and effective because it provides flexibility and feedback to manage natural resources in the face of often considerable uncertainty.

BARRIERS TO ADAPTIVE MANAGEMENT

Although there have been several attempts to develop and implement adaptive management strategies in the Bay-Delta system and elsewhere, most have been unsuccessfully implemented. Adaptive management is not easy, quick, or inexpensive (NRC 2010). An adaptive management strategy for the CALFED Ecosystem Restoration Program (ERP) was developed in 2000 (CALFED Bay-Delta Program 2000), but implementation of the program's adaptive management elements was never achieved (Healey et al. 2008). Healey (2008) identified several barriers to implementing CALFED's adaptive management strategies. One such barrier was the struggle to change the traditional agency approach to managing problems, which limited the ability to take essential steps outside of normal agency operations, such as pre-project modeling and identification of specific outcomes, along with post-project monitoring and evaluation. Other barriers to implementing adaptive management under CALFED's ERP included a lack of secure funding and mechanisms for implementing large-scale adaptive management experiments, lack of stakeholder buy-in in the form of landowner assurances (e.g., economic viability and compensation for land use changes), changes in support for the projects under administration changes, and high implementation costs.

Additionally, the CALFED-funded Adaptive Management Forum Scientific and Technical Panel (Panel) (2004) identified both the regulatory environment along with human resources and communication as barriers to implementing adaptive management. They found that current permitting requirements for threatened and endangered species, water quality, flows and flow regimes, and floodway management and conveyance do not allow the design flexibility and speed of response required for adaptive management. To overcome this constraint, the Panel recommended that regulatory exemptions or special status need to be negotiated for innovative and creative approaches to adaptive management. The Panel also identified the need for specialized staff to design and implement adaptive management experiments, analyze and share the results of monitoring programs, and effectively communicate lessons learned. The Panel recommended recruiting specialized staff for these purposes as a means for overcoming this barrier.

CALFED's struggle to implement its adaptive management strategies is not uncommon. Walters (2007) concluded that nearly all 100 adaptive management efforts examined worldwide failed to implement adaptive management. Three main factors contributing to the widespread implementation difficulties in adaptive management programs were identified: (1) failure of decision makers to understand why adaptive management programs are needed, (2) lack of leadership for the complex process of implementing an adaptive approach, and (3) inadequate funding for the increased ecological (and often economic) monitoring needed to successfully compare the outcomes of alternative polices (Walters 2007). To overcome each of these barriers, Walters (2007) recommends identifying and nurturing adaptive management leaders dedicated to successful implementation, creatively investing in innovative monitoring programs, and forcing decision makers to confront uncertainty and think carefully about how to reduce risks in decision making under conditions of uncertainty.

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To be effective, governance to support and implement adaptive management in the Sacramento-San Joaquin Delta (Delta) must be flexible and have the capability to make timely changes to policies and practices in response to what is learned over time (e.g., the Delta Plan adaptive management approach described in Chapter 2). Governance for adaptive management should provide a decision-making structure that fosters communication among scientific experts, independent scientific reviewers, and the relevant decision-making authorities (e.g., State and federal fisheries agencies on issues related to aquatic ecosystem restoration), and provide a balanced approach to the involvement of interested stakeholders.

A Three-phase and Nine-step Adaptive Management Framework

The Council will use the three-phase and nine-step adaptive management framework on Figure C-1 that is described in detail below. The Council will use this framework to evaluate the usefulness of adaptive management for reviewing proposed covered actions involving ecosystem restoration and water management along with developing, implementing, and updating the Delta Plan (see Chapter 2). Ecosystem restoration and water management covered actions should include an adaptive management plan that considers all nine steps of this framework; however, they need not be rigidly included and implemented in the order described here and should not be used as a means to prevent action, but rather as a tool to enhance decision making. The intent is to build logical and clear information exchange and decision points into management actions that increase options and improve outcomes. In developing an adaptive management plan, the best available science should be used to inform the various steps of the adaptive management process.

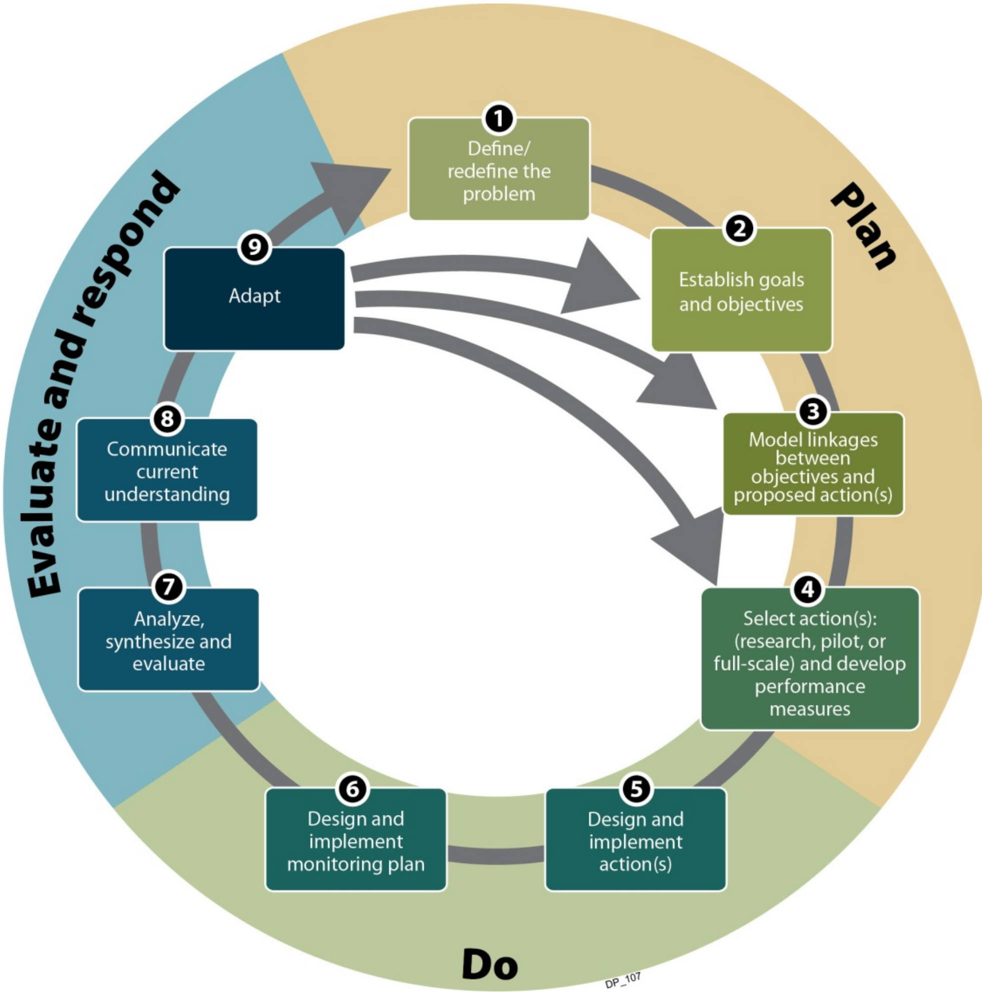


Figure C-1
A Nine-step Adaptive Management Framework
The shading represents the three broad phases of adaptive management (Plan, Do, and Evaluate and Respond), and the boxes represent the nine steps within the adaptive management framework. The circular arrow represents the general sequence of steps. The additional arrows indicate possible next steps for adapting (e.g., revising the selected action based on what has been learned). This framework and the description of each step are largely derived from Stanford and Poole (1996), CALFED Bay-Delta Program (2000), Abal et al. (2005), and the Bay Delta Conservation Plan Independent Science Advisors on Adaptive Management (2009).

Plan

The *Plan* phase of the adaptive management framework is presented as four steps.

1. Define/Redefine the Problem

The first step of effective adaptive management is to clearly define the problems that will be addressed in the form of a problem statement. The problem statement should clearly link to program goals and to specific objectives, which should be developed by proponents in an open manner. The boundaries of the problem (e.g., its geographic and temporal scales) should be defined in the problem statement.

2. Establish Goals and Objectives

Clear goals and objectives must be established by proponents of proposed covered actions for ecosystem restoration and water management, and be based on the best available science (see G P1 in Chapter 2). Goals are broad statements that propose general solutions. Objectives are more specific than goals, and are often quantitative, specific, narrative statements of desired outcomes, allowing evaluation of how well the objectives are being achieved.

3. Model Linkages between Objectives and Proposed Action(s)

Models formalize and apply current scientific understanding, develop expectations, assess the likelihood of success, and identify tradeoffs associated with different management actions. Models can be conceptual, statistical, physical, decision support, or simulation. Models link the objectives to the proposed actions and clarify why an intended action is expected to result in meeting its objectives. Models provide a road map for testing hypotheses through statements that describe the expected outcome of an action.

Both qualitative (conceptual) and quantitative models can effectively link objectives and proposed actions by illuminating if and how different actions meet specific objectives. Conceptual models are particularly useful for decision makers, scientists, and the public because they illustrate the most critical cause-and-effect pathways. Conceptual models provide an articulation of the hypotheses being tested and how various actions might achieve particular objectives. Conceptual models also help to develop performance measures, which are qualitative or quantitative information that tracks status and trends toward meeting objectives. Conceptual models should be used in adaptive management planning because they help explain how other types of models, research, and actions will be used to explore hypotheses and address specific existing and anticipated uncertainties.

Recent conceptual models developed specifically for the Delta include comprehensive models developed as part of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). The DRERIP models were designed to aid in the identification and evaluation of ecosystem restoration actions in the Delta, and include both ecosystem models (processes, habitats, and stressors) and species life history models. Another set of conceptual models was developed to plan the Interagency Ecological Program's Pelagic Organism Decline (POD) investigations and to synthesize the POD results into "stories" about what may have happened to cause the rapid decline of multiple open-water fish species.

4. Select Action(s) (Research, Pilot, or Full-scale) and Develop Performance Measures

The process for selecting an action or several actions to meet objectives includes an evaluation of the best available science represented in the conceptual model. This evaluation should guide development of the action. Consideration should be given to the following:

- Level of the action(s) to be taken (research project, pilot-scale project, or full-scale project)
- Geographical and temporal scale of the action(s)
- Degree of confidence in the benefits
- Consequences of being wrong

The scale of the action selected should be informed by the certainty of the relevant scientific information, consider the reversibility of the action, and account for the potential cost of delaying larger-scale actions. For example, when the best available science cannot predict the outcome of an action with a reasonable degree of certainty, and irreversible consequences exist for incorrectly predicting the outcomes of an action, further research or a pilot-scale action is likely more appropriate than a full-scale action, unless the cost of delaying a larger-scale action is very high (e.g., a species of concern goes extinct or urban water supplies are cut off). In some instances, choosing to take no action could be the best selection (when no foreseen benefit would result from a research, pilot-scale, or full-scale action). Where possible, the action(s) selected should test cause-and-effect relationships in the conceptual model so that the model can be adapted using the information learned from implementing the action(s).

Performance measures derive from goals and objectives, and help to address the status and trends of progress toward achieving the goals and objectives. Performance measures can be placed in three general classes:

- Administrative: performance measures that describe decisions made by policy makers and managers to finalize plans or approve resources (funds, personnel, projects) for implementation of a program or group of related programs
- Output (also known as driver): performance measures that evaluate factors that may be influencing outcomes and include on-the-ground implementation and management actions
- Outcome: performance measures that evaluate ecosystem responses to management actions or natural outputs

The distinction between performance measure types is not rigid. In some cases, an outcome performance measure for one purpose may become an output performance measure for another purpose.

Development of informative performance measures is a challenging task. Performance measures must be designed to capture important trends and to address whether specific actions are producing expected results. Performance measures are selected based on the conceptual model. In addition, the monitoring plan should be designed so that the information collected supports performance measure analysis and reporting.

Efforts to develop performance measures in complex and large-scale systems with many ecosystem types like the Delta are commonly multiyear endeavors; however, initial performance measures provide value for initial assessments of progress made in the interim. The process for developing performance measures should address the rationale for each performance measure, metrics, method for analysis, baseline and reference conditions, expected outcomes, timeline for evaluation, and a communication/visualization element. The development of performance measures should be informed by the best available science and involve key stakeholders.

Do

The *Do* phase of adaptive management includes two steps that occur in parallel.

5. Design and Implement Action(s)

The design and implementation of action(s) include clearly describing specific activities that will occur under the selected action(s) and how they will link to the monitoring plan. Design includes creating a plan for implementing the action(s) and monitoring responses resulting from the action(s). The design of the action(s) should be informed by existing uncertainties, and should be directly linked to meeting the goals and objectives.

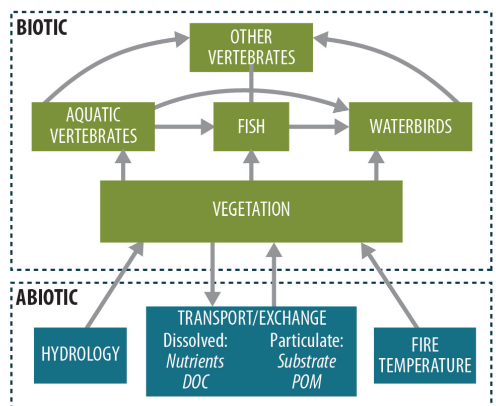
KISSIMMEE RIVER RESTORATION PROJECT

The Kissimmee River Restoration Project uses an adaptive management process that provides a positive example of adaptive management in practice. The project thoughtfully modeled linkages between objectives and proposed action(s), and successfully designed and implemented a comprehensive monitoring plan with clear and quantifiable expectations. As a result, the intended goals of the restoration effort are being met and documented. South Florida Water Management District Executive Director Melissa Meeker, who oversees the restoration project, has reported that, "The abundant wildlife now seen along the Kissimmee is a powerful indicator of the benefits of long-term investments in restoration. The District's documentation of these improvements provides us and our restoration partners—as well as the public—with critical insights into the ecosystem's ongoing recovery."[1]

Environmental monitoring conducted since completing phase one of restoration construction (backfilling the canal and reconnecting and recarving river channels) in 2001 has resulted in the following indicators of success as of February 2012:

- The number of wading birds observed increased by 64 percent. Three species long absent from the river are now documented regularly.
- Shorebird species commonly observed jumped from 2 to 11.
- Waterfowl sightings increased dramatically—by 29 times compared to pre-restoration sightings.
- Wetland vegetation, which once covered only 37 percent of the phase one restoration area prior to construction, has fully achieved the restoration target of 80 percent coverage.

February 9, 2001, photo of implemented phase one Kissimmee River Restoration Project showing the backfilled canal, degraded soil area, remnant river channel, the connector channel, and wetland areas.



General conceptual model of ecosystem structure and interactions for the Kissimmee River and floodplain (Dahm et al. 1995)

These results suggest that after construction is complete in 2014, and hydrologic conditions are fully restored in 2015, the region is on track to achieve its goal of restored ecological integrity in the Kissimmee River and its floodplain. In the 1960s, the Kissimmee River, located in south-central Florida, was channelized for flood-control purposes (Toth et al. 1998). In the 1990s, planning began for a 15-year restoration project. The restoration design included 70 kilometers of river channel and 104 square kilometers of floodplain—the largest attempted river restoration project in the world (Dahm et al. 1995). Adaptive research, monitoring, and evaluation programs were developed to provide a scientific foundation for fine-tuning each phase of the restoration effort (Toth et al. 1998). To "model linkages between objectives and proposed action(s)," conceptual models were developed to anticipate the restored Kissimmee River ecosystem, predict patterns of response for abiotic and biotic variables, and consider methods and performance measures for evaluating progress toward restoration in the river basin (Dahm et al. 1995).

The Kissimmee River Restoration Evaluation Program (KRREP) provides a practical example of the "design and implementation of a monitoring plan" step used in adaptive management. The KRREP is a comprehensive monitoring program designed to evaluate ecosystem responses to the restoration project through comprehensive monitoring and assessment of data collected before and after major construction phases (South Florida Water Management District 2011). If the KRREP determines that changes in the river and floodplain ecosystems after construction are not achieving expected results, adaptive management strategies are considered for implementation. More information about the Kissimmee River Restoration Project is available on the program website:
http://my.sfwmd.gov/portal/page/portal/xweb%20protecting%20and%20restoring/kissimmee%20river.

[1] http://www.sfwmd.gov/portal/pls/portal/docs/16721677.PDF (Accessed 03/02/2012)

6. Design and Implement Monitoring Plan

A well-designed monitoring plan includes a data management plan. A data management plan describes the process for organizing and clearly documenting observations, including how data are collected; the methods, quality assurance, and calculations used; the time and space scales of the variables; and accurate site locations and characteristics. Data management is critical for analyses, syntheses, and evaluations.

A well-designed monitoring plan goes beyond data collection and data management. A monitoring plan often includes targeted research to answer why certain results are observed and others are not. A monitoring plan also includes clear communication of the information gathered and current understanding drawn from this information. A complete monitoring plan includes:

- Compliance monitoring (required by permits)
- Performance monitoring with pre-project monitoring (measuring achievement of targets)
- Mechanistic monitoring with concurrent targeted research (testing the understanding of linkages in the conceptual model)
- System-level monitoring (holistic, integrative, and long term)

These types of monitoring can measure and communicate various types of information, including administrative/inputs (such as dollars awarded and spent or projects funded), compliance/outputs (such as tons of gravel added or acres exposed to tidal action), and effectiveness/outcomes (such as actual outcome expected from implementing an action at the local scale, suites of actions at the systemwide scales, and status and trends assessments). The monitoring plan design must include the development of monitoring metrics that can be integrated and summarized to inform decision makers and the public as described in step eight, *Communicate Current Understanding*.

Monitoring plan design requires making tradeoffs between resources spent on monitoring and resources spent on actions and analyses. To aid in this evaluation of tradeoffs, a rigorous pre-analysis using simulation models can show the information value of different variables that might be monitored. These values assessments can then be used to compare the benefits from monitoring certain variables against the benefit of using resources for other actions.

Implementation of actions and monitoring should be closely coordinated. Before an action is implemented, initial conditions should be clearly documented to the extent practical so that a baseline is established. Baseline data include characterization of natural variation observed in the examined system over space and time. For many ecological and hydrological variables, an extensive set of baseline data is available because of the efforts of the Interagency Ecological Program and repositories of information such as those available from the U.S. Geological Survey and the California Department of Water Resources. The implementation of action(s) and monitoring should be clearly executed and communicated to the public. Status and trends metrics that compare conditions before and after action implementation are often good assessment and communication tools.

Evaluate and Respond

The *Evaluate and respond* phase of adaptive management includes three key steps.

7. Analyze, Synthesize, and Evaluate

Analysis, synthesis, and evaluation of the action(s) and monitoring are critical for improving current understanding. Analysis and synthesis should incorporate information on how conditions have changed, expectedly and unexpectedly, as a result of implementing the action(s). Because measurable change might not occur on short timescales, evaluations should also examine whether actions prevented further deteriorating conditions that would have occurred if no actions were taken. The evaluation should examine whether performance measures indicate that one or more of the objectives have been met as a result of the implemented action(s), and if so, why. If an objective is not met, the potential reasons why it was not met should be clearly identified and communicated. Analyses should be cumulative. As each year's data become available, analyses should assess whether the probability of the desired outcome has changed and, if so, how this affects decisions about the action. The results of the analysis, synthesis, and evaluation step could be published in technical peer-reviewed papers and reports for the purpose of external review, disclosure, and accessibility where results warrant this level of communication. Scientists and technical experts will be critical for carrying out this step.

8. Communicate Current Understanding

Communication of current understanding gained through analysis, synthesis, and evaluation of implemented action(s) and monitoring is a key step for informing and equipping policy makers, managers, stakeholders, and the public to appropriately respond and adapt. This step spans the *Do* and the *Evaluate and respond* phase of adaptive management because the communication of current understanding and related recommendations for change requires both policy and technical expertise. The information communicated should be technically sound, well synthesized, and translated into formats conducive to informing a nontechnical audience (e.g., a report card format or a general science outlet such as a newsletter). The information should then be disseminated to those directly involved in the adaptive management process for the plan, program, or project and to those interested in the outcome of the action.

Technical staff and decision makers should be regularly involved in the exchange of information as data are analyzed and synthesized. Communication should be ongoing and occur at appropriate intervals at which an improved understanding could help refine other steps of the adaptive management framework.

The key to successful communication is a skilled and dedicated interdisciplinary person or team who understands the technical information learned, the functional needs of the decision makers, and how to best transmit this information. Communication should utilize various media (e.g., web-based materials, social media, outreach opportunities, public forums, etc.) and strive to meet the goals of transparency and clarity.

9. Adapt

Proponents of covered actions for ecosystem restoration and water management should be engaged and prepared to adapt to changes in current understanding and changes in current conditions (e.g., environmental or socioeconomic). Informed and equipped with new results and understanding, decision makers should re-examine the other steps of the adaptive management framework and revise these steps where current understanding suggests doing so. Possible next steps could include redefining the problem statement, amending goals and objectives, altering the conceptual model, or selecting an alternative action for design and implementation. Also, decisions to adapt might be needed at various time intervals for the same adaptive management experiment. For example, decisions might need to be made daily (e.g., Delta water operations), yearly (e.g., implementation of landscape-scale restoration), or decadal (adaptive management of landscape-scaled restoration design).

Knowing when to adapt is not always obvious. Adaptive management actions should have a planned timeframe that includes when to adapt (based on understandings of the system and its uncertainties), and that timeframe should be abandoned only if the results show that the action is doing more harm than good or the anticipated benefit is not noted within a reasonable timeframe beyond what was expected. In general, one year's results, however anomalous, are seldom enough to demonstrate that the action should be subject to adaptive measures. Furthermore, when the analysis, synthesis, and evaluation of information learned from implementing an action indicates that no benefit results from the undertaken action, resources should no longer be spent on that action no matter how popular the action might be.

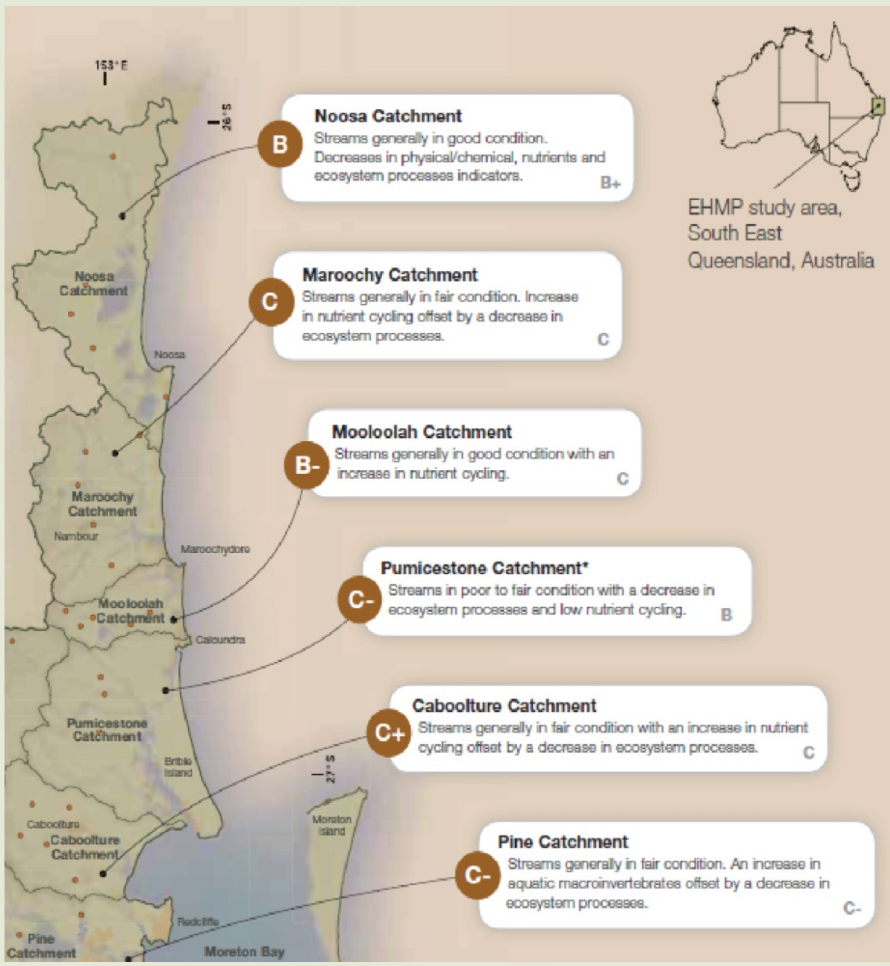
HEALTHY WATERWAYS

In South East Queensland, Australia, Healthy Waterways is an organization using an adaptive management process that provides a positive example of adaptive management that might be practiced for the Delta. Healthy Waterways has excelled at two specific steps of adaptive management: “communicate current understanding” and “adapt.” Achievements of the Healthy Waterways Partnership to date include an extensive public awareness and education program, urban stormwater or catchment management plans for all major catchments in South East Queensland, and local and state government investment in upgrading 25 wastewater treatment plants leading to about a 40 percent reduction in nitrogen load to waterways.

Healthy Waterways has collaborative partnerships and works to improve the health of waterways, catchment, and ecosystems that support the livelihoods and lifestyles of the region’s people. An adaptive management framework developed by Healthy Waterways’ partners has served as the operating philosophy and cornerstone of program implementation for over a decade. Healthy Waterways’ practice of adaptive management has led to improved understanding about how to deal with resource management issues and the flexibility necessary for changing socioeconomic and socioecological relationships occurring in South East Queensland (Abal et al. 2005).

Healthy Waterways’ communication of current understanding is facilitated through a commitment to public education and outreach; annual public report cards; and the use of leading technology to analyze, interpret, and communicate information through the health-e-waterways dynamic report cards (http://www.health-e-waterways.org/). These communication efforts have led to adapting management actions based on current ecosystem understanding; these actions are subsequently evaluated in annual report cards.

Details about Healthy Waterways and its adaptive management elements are available at www.healthywaterways.org.



Healthy Waterways 2010 Annual Report Card Sample
(2010 grades are brown, 2009 grades are gray)

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Decisions made within the adaptive management process for ecosystem restoration and water management actions should be made by decision makers for the entity responsible for implementing adaptive management. Adaptive management decisions relevant to revising and updating the Delta Plan will be made by the Council.

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