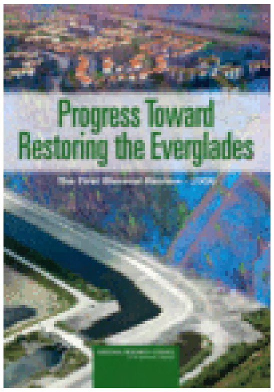

Progress Toward Restoring the Everglades: The First Biennial Review, 2006

Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP), National Research Council

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Progress Toward Restoring the Everglades

The First Biennial Review – 2006

Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP)

Water Science and Technology Board

Board on Environmental Studies and Toxicology

Division on Earth and Life Studies

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Preface

The Everglades are unique in the world in its assemblage of geographic and ecological wonders, ranging from tree islands to exotic reptiles and wading birds. With a landscape that slopes as little as an inch per mile, the water in the "River of Grass" historically moved slowly but inexorably from the region of Lake Okeechobee southward toward the current Everglades National Park and Florida Bay, sustaining its unique ecological riches. However, nearly 130 years of drainage, channelization, encroachment, and development for the beneficial uses of agriculture, industry, and cities have reduced the original 3 million acres of natural landscape by about half. Water destined for Everglades National Park must now run a gauntlet of canals, levees, pump stations, and hydraulic controls. Pollution of pristine natural waters by phosphorus and mercury and invasion by exotic species further compromise the ability of the Everglades to support its ecological functions.

In response to these issues, the state of Florida and the nation have formed a partnership to restore the remaining Everglades ecosystem as nearly as possible to pre-drainage hydrologic conditions, under the reasonable assumption that if we "get the water right" a positive ecological response will follow. The nearly 11 billion dollar (2004 estimate) Comprehensive Everglades Restoration Plan, or CERP, is the realization of this partnership, as jointly managed by the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD). Authorized by the Water Resources Development Act of 2000, or WRDA 2000, the Plan includes provision for independent scientific oversight as to progress in restoring the natural system. The National Research Council's (NRC's) Committee on Independent Scientific Review of Everglades Restoration Progress, or CISRERP, was formed for this purpose in 2004; this report is the first of a series of biennial evaluations that are scheduled to last the 30-year lifetime of the CERP.

Our committee met seven times, including five times in Florida, for the purposes of gathering information, receiving input from professionals and the public, and formulating and reaching consensus on this first report. We heard from state and federal personnel, environmental groups, academicians, and citizens. The committee relied on scientific literature, agency reports, online resources, presentations, field trips, and other information relevant to our charge. Evaluating this information and synthesizing our report has easily filled up the approximately 2-year span of our activities. Restoration activities are highly dynamic; of necessity, we were unable to review in detail any material developed past about December 1, 2005.

Although the CERP has been active for 5 years, little if any in-ground construction has occurred while detailed design efforts are under way. Nonetheless, there are more than enough topics on which to report, including project management, financing, sequencing, the role of science, monitoring and assessment, non-CERP restoration projects, and the importance of land acquisition. In particular, we highlight the opportunities for active adaptive management on the part of the USACE and the SFWMD to reduce scientific uncertainties while simultaneously initiating projects at a scale that will positively affect the natural system.

Needless to say, our committee could not address all scientific and technical issues that affect restoration progress in this first report. The timing of the release of key restoration documents by the CERP and the emergence of particular issues of concern influenced the topics addressed in this report. Thus, many topics await evaluation by succeeding incarnations of the CISRERP. For example, future topics might include the output of models that attempt to simulate the pre-drainage hydrology of the Everglades, the appropriate spatial scales for understanding and managing hydrology, better understanding of how the CERP is affected by changes in the timing or design of individual projects, and the potential influence of climate change on restoration success. By delivery of the next report in 2008, construction will have been completed on some pilot and other CERP projects, and more effort will also have been expended by the committee in analyzing such accomplishments.

Our committee is indebted to many individuals for their contributions of information and resources. Specifically, we appreciate the guidance of our committee's technical liaisons: Elmar Kurzbach (USACE), Garth Redfield (SFWMD), Tom Van Lent (formerly of the National Park Service), Barry Rosen (formerly of the U.S. Fish and Wildlife Service [USFWS]), and Todd Hopkins (USFWS). Numerous others helped educate our committee on the complexities of the Everglades restoration through their presentations, field

trips, and public comments (see Acknowledgments). The 12 members of the committee worked in full partnership with senior project officer Stephanie Johnson, who directed the study for the NRC, and NRC scholar David Policansky. Stephanie's particular dexterity in simultaneously running a meeting, contributing to the discussion, taking notes, and synthesizing the results is truly amazing. The committee enjoyed thoughtful oversight by director of the Water Science and Technology Board Stephen Parker and expert logistical and editorial support from Dorothy Weir.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making its published report as sound as possible and will ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report: John J. Boland, Johns Hopkins University; Rita R. Colwell, University of Maryland; Dara Entekhabi, Massachusetts Institute of Technology; Elsa M. Garmire, Dartmouth College; Louis J. Gross, University of Tennessee; Lt. Gen. Elvin R. Heiberg III, Heiberg Associates, Inc.; Charles D. D. Howard, CddHoward Consulting Ltd; Thomas K. MacVicar, MacVicar, Federico and Lamb, Inc.; Judith L. Meyer, University of Georgia; Robert R. Twilley, Louisiana State University; and Thomas Van Lent, The Everglades Foundation. Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Leo M. Eisel, Brown and Caldwell, appointed by the NRC's Division on Earth and Life Studies, and Frank H. Stillinger of Princeton University, appointed by the NRC's Report Review Committee. They were responsible for ensuring that an independent examination of this report was carried out in accordance with NRC institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the NRC.

Wayne C. Huber, *Chair*

Contents

Summary

Florida's Everglades have been transformed in the past century by urban and agricultural development. Once encompassing 3 million acres, they are now about half that size, and their waters are polluted with phosphorus, nitrogen, mercury, and pesticides. Associated drainage and flood-control structures have diverted large quantities of water to the ocean, reducing the freshwater inflows that defined the original ecosystem. The altered hydrologic system has contributed to dramatic declines in populations of wading birds, a 67 percent decline in the area of tree islands, and manifold changes in the ecosystem of Florida Bay. Invasive exotic species occupy much of the Everglades watershed, cattail has replaced vast areas of native sawgrass marsh, and 68 plant and animal species in South Florida are listed as federally threatened or endangered. Restoration of what remains of the Everglades ecosystem became the focus of activities that began in the 1990s and continue today, representing one of the most ambitious ecosystem restoration projects ever conceived.

The Comprehensive Everglades Restoration Plan (CERP) was unveiled in 1999 by the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD). The CERP aims to achieve ecological restoration by reestablishing hydrologic characteristics as close as possible to their pre-drainage conditions in what remains of the Everglades ecosystem, recognizing that irreversible changes to the landscape make restoration to full pre-drainage conditions impossible. The CERP includes more than 40 major projects and 68 project components to be constructed at an estimated cost of $10.9 billion in 2004 dollars. The projects embodied in the CERP are expected to take more than three decades to complete.

The Committee on Independent Scientific Review of Everglades Restoration Progress was established in 2004 in response to a request from the USACE, with support from the SFWMD and the U.S. Department of the Interior, based on Congress's mandate in the Water Resources Develop-

BOX S-1
Statement of Task

This congressionally mandated activity will review the progress toward achieving the restoration goals of the Comprehensive Everglades Restoration Plan (CERP). The committee will meet approximately four times annually to receive briefings on the current status of the CERP and scientific issues involved in implementing the Plan. It will publish a report every other year providing:

1. an assessment of progress in restoring the natural system, which is defined by section 601(a) of WRDA 2000 as all the land and water managed by the federal government and state within the South Florida ecosystem;
2. discussion of significant accomplishments of the restoration;
3. discussion and evaluation of specific scientific and engineering issues that may impact progress in achieving the natural system restoration goals of the Plan; and
4. independent review of monitoring and assessment protocols to be used for evaluation of CERP progress (e.g., CERP performance measures, annual assessment reports, assessment strategies).

ment Act of 2000 (WRDA 2000). The committee is charged to submit biennial reports that review the CERP's progress in restoring the natural system (see Box S-1). This is the committee's first report in a series of biennial evaluations that are scheduled to last the lifetime of the CERP.

The committee concludes that much good science has been developed to support the restoration efforts and that progress has been made in CERP program support, particularly in the monitoring and assessment program. However, no CERP projects have been completed to date, and anticipated restoration progress in the Water Conservation Areas (WCAs) and Everglades National Park appears to be lagging behind the production of natural system restoration benefits in other portions of the South Florida ecosystem. Additionally there have been some troubling delays in some projects that are important to the restoration of the Everglades ecosystem. These delays have resulted from several factors, including budgetary restrictions and a project planning process that that can be stalled by unresolved scientific uncertainties. Restoration benefits from early water storage projects remain uncertain because decisions have not yet been made regarding water allocations for the natural system.

SOUTH FLORIDA ECOSYSTEM RESTORATION

The South Florida Ecosystem Restoration Task Force (Task Force), an intergovernmental body established to facilitate coordination in the restoration effort, has three broad strategic goals for the South Florida ecosystem:[1] (1) "get the water right;" (2) "restore, preserve, and protect natural habitats and species;" and (3) "foster compatibility of the built and natural systems." These goals encompass, but are not limited to, the CERP.

The goal of the CERP, as stated in WRDA 2000, is "restoration, preservation, and protection of the South Florida Ecosystem while providing for other water-related needs of the region, including water supply and flood protection." The Programmatic Regulations that guide implementation of the CERP further clarify this goal by defining restoration as "the recovery and protection of the South Florida ecosystem so that it once again achieves and sustains the essential hydrological and biological characteristics that defined the undisturbed South Florida ecosystem." These defining characteristics include a large areal extent of interconnected wetlands, extremely low concentrations of nutrients in freshwater wetlands, sheet flow, healthy and productive estuaries, resilient plant communities, and an abundance of native wetland animals. At the same time, the CERP is charged to maintain current levels of flood protection and to provide for other water-related needs, including water supply, for a rapidly growing human population in South Florida. Although the CERP contributes to each of the Task Force goals, it focuses primarily on restoring the hydrologic features of the undeveloped wetlands remaining in the South Florida ecosystem, on the assumption that improvements in ecological conditions should follow.

Both political and scientific issues contribute to the difficulty of specifying restoration goals. The goals, therefore, cannot be viewed as fixed endpoints but are instead approximations of the objectives that should be developed by careful analyses and reevaluated as new knowledge emerges. Even with clearly articulated restoration goals, disparate expectations for restoration may exist among stakeholders, including both its geographic extent and its functional characteristics. The Everglades restoration efforts are thus occurring in a challenging environment.

Restoration Activities

Several restoration programs, including the CERP—the largest of the initiatives—are now under way. The CERP, led by the USACE and the

[1] See Box 1-1 for definitions of geographic terms used in this report.

SFWMD, consists primarily of projects to increase storage capacity (e.g., conventional surface-water reservoirs, aquifer storage and recovery, in-ground reservoirs), improve water quality (e.g., stormwater treatment areas [STAs]), reduce loss of water from the system (e.g., seepage management, water reuse, and conservation), and reestablish pre-drainage hydrologic patterns wherever possible (e.g., removing barriers to sheet flow, rainfall-driven water management). The largest portion of the budget is devoted to water storage and conservation and to acquiring the lands needed for those projects.

The CERP builds upon other activities of the state and federal government aimed at restoration (hereafter, non-CERP activities), many of which are essential to the success of the CERP. These include Modified Water Deliveries to Everglades National Park (Mod Waters) and modification of the C-111 canal—projects that will alter hydrologic patterns to more closely resemble pre-drainage conditions. Several non-CERP projects address water quality issues, including the Everglades Construction Project (construction of over 44,000 acres of STAs), restoration of the Kissimmee River, and restoration of Lake Okeechobee and its estuaries. In addition, research on and management of invasive species is important to the overall restoration program. Finally, the state of Florida's Acceler8 initiative is a mix of accelerated CERP project components and some non-CERP components.

What Natural System Restoration Requires

Although "getting the water right" is the oft-stated and immediate practical goal, the ultimate restoration goal is to reestablish the distinctive characteristics of the historical Everglades to what remains of the undeveloped South Florida ecosystem. Getting the water right is a means to an end, not the end in itself. **Natural system restoration will be best served by moving the system as quickly as possible toward physical, chemical, and biological conditions that previously molded and maintained the historical Everglades.** Toward this end, this committee judges five components of the Everglades restoration to be critical:

1. enough water-storage capacity combined with operations that provide appropriate volumes of water to support healthy estuaries and the return of sheet flow through the Everglades ecosystem while meeting other demands for water;
2. mechanisms for delivering and distributing the water to the natural

system in a way that resembles historical flow patterns, affecting volume, depth, velocity, direction, distribution, and timing of flows;

3. barriers to eastward seepage of water so that higher water levels can be maintained in parts of the Everglades ecosystem without compromising the current levels of flood protection of developed areas as required by the CERP;

4. methods for securing water quality conditions compatible with restoration goals for a natural system that was inherently extremely nutrient poor, particularly with respect to phosphorus; and

5. retention, improvement, and expansion of the full range of habitats by preventing further losses of critical wetland and estuarine habitats and by protecting lands that could usefully be part of the restored ecosystem.

If these five critical components of restoration are achieved and the difficult problem of invasive species can be managed, then the basic physical, chemical, and biological processes that created the historical Everglades can once again create a functional mosaic of biotic communities that resemble what was distinctive about the historical Everglades. However, **the remaining Everglades landscape will continue to move away from conditions that support the defining ecosystem processes until greater progress is made in implementing CERP and non-CERP projects.**

Rapid population growth, with its attendant demands on land and water resources for development, water supply, flood protection, and recreation, only heightens the challenges facing the restoration efforts. Yet, despite new challenges and complexities, some positive examples of restoration progress offer hope that restoration is within reach given continued state and federal support.

PROMISING EXAMPLES OF RESTORATION PROGRESS

Restoring the Everglades is still in its early stages. **It is too early to evaluate the response of the ecosystem to the current restoration program, because no CERP projects have been constructed.** It is also too soon to fully assess the effects of non-CERP activities that are already under way, because the ecosystem is only beginning to respond to changes that these projects are designed to effect. However, several non-CERP activities are positive harbingers of future CERP programs.

For example, **the Kissimmee River Restoration Project has shown demonstrable ecological improvements and benefits to the natural system.**

Improvements in the restored portions of the formerly channelized river include increases in river dissolved oxygen, increased density of wading birds, and colonization of the filled canal with wetland vegetation. Among several lessons learned from this project is that natural system restoration can be performed while continuing to maintain the flood-control function of the original channelization project. These achievements should be cause for cautious optimism that the CERP can achieve positive results as well.

Stormwater treatment areas and best management practices, implemented as part of non-CERP initiatives started in the 1990s, have proven remarkably effective at reducing phosphorus levels found in agricultural runoff. While falling short of the goal of 10 parts per billion (ppb) total phosphorus in the ambient waters, flow-weighted effluent concentrations from the STAs averaging 41 ppb are much reduced from influent concentrations that average 147 ppb. Because water quality is such a critical aspect of ecosystem restoration, additional research is needed to evaluate the need for additional acreage of STAs, to enhance removal of phosphorus and other constituents within these treatment wetlands, and to investigate their long-term sustainability.

The Mod Waters and C-111 projects have suffered long delays but are now moving forward, although Mod Waters should be completed without further delay. The Mod Waters and C-111 projects are non-CERP foundation projects that are necessary prerequisites to the CERP. Mod Waters represents a first major step toward restoration of the WCAs and Everglades National Park and a valuable opportunity to learn about the response of the natural system to restoration of sheet flow. Since the Mod Waters project is an assumed precursor for the WCA 3 Decompartmentalization and Sheet Flow Enhancement—Part 1 (Decomp) project, further delays in the project's completion may ultimately delay funding appropriations for Decomp. Additionally, limitations in its scope, such as in the extent of levee removal, may compromise the ultimate effectiveness of Decomp and restoration of flow to Northeast Shark River Slough.

CERP PROGRAM IMPLEMENTATION

During the first 6 years after WRDA 2000 was authorized, significant progress has been made in program support efforts, particularly in the monitoring and assessment program and the development of an adaptive management strategy, which represents the pathway by which science is used in support of decision making. Yet progress in CERP project implementation has been uneven, and many projects have been significantly delayed. Current barriers to project planning and implementation, highlighted below, threaten the timely delivery of restoration benefits.

Progress in the Use of Science in Decision Making

The committee reviewed three major science program documents that collectively provide a foundation for ensuring that scientific information needed to support restoration planning will be available in a timely way. The committee also examined the extensive set of models that have been developed to support restoration planning and adaptive management.

The Monitoring and Assessment Plan (MAP) documents reviewed describe a well-designed, statistically defensible monitoring program and an ambitious assessment strategy. The plan provides for a continuous cycle of monitoring and experimentation, as well as regular and frequent assessment of the findings. In combination, the MAP provides an approach to reduce uncertainty associated with the conceptual ecological models that are the foundation of the monitoring plan and to create new knowledge for understanding old and emerging problems. The MAP should also help identify information gaps to support adaptive management.

Implementation of the monitoring plan is occurring more slowly than planned. The effectiveness of the MAP as a component of the adaptive management strategy can be determined only by implementation. Each of the components of the MAP needs to be in place and tested to enable integration of scientific information into the decision-making process. A spatially and temporally robust baseline of monitoring data is essential for a rigorous assessment of restoration progress, and a well-planned information management system is required to facilitate effective information sharing. Additional key staff and staff-support positions devoted to information management and implementation of the monitoring activities are needed to facilitate more rapid implementation of the MAP. Continuing to winnow the number of performance measures from 83 to an even smaller subset that includes a limited number of whole-system performance measures would help ensure that the MAP is sustainable over the lifetime of the CERP.

The CERP Adaptive Management Strategy provides a sound organizational model for the execution of a passive adaptive management program. The strategy should be implemented soon to test and refine the approach. The CERP Adaptive Management Strategy proposes a process for addressing uncertainty and supporting collaborative decision making. Although the objectives, mechanisms, and responsibilities are well specified in the Adaptive Management Strategy, the all-critical linkages among the planning, assessment, integration, and update activities require further development. The committee also judges that incorporating active adaptive management practices whenever possible will reduce the likelihood of making management mistakes and reduce the overall cost of the restoration. Regardless of which adaptive management approach is used, it remains to be seen how willing decision makers will be to make significant alterations to project design and sequencing, as opposed to limiting adaptive management to making modest adjustments in the operation of CERP projects after their construction.

A coordinated, multidisciplinary approach is required to improve modeling tools and focus modeling efforts toward direct support of the CERP adaptive management process. Models are used to forecast the short- and long-term responses of the South Florida ecosystem to CERP projects and, thus, are the critical starting point for adaptive management. An impressive variety of models has been developed to support the CERP, but better linkages between models, especially between hydrologic and ecological models, are needed to better integrate scientific knowledge and to extrapolate new information to the spatial scales at which decisions are made. In addition, hydrologic models suffer from the lack of high-resolution input data describing the basic terrain, so that their predictions are sometimes in error, and their connections to other more high-resolution ecosystem models is difficult. The development of quantitative ecological models is lagging behind the development of hydrologic models. Because models themselves must be improved through comparison with actual outcomes, coordination between modeling and monitoring efforts, within the adaptive management framework of iterative improvement, should be a high priority.

Status of CERP Planning and Coordination

The large size of the South Florida ecosystem as well as the cost, complexity, and number of years required to complete the CERP necessitates that the restoration effort be carefully planned and coordinated. Therefore, the committee reviewed several important planning, financing, and coordination issues that influence the progress being made on natural system restoration.

Although progress has been made in the planning, coordination, and program management functions required to implement the CERP, there have been significant delays in the expected completion dates of several construction projects that contribute to natural system restoration. Between 2000 and 2004 the USACE and SFWMD largely focused on developing a complex coordinating structure for planning and implementing CERP projects. However, while the management structures were being refined, all 10 of the CERP components that were scheduled for completion by 2005 were delayed. Additionally, six pilot projects originally scheduled for completion by 2004 are expected to be delayed on average by 8 years. The project implementation delays seem to be the result of a number of factors, including budgetary and manpower restrictions, the need to negotiate resolutions to major concerns or agency disagreements in the planning process, and a project planning process that can be stalled by unresolved scientific uncertainties, especially for complex or contentious projects. The observed project delays are of concern because they have affected projects on which substantial benefits to the natural ecosystem depend.

The Decomp project has been significantly delayed, although recent plans to implement an active adaptive management approach may move the project forward. Progress in implementing Decomp has been slowed by conflicts among stakeholders and inherent constraints in project planning in the face of scientific uncertainties. The committee is also concerned that project planning procedures may favor project alternatives that are limited in scope over project designs with less certain outcomes that have the potential to offer greater restoration benefits. Both the Decomp Physical Model and the Loxahatchee Impoundment Landscape Assessment experiments should help resolve some of the uncertainties that are constraining the project planning process. These are impressive adaptive management activities that should improve the likelihood of restoration success. Progress could be enhanced further if these experiments pave the way for additional experiments, some at even larger scales, that could be incorporated into an incremental approach to restoration.

Production of natural system restoration benefits within the Water Conservation Areas and Everglades National Park is lagging behind production of natural system restoration benefits in other portions of the South Florida ecosystem. The eight Acceler8 projects should provide ecological benefits primarily to the Lake Okeechobee region, the northern estuaries, the Ten Thousand Islands National Wildlife Refuge, and Biscayne Bay. Expected restoration benefits to the WCAs and Everglades National Park largely come from one project—the WCA 3A/B Seepage Management. The Acceler8 program may also provide momentum to the remaining restoration projects by hastening early construction efforts. Because determinations to allocate the water captured by the Acceler8 storage projects have not yet been finalized, future projections of benefits to the South Florida ecosystem remain unclear.

Federal funding will need to be significantly increased if the original CERP commitments are to be met on schedule. Inflation, project scope changes, and program coordination expenses have increased the original cost estimate of the CERP from $8.2 billion (in 1999 dollars) to $10.9 billion (in 2004 dollars). Further delays will add to this increase, particularly because of the escalating cost of real estate in South Florida. Despite these cost increases, current planned federal expenditures for fiscal year (FY) 2005 to FY 2009 fall far short of even those envisioned in the original CERP implementation plan. Although the CERP is intended to be a 50/50 cost-sharing arrangement between the federal and nonfederal (state and local) governments, federal expenditures from 2005 to 2009 are expected to be only 21 percent of the total. If federal funding for the CERP does not increase, major restoration projects directed toward the federal government's primary interests (e.g., Everglades National Park) may not be completed in a timely way.

The active land acquisition efforts should be continued, accompanied by monitoring and regular reporting on land conversion patterns in the South Florida ecosystem. Land management for a successful CERP depends on acquiring particular sites within the project area and protecting more general areas within the South Florida ecosystem that could help meet the broad restoration goals. The committee commends the state of Florida for its aggressive and effective financial support for acquiring important parcels. Rapidly rising land costs imply that land within the project area should be acquired as soon as possible. Given the importance of wetland development and land-use conversion to the restoration potential of the CERP, the state should closely monitor and regularly report land conversion patterns within the South Florida ecosystem to stakeholders.

A significant challenge for the CERP is to implement the plan in a timely fashion while maintaining the federal and state partnership and the coalition of CERP stakeholders. The restoration of the Everglades rests on a fragile coalition of 66 signatory partners who agree in principle on the overarching goals of the CERP. Beyond the venerable notion of "getting the water right," virtually every signatory may find some part of the CERP with which to disagree and may have different views on the trade-offs that will need to be made as plan implementation begins. One particular concern expressed by stakeholders is whether the water supply goals of the CERP are being unduly emphasized in the current CERP implementation plan at the expense of the natural system restoration goals. Of the many partnerships, the most important is that between the state of Florida and the USACE. The state's Acceler8 initiative has raised concerns about disproportionate funding and control by the state over the implementation of the program. In the end, success will require cooperation among a disparate group of organizations with differing missions as the broad goal of getting the water right is more precisely defined.

AN ALTERNATIVE APPROACH TO ADVANCING NATURAL SYSTEM RESTORATION

To help address some sources of delay in the pace of restoration progress, including resolving conflicts over scientific uncertainty and addressing project sequencing constraints, the committee proposes an alternative framework for initiating and evaluating restoration actions, here called Incremental Adaptive Restoration (IAR).

To accelerate restoration of the natural system and overcome current constraints on restoration progress, many future investments in the South Florida ecosystem could profitably use an IAR approach. An IAR approach makes investments in restoration that are significant enough to secure environmental benefits while also resolving important scientific uncertainties about how the natural system will respond to management interventions. An IAR approach is not simply a reshuffling of priorities in the project implementation schedule. Instead it reflects an incremental approach using steps that are large enough to provide some restoration benefits and address critical scientific uncertainties, but generally smaller than the CERP projects or project components themselves, since the purpose of the IAR is to take actions that promote learning and that can guide the remainder of the project design. The improved understanding that results from an IAR approach will provide the foundation for more rapidly advancing restoration benefits. Without appropriate application of an IAR approach, valuable opportunities for learning would be lost, and subsequent actions would likely achieve fewer or smaller environmental benefits than they would if they had built upon previous knowledge. IAR is likely to be of particular value in devising management strategies for dealing with complex ecosystem restoration projects for which probable ecosystem responses are poorly known and, hence, difficult to predict (e.g., the role of flows in establishing and maintaining tree islands and ridge-and-slough vegetation). An IAR approach would also help address current constraints on restoration progress, including Savings Clause requirements (assurance that existing water supply and flood-control obligations will be met during CERP implementation; see Box 2-1), water reservation obligations, water quality considerations, and stakeholder disagreements.

An IAR approach would support the innovative adaptive management

program now being developed for the CERP. IAR can be used in combination with a rigorous monitoring and assessment program to test hypotheses, thereby yielding valuable information that can expedite future decision making. A significant advantage of IAR over the present CERP adaptive management approach is that there may be early restoration benefits, as major restoration projects proceed incrementally in ways that enhance learning, improve efficiency of future actions, and potentially reduce long-term costs.

The existing authorization and budgeting process can be modified to accommodate the IAR process. To facilitate the IAR process and better support an adaptive management approach to the restoration effort, a modified programmatic authorization process would be needed that allows for the continuing reformulation and automatic authorization of added investment increments. This budgeting authority would still require securing individual appropriations for each new investment increment. This would constitute a variant of the current CERP programmatic authorization of groups of projects, where a project implementation report is required before the final authorization of a project is secured and funding can be requested.

OVERALL EVALUATION OF PROGRESS AND CHALLENGES

No CERP projects have been completed at this writing. Nonetheless, some conclusions are reasonably clear. First, the scientific program accompanying the restoration efforts has been of high quality and comprehensive. Important issues concerning scientific understanding, scientific coordination, and the incorporation of science into program planning and management remain, but the committee judges that no significant scientific uncertainty should stand in the way of restoration progress. Second, there have been some significant restoration achievements by non-CERP activities, most notably in reducing phosphorus inputs and loads and in restoring the Kissimmee River. Although those projects are not complete and the scientific and engineering challenges have not been entirely conquered, the achievements should be cause for cautious optimism that other elements of the program can achieve positive results as well.

Natural system restoration will be best served by moving the ecosystem as quickly as possible toward biological and physical conditions that previously molded and maintained the Everglades. However, restoration progress has been uneven and beset by delays. The state of Florida's Acceler8 and Lake Okeechobee and Estuary Recovery programs are providing a valuable surge in the pace of project implementation, especially in the northern portions of the ecosystem and its estuaries, although the expected ecosystem benefits from early water storage projects remain uncertain. Other important projects, including the work to reestablish sheet flow in the WCAs and Everglades National Park, are far behind the original schedule. Some of the sources of delay, such as the expansion of the aquifer storage and recovery pilot projects to address important uncertainties, are in the best interest of overall restoration success. Other sources of delay, including budgetary restrictions and a project planning and authorization process that can be stalled by unresolved scientific uncertainties, merit additional attention from senior managers and policy makers. Escalating land and other prices affect the restoration's budget, and federal funding has also fallen behind its original commitments. If federal funding for the CERP does not increase, restoration efforts focused on Everglades National Park and other federal interests may not be completed in a timely way. To help address the project planning concerns, the committee proposes an incremental adaptive-management-based approach, termed IAR, which can help resolve scientific uncertainties while enabling progress toward restoration goals. Finally, perhaps the largest challenge is maintaining the continued support of the coalition of stakeholders through the restoration process.

6

An Alternative Approach to Advancing Natural System Restoration

As stated in Chapter 2, the restoration of the Everglades will be best served by moving the ecosystem as quickly as possible toward biological and physical conditions that previously molded and maintained the ecosystem. However, as discussed in Chapters 3 and 5, restoration progress has been uneven and beset by delays. The state of Florida's Acceler8 and Lake Okeechobee and Estuary Recovery programs are providing a valuable surge in the pace of project implementation, especially in the northern portions of the ecosystem and its estuaries. However, other important projects, such as the work to reestablish sheet flow in the Water Conservation Areas (WCAs) and Everglades National Park (WCA 3 Decompartmentalization and Sheet Flow—Part 1 or Decomp), are far behind the original schedule. Some of the sources of delay, such as the expansion of the aquifer storage and recovery pilot projects to address important uncertainties and the need to address extensive review comments in project planning, are in the best interest of overall restoration success. Other sources of delay, including budgetary restrictions and a project planning and authorization process that can be stalled by unresolved scientific uncertainties, need attention from senior managers and policy makers.

The committee is specifically charged to discuss and evaluate scientific and engineering issues that may affect progress in achieving the natural system restoration goals of the Comprehensive Everglades Restoration Plan (CERP; see Box S-1). Its review of progress led the committee to identify two broad scientific and engineering issues that seem likely to affect the pace of restoration progress: (1) the difficulty in accommodating major scientific uncertainties in the project planning process, especially for complex and contentious ecosystem restoration projects, and (2) the sequential authorization and implementation of CERP projects.

As discussed in Chapter 5, uncertainties regarding projected restoration outcomes have, so far, prevented Decomp project managers from resolving disagreements about the alternative project designs. Although a bold plan has recently been initiated to address this problem in Decomp through an active adaptive management approach, Decomp planners face many challenges ahead to resolve these disputes, and the issue of uncertainty has the potential to delay other restoration projects as well.

In the CERP approach to restoration implementation, projects are authorized and implemented sequentially. The Yellow Book (USACE and SFWMD, 1999) expresses the issue as follows:

> The large scale hydrologic improvements that will be necessary to stimulate large scale ecological improvements will only come once the features of the Comprehensive Plan which substantially increase water storage capacities of the regional system and the infrastructure needed to move this water, are in place. To the extent that certain features of the Comprehensive Plan must be in place before additional storage and distribution components can be constructed and operated, some of the major ecological improvements anticipated by the Plan will not occur in the short term. . . . The features of the Comprehensive Plan currently proposed to be fully implemented by 2010 include the components (e.g. seepage control, land acquisition, reservoir construction, development of water preserve areas) that must be in place to set the stage for the addition of substantial amounts of clear water into the natural system. For example, in order to bring water from the urban east coast into the natural system and avoid additional water quality problems, the features required to clean that water must be in place. In order to decompartmentalize the interior Everglades and avoid additional over-drainage problems in Lake Okeechobee and the northern Everglades, the features required to substantially increase the regional storage capacity must be in place (USACE and SFWMD, 1999).

The conclusion that decompartmentalization and sheet-flow restoration cannot be initiated until most CERP projects have been completed is an important reason why environmental benefits to the Everglades ecosystem are likely to materialize slowly. Although early Acceler8 efforts have the potential to produce substantial benefits to Lake Okeechobee and the estuaries, the Yellow Book's philosophy for CERP project sequencing suggests that several supporting projects will need to be in place before subsequent restoration efforts in the central and southern Everglades can proceed. If the public and its elected representatives in Congress and the administration are to continue to be willing to provide financial support for projects in the Everglades, they must believe that CERP expenditures are contributing to the restoration of the central and southern parts of the Everglades ecosystem, which include such iconic areas as Everglades National Park.

The committee concludes that some currently delayed restoration activities for the Everglades ecosystem can be initiated now, even though the ultimate scale, scope, and configuration of the restoration actions cannot be entirely known. Important incremental restoration gains can, therefore, be achieved concurrently with completion of other restoration activities. In this chapter the committee presents an alternative framework for initiating and evaluating restoration actions, here called Incremental Adaptive Restoration (IAR), which is proposed to help address these two sources of delay.

INCREMENTAL ADAPTIVE RESTORATION

By making incremental restoration investments, CERP managers can help accelerate restoration by facilitating decision making in spite of uncertainty and by reducing some project sequencing constraints. The initial incremental restoration actions under IAR are designed to secure environmental gains, but, equally important, they are also designed to generate improved understanding that will provide the foundation for more rapidly moving forward with restoration. IAR differs from current procedures by making greater use of active adaptive management and by more carefully targeting new investments.

Although an IAR approach is consistent with the way that active adaptive management is now being advanced for the CERP (see Chapters 4 and 5), conceiving and implementing IAR differs in important ways from the Master Implementation Sequencing Plan (MISP). The current MISP investment schedule is a construction sequence of the specific projects that were formulated in broad terms and included in the Yellow Book (USACE and SFWMD, 1999). An IAR approach is not simply a reshuffling of priorities in the MISP. Instead, it reflects an incremental approach using steps that are large enough to provide some restoration and address critical scientific uncertainties, but the IAR steps would, in some cases, be smaller than the CERP projects or project components themselves, since the purpose of IAR is to take actions that promote learning that can guide the remainder of the project design. An IAR framework would enhance the active element in the CERP adaptive management strategy (see Chapter 4) and would allow new investment actions to be at least partially decoupled from the list of current CERP projects. IAR is not a new concept. Indeed, it is similar to the process being employed in the restoration of the Kissimmee River (see Chapter 5) and the process attempted in the Experimental Water Deliveries project (see Chapter 2). However, an IAR approach differs enough from current CERP procedures that implementing it would require modified approaches for project authorization and funding.

Incremental investments may yield surprising short-term restoration benefits and are likely to generate knowledge that can guide future decision making. Incremental restoration investments in Decomp, for example, may be possible without fully developing the prospective water storage. It may also be feasible to advance the seepage management program incrementally, but concurrently, with increases in sheet flows. More specifically, initiating some additional water delivery and sheet-flow restoration as soon as possible, accompanied by carefully targeted and well-designed monitoring, will enhance scientific understanding of the effects of the interventions. Although an IAR approach may lead to increased up-front project planning costs, the enhanced scientific understanding generated should improve the likelihood of restoration success, thereby reducing costs over the long term. Although this committee does not presume that IAR will solve all sources of delay in the progress of natural system restoration, it encourages the IAR approach to help accelerate restoration progress and overcome the technical, budgetary, and political difficulties that now accompany restoration planning.

CHARACTERIZING THE BENEFITS OF IAR

In the following section, potential ecosystem responses to incremental restoration investments are discussed to support the rationale for an IAR approach. As discussed in Chapter 2, restoration depends on "getting the water right," because the amount, quality, timing, and flow of water delivered to the natural system are major determinants of its characteristics. For this conceptual discussion, hydrologic improvements include all attributes of getting the water right (i.e., the quality, quantity, timing, spatial distribution, and flow characteristics [e.g., velocity, depth]). The framework described here is based on two reasonable assumptions: (1) incremental hydrologic improvements resulting from restoration investments are likely to result in substantial benefits to ecosystem recovery and restoration and (2) IAR will yield benefits in the form of learning that will reduce the scientific uncertainties that make it difficult to design the scale, geographic scope, and operation of restoration actions. Thus, the knowledge generated by targeted investments and their operations should lead to reduced time to formulate and implement future investments and ensure their cost effectiveness.

According to the Yellow Book, "the recovery of healthy ecosystems is most likely to occur in one of three ways." Figure 6-1 shows the three response curves presented in the Yellow Book (A, B, and C) plus two additional curves added by the committee (D and E). Curve A represents the

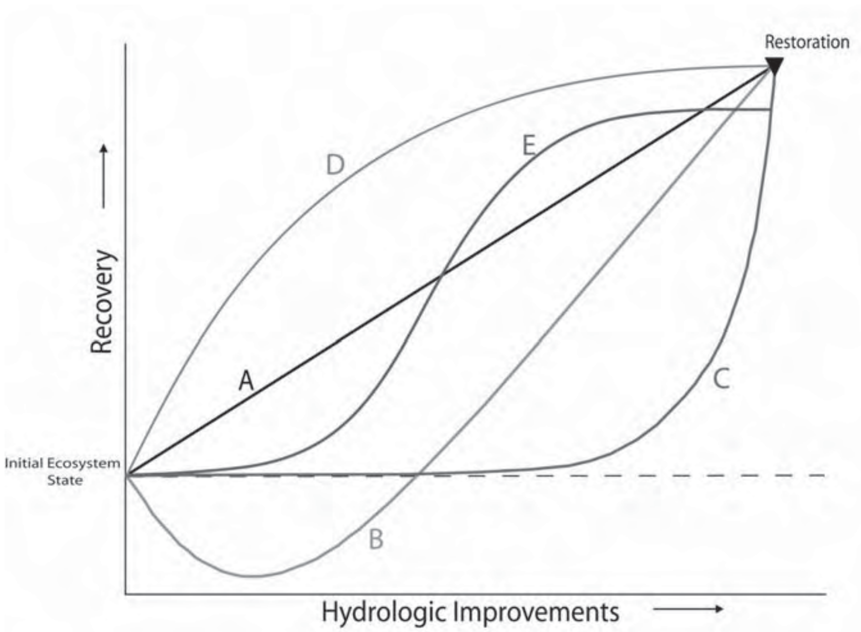

FIGURE 6-1 Five hypothetical response curves that illustrate how partial or full recovery might be achieved in a natural ecosystem from incremental hydrologic improvements. The y-axis is scaled to some maximum performance measure associated with the desired end state, or "restoration." The x-axis reflects one or more drivers of change resulting from restoration actions. For the purposes of the CERP, most of the restoration actions are intended to effect hydrologic improvements (e.g., quality, quantity, timing, distribution, flow). Incremental recoveries of the ecosystem in response to the partial hydrologic improvements occur over time; thus, time is an implicit component of this figure. These example response curves represent a subset of possible responses and could apply to a range of spatial scales.

SOURCE: Adapted from USACE and SFWMD (1999).

case in which recovery has a linear relationship with hydrologic improvements. Curve B represents the case in which changes in hydrologic improvements cause an initial negative response, followed by recovery. A possible example of curve B noted in the Yellow Book might occur after small increases in flows to the estuaries below Shark River Slough that may initially cause reduced densities of the large-sized fishes favored by foraging wood storks. However, higher flows maintained over longer periods should eventually lead to increased numbers of prey fish above current levels (USACE and SFWMD, 1999). These initial adverse environmental effects are part of the cost of ultimately securing restoration benefits. They do not constitute a basis for rejecting actions likely to facilitate long-term restoration. Another committee reached this same conclusion when considering effects of restoration on populations of endangered birds in the Everglades watershed (SEI, 2003).

Curve C in Figure 6-1 represents the case in which ecological responses do not occur until a threshold level of hydrologic improvements has been implemented. According to the Yellow Book:

> Most response patterns will resemble 'C.' It is widely believed that much of the recovery in the South Florida wetland systems will lag behind hydrologic improvements, at a wide range of mostly unknown temporal scales. Some responses may occur within months (short-term responses, e.g. shifts in periphyton species composition), some may require one to several years (mid-term responses, e.g. recovery of fish biomass), and some may require decades (long-term responses, e.g. recovery of pre-drainage soil and plant community patterns).

Responses of wetland systems are likely to lag behind alterations of hydrologic patterns, but the committee believes, based on results of ecosystem restoration efforts elsewhere, that curve C is unduly pessimistic (see below). Curve D in Figure 6-1 provides another plausible response curve in which greater recovery occurs with smaller hydrologic improvements.

Experience with restoring a variety of ecological systems indicates that responses of complex systems to management interventions often take a sigmoid form in which small investments yield little benefit, but that once a threshold is reached, benefits accrue rapidly with incremental investments (Figure 6-1, curve E). The primary reason for sigmoid responses is that improvements in one component of a system often stimulate rapid responses in other components. Once the major restoration benefits have been realized, however, the marginal value of additional investments is typically small. This is a special case of the well-known "law" of diminishing marginal returns, originally postulated by Anne Robert Jacques Turgot (1844). Curve E also differs from the ones in the Yellow Book (curves A-C) in that complete restoration is not assumed at the end of the CERP. Thus, an IAR approach can potentially yield important benefits even if only partial restoration has been, or ultimately can be, achieved.

Whatever the precise shape of the response curves turns out to be, the committee judges it likely that there will be positive ecosystem responses to incremental hydrologic improvements. The rapid return of periphyton, fish, and wading bird populations following the partial restoration of the

Kissimmee River (see Chapter 5; SFWMD and FDEP, 2005) illustrates the substantial benefits that can accrue from incremental restoration. Empirical approaches based on an understanding of the form of system responses to incremental investments have been usefully employed for decision making in the proposed framework for remediation of contaminant source zones at hazardous waste sites (e.g., Falta et al., 2005a, 2005b; Jawitz et al., 2005). In addition, positive system responses have been noted for an incremental approach to dam removal on small streams with multiple dams (Heinz Center, 2002). A recent National Research Council (NRC) report used formal risk-analysis and decision-analysis frameworks to understand and address problems of restoring declining Atlantic salmon populations in Maine (NRC, 2004b), an approach likely to be very useful in restoring the Everglades watershed. That report, in advocating a selective and sequential approach to removing dams from some Maine salmon rivers rather than trying to remove many at one time, expressed confidence that an incremental approach would be the appropriate way to sequence actions.

An important benefit of an IAR approach is the knowledge gained about the forms of the ecosystem response functions. Although many end-state targets may be achieved only over the long term, some responses may occur quickly, and knowledge gained from these short-term responses is intrinsically valuable. Incremental restoration actions in the form of large-scale experiments that link hydrologic alterations to key performance targets can help identify the time course of the ecosystem recovery responses. With the assistance of empirical and conceptual models, these findings can be used to inform decision making with regard to future restoration actions. Even if curve C (Figure 6-1) proves to be the form of the response, the lack of response to initial investments is still important knowledge that can inform decisions as to whether to continue to pursue restoration, in what form, and on what time path. Future decisions would likely be less effective and would result in poor use of limited resources if the knowledge generated by the early actions were not available.

The curves presented in Figure 6-1 are only a small sample of the many possible response functions, some of which may be more complex. However, these example response curves illustrate the following important points:

- Because the magnitude of responses to management interventions may vary greatly, investments will yield the greatest benefits if they are targeted toward responses that are likely to yield greater restoration sooner. In this way, restoration may occur faster than would otherwise be possible.

- Complete recovery may not be possible within the CERP time frame or at all; therefore, experimentation could inform decision makers about how much recovery might be achievable. The maximum recovery may be less than the desired predisturbance end state, but how much less depends on the resilience of the ecosystem, including the behavior of the ecosystem processes that govern recovery and, importantly, political decisions on investment priorities. If the response function has a sigmoid shape, continuing to invest when a plateau in recovery has been reached is certain to yield little restoration, despite considerable investment, and to generate considerable frustration.
- A threshold minimum investment may be required before any ecosystem recovery is achieved. The position of such thresholds has major implications for the nature and extent of management interventions that may be needed to achieve restoration goals.
- In some ecosystems, hydrologic improvements may, in the early stages, lead to declines in some valued attributes of the ecosystem. However, that is not a reason to abandon restoration efforts if existing information suggests that continued improvements would eventually yield progress toward the desired end state.

Experiments designed to determine the shape of the response curve or where recovery thresholds lie could be vital components of restoration actions. For example, the IAR conceptual framework could help scientists and managers estimate the achievable recovery of the natural ecosystem under current constraints and as new conditions develop in the future. The maximum achievable restoration cannot be known in advance, but it can be assessed progressively by initiating actions designed to resolve the most important uncertainties surrounding the responses of the system to management interventions, and the learning benefits from IAR actions are likely to be more than sufficient to justify the early investments.

APPLYING THE IAR FRAMEWORK

The goal of IAR is to create progress in natural system restoration while improving the understanding of the form of the responses of various ecosystem components to incremental changes in some drivers (e.g., Figure 6-1), thereby informing future restoration planning and decision making. IAR begins with articulation of one or more hypotheses about the response of performance measures (y-axis in Figure 6-1) to changes in a driver (x-axis in Figure 6-1). For example, hypotheses might be developed about the response of the ridge-and-slough landscape to increases in incremental flows (see Box 6-1) or the development and extent of tree islands to changed hydrologic patterns. (For instance, is there a maximum level of water above which tree islands deteriorate? Are tree islands adversely affected by hydrological patterns that deviate strongly from natural ones?) Or IAR could be used to address questions about the areal extent and condition of habitats needed for the survival of threatened and endangered species. (For example, does the long-term survival of the Cape Sable Seaside Sparrow depend on a certain minimum extent of suitable breeding habitat?)

IAR requires a clear science plan that serves the information needs for investment decision making; that is, IAR should focus on *decision-critical uncertainties*—uncertainties that currently prevent identification of appropriate management interventions. Such a plan should identify testable hypotheses (see Box 6-1 for additional examples) and include initial agreement on performance measures deemed likely to show a response during the time frame of the incremental restoration action. Restoration scientists have identified numerous hypotheses that address uncertainties about how the CERP will affect the natural system, and the Restoration Coordination and Verification (RECOVER) program intends to address these hypotheses through the Monitoring and Assessment Plan. However, decision-critical uncertainties need to be resolved to make sound restoration planning decisions, even considering the adaptive management framework in which the CERP operates. Decision-critical uncertainties have delayed progress in restoration planning with Decomp (see Chapter 5), but IAR offers a framework to move forward with restoration while addressing these uncertainties (see Box 6-1). Using IAR based on active adaptive management, hypotheses can be tested through actions of sufficient scale and geographic scope to gain appropriate new knowledge and to secure near-term restoration benefits. As new knowledge is gained through IAR, decision-support hypotheses and associated models can be refined and revised over time.

To illustrate the use of the IAR framework, Box 6-1 describes how practitioners could develop and test hypotheses about how the ridge-and-slough system in the WCAs (a performance metric on the y-axis) might respond to increases in flows of water through them (a driver on the x-axis). Additional examples are also provided in the next section on how IAR can be applied to break through common restoration constraints.

Examples of Using IAR to Overcome Current Constraints

The preceding discussion and Box 6-1 argue that the IAR process can help overcome at least some scientific uncertainties about the response of ecological performance measures to hydrologic alteration. The presence of

BOX 6-1
Using IAR to Test Uncertainties Regarding Sheet-Flow Restoration

The deterioration of the ridge-and-slough patterns in the WCAs, where flows have been eliminated, demonstrates that restoration and maintenance of those important features of the Everglades ecosystem requires reinstituting sheet flows. However, the functional relationship between the temporal and spatial patterns of flows (e.g., velocity, depth) and both the formation and maintenance of the ridge-and-slough landscape has yet to be determined (NRC, 2003c; SCT, 2003) and cannot be assessed purely by small-scale experiments. Establishing these relationships is a high priority that can be advanced by making and learning from incremental investments at larger scales.

To inform restoration decision making, hypotheses could be developed to predict the responses of the ridge-and-slough landscape to incremental hydrologic improvements (e.g., increased flow volumes, increased flow velocities, approaches to decompartmentalization). Example hypotheses related to the sheet-flow restoration in the ridge and slough include the following:

- What are the ecological consequences from incremental increases in flows through the WCAs and into Everglades National Park?
- Does the ridge-and-slough landscape respond linearly to increases in flows or are there thresholds at which responses change dramatically?
- What are the flow characteristics at which the majority of achievable benefits will be realized?
- Are there thresholds below and above which increased water deliveries are likely to yield little or no ecological benefit?
- What are the downstream effects, at a range of scales, from the various options to remove or reduce barriers to sheet flow?

Data from the Experimental Water Deliveries Program (see Chapter 2) and early implementation of Mod Waters (see Chapter 5) might inform some of these hypotheses. Field experiments could be planned to address those uncertainties that cannot be easily resolved with today's modeling capabilities or scientific knowledge and which significantly impact the project planning process.

As discussed in Chapter 5, experimental plans have recently been developed to test the restoration impacts of various approaches to decompartmentalization in WCA 3, and the committee commends these active adaptive management initiatives. The Decomp Physical Model is a positive step forward that is in many ways consistent with the IAR approach described in this chapter. However, Chapter 5 notes some scale issues that may need to be addressed to fully answer decision-critical hypotheses.

An IAR approach to these uncertainties would involve implementing portions of the Decomp project at scales large enough to address the decision-critical uncertainties but small enough so that actions to mitigate flood-control and water supply concerns could also be addressed with incremental investments. These incremental restoration actions would need to be made in a manner that would contribute toward the ultimate restoration goals while also preserving flexibility for later project design changes. Such incremental actions could provide important information that should improve future project designs and promote more cost-effective decisions. IAR offers a way to move forward immediately, in the face of uncertainty, while creating near-term restoration benefits.

those uncertainties is one constraint that has impeded restoration progress. However, other constraints to moving forward also are affecting the progress of natural system restoration. In this section, four of these key constraints are described along with ways that the IAR process can address them.

Protecting Urban Areas from Flooding: Meeting the Savings Clause

The Savings Clause in the Water Resources Development Act of 2000 mandates that existing levels of flood protection not be reduced through CERP implementation. The higher water levels in some locations necessary for the Everglades ecosystem restoration are likely to generate increased subsurface seepage, and therefore higher risks of flooding in nearby urban and agricultural areas, but the form of the response curve is not known. Before decompartmentalization projects, accompanied by yet-to-be-determined higher water levels, can be fully implemented, better understanding and control of seepage will be needed.

The relative risks of allowing higher water levels in parts of the Everglades ecosystem and the full range of alternatives for reducing the associated flooding risks can be assessed using the best available models designed at appropriate scales. The models could translate data on water levels in a network of monitoring wells into an understanding of the changes in flood risks, measured by frequency and stage-damage relationships, that might result from different restoration flow volumes and distributions. Such analysis would be essential to inform operations of the water distribution network and to the design of multiple ways to manage seepage along the eastern boundary of the Everglades ecosystem.

Options for seepage control (e.g., constructing seepage barriers) as developed in the Yellow Book can then be refined and possible new options identified and evaluated, both to assess the economic and social risk of flooding and to assess the potential for retaining the valuable water within the natural system. Using an IAR approach, seepage management could be implemented incrementally to inform and improve the ultimate project designs while enabling some concurrent increases in flows associated with an incremental approach to decompartmentalization.

Balancing Water Quantity and Quality for Restoration

The quality criteria for water discharged into the Everglades ecosystem may limit the amount of water from the Kissimmee River basin, Lake Okeechobee, and the Everglades Agricultural Area that can be released to flow southward through the Everglades ecosystem. An adaptive management approach used to develop and refine the design and operation of stormwater treatment areas (STAs), for example, changing the operations from a "single-pass" flow to a "multi-pass" system, has achieved considerable success in reducing phosphorus concentrations in the water discharged into the natural system (Chapter 5). About 41,000 acres of STAs have been constructed to date and, over the 10-year period of their operation, total phosphorus load has been reduced by nearly 600 metric tons. This is relative to an estimated total phosphorus loading (mass inflow rate) of about 2,260 metric tons during the same time period (Table 5-2).

Research to improve the performance of STAs needs to be continued, as new investments in water quality improvement are made. During this time, however, sheet-flow restoration could be initiated while efforts to achieve better phosphorus control in the STAs continue. More wetlands to absorb phosphorus could be created in the Everglades Agricultural Area. In the short term, the northern edges of the WCAs could be used to absorb phosphorus. Rather than delaying initiation of sheet flows until total phosphorus concentrations of 10 parts per billion (ppb) have been achieved by the STAs, or by other means yet to be employed, some parts of the WCAs could temporarily receive water with somewhat higher phosphorus concentrations to allow restoration of flows and the associated substantial benefits that might be realized elsewhere in the Everglades ecosystem. Recognition that this action would expand the range of cattails, alter periphyton communities, increase soil phosphorus, and make these areas exceedingly difficult to restore once phosphorus loading is stopped demands a detailed evaluation of the trade-offs between water quality in the affected portions of the ecosystem and increased water flow in other areas of the ecosystem.

Detailed evaluations would be necessary to determine the probable relationship between water inflows having, say, concentrations of 12, 15, or 20 ppb of total phosphorus, on the extent of the area of the WCAs likely to be affected. Expected "cattail expansion costs" and other ecological costs could then be compared to the "benefits" derived from incremental flows of water through the Everglades ecosystem. The eventual assessment might, of course, be that the trade-off is unfavorable, but until the trade-off function is established, there is no way to know. Most important, a decision to initiate restoration of the Everglades ecosystem with water that exceeds 10 ppb total phosphorus is not a decision to stop seeking water quality improvements. The IAR approach requires a commitment (organizational, legal, and financial) to continually improve water quality inputs, as well as a commitment to build on knowledge gained from the initial incremental perturbations.

Water Reservation

Getting the water right requires storage to reduce the need to discharge water to estuaries during times of high water and to maintain sufficient flows during times of low water. Therefore, increasing water storage is a vital component of restoration, and significant increases in aboveground storage are planned in the band 1 (2005-2010) CERP construction projects (see Chapter 3). As argued above, managers do not need to wait until all planned storage is available before initiating natural system restoration. Unfortunately, the allocation of stored water to different purposes remains unclear, in part because modeling to quantify the benefits of these projects has not been completed. No currently stored or future-stored water is yet legally designated for delivery to the natural system through water reservations.

If an IAR approach is to work, there needs to be an incremental process for water reservations to support it. However, the logic of an IAR program also can support a water reservation process. As new water storage components come online, that water can be formally reserved to multiple uses, including natural system restoration. As additional projects are added, the new water can be allocated in relation to the water reservation already in place, subject to the constraint that the overall water reservation to each use would not be reduced as new water comes online. Optimization of the operations of the system of projects in place at any time might result in alteration of the allocation to any given project. At the end of the CERP program, the reservations to uses would match those called for in the Yellow Book, unless future policy decisions change that allocation. Currently a lack of formal designation for use of stored water fosters disputes over how water will be allocated at the end of the CERP and stands in the way of incremental restoration progress.

Managing Competing Interests

Not all groups favor maintaining or expanding the amount of existing wetlands or fully restoring sheet flows. Some landowners are likely to profit from conversions of agricultural or other lands to industrial or urban uses. Some recreational users of the Everglades watershed believe that their interests would be impaired by removal of levees and filling of canals. For example, some bass fishermen want to preserve the canals, which provide some of the best bass-fishing areas (see Chapter 3 for further discussion).

An IAR approach could help facilitate dealing with these competing views of preferred future states of the South Florida ecosystem. At least some of the opposition to current Decomp project plans is based on the presumption that decompartmentalization will be inevitable and will proceed exactly as described in the Yellow Book. An IAR approach might help address these concerns, because the losses of recreational uses could be carefully weighed against the anticipated ecosystem restoration benefits. If fears about loss of valued uses prove well founded, then mitigation actions might be identified and taken. In the extreme, the restoration process might be halted short of some technically attainable level if the costs to these other interests were deemed significant. Even if that happens, progress on some socially acceptable levels of restoration will have been secured. IAR, however, should not be equated with scaling back CERP goals. The results of IAR experiments may show that compromises in project designs lead to unacceptable restoration effects and may also suggest project design changes that could create greater restoration benefits. Ultimately, IAR provides scientific information to help resolve conflicts among competing interests and make informed project planning decisions.

AUTHORIZATION AND BUDGETING TO SUPPORT AN IAR APPROACH

The planning and budgeting requirements for IAR are the same ones that accompany any robust and ongoing adaptive management program. Accelerating progress in restoring the South Florida ecosystem through an IAR approach would, therefore, need to be accompanied by an authorization and budgeting process designed to facilitate incremental improvements and learning while doing, recognizing that elements of major projects would need to be formalized separately and funded as increments. The IAR approach would also need to be supported by a commitment to follow up each increment of investments and operation with an analysis of the results and a commitment to design, fund, and carry out the next increment in accordance with those results.

Based on the committee's understanding, such a process can be accommodated by current budgeting procedures, but some adjustments will be needed. The current authorization and budgeting process assumes that the planners will propose and then build the "best possible" project and then fine-tune project operations through adaptive management (NRC, 2004a). The purposes to be served by the project and the water dedicated to those purposes are defined at authorization and are not subject to adjustment except by a new authority. Thus, under current procedures and unless project changes are seriously entertained as a result of the periodic interim CERP updates, adaptive management becomes fine-tuning the performance and operations of each new project in the context of the existing projects in the system, after the complete project has been built. For this reason, the budget available for adaptive management is limited to a fixed proportion of the project construction costs.

This conception of the purpose and meaning of adaptive management differs from the logic described here under the IAR framework. There is no federal budget category of activity for the large-scale experiments that are part of the rationale for IAR. Indeed, it is not clear what authority exists to propose and secure funding for actions that will have unpredictable outcomes and that need to be monitored to assess what additional action is warranted.

The current authorization and appropriations process requires that proposals demonstrate the need for funds according to justification criteria that presuppose an analytical and scientific certainty about the investment results. In contrast, the IAR process recognizes that an important rationale and justification for such incremental funding is to reduce uncertainty. The promise of knowledge is a new benefit category that is on a par with restoration outcomes in justifying an investment under IAR. A related benefit category in the IAR framework is the flexibility to adjust to new knowledge. These benefits of added flexibility and knowledge would need to be acknowledged in the authorization process to support IAR because costs may be incurred to secure them.

An IAR approach also requires planners to keep the ultimate restoration goals firmly in mind so that the investments made at each stage do not foreclose future options. Within IAR, actions could be taken to preserve future flexibility, even if such flexibility comes at a higher cost. As a hypothetical example, if a bridge is proposed to be built as a part of a two-lane highway, and there is some good chance—but not a certainty—that the road will be expanded to four lanes in the future, a small added investment to construct bridge abutments that would accommodate four lanes may be justified to facilitate future expansion. Similarly, using an IAR approach, the construction of the new bridges on Tamiami Trail could be executed so that the road could accommodate the possibility to broaden the zone over which it might eventually be bridged. Any added costs for such construction could be justified by the value of maintaining future flexibility.

The IAR process requires a commitment to continually make new investments in restoration until there is compelling evidence that the cost of the next added investment is no longer warranted by the benefits received. For this commitment to have credibility, there needs to be a programmatic authorization that allows for the continuing reformulation and automatic authorization of next added investment increments, subject to an overall budget cap set by the Congress. This authority would still require securing individual appropriations for each new investment increment. This is in effect a variant of the CERP programmatic authorization of groups of projects where a project implementation report is required before the final authorization of a project is secured and funding can be requested.

To support project authorization and appropriations under an IAR framework, a project implementation report could be developed for the most ambitious scale of restoration action (the far right of the y-axis in Figure 6-1). However, the report would also identify a set of separable increments that could be funded, implemented, and evaluated, using metrics that include the new benefit and cost categories described above, as well as the performance outcomes that are predicted for each increment. The report would be the basis for the authorization of a number of separable elements that are expected to comprise the scope of the whole set of separable projects, but funds would be requested for each increment. Of course, the plan would be revised as new information is secured and evaluated. Significantly, and different from current approaches to funding adaptive management, funds would be requested, authorized, and appropriated not only for the construction and operations, but also for the monitoring and assessment program that is expected to yield both the knowledge benefits and the translation of the knowledge gained into support for model improvements for future decision making.

CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the committee has argued that the restoration of the South Florida ecosystem could be advanced if both an alternative adaptive management framework and a modified funding system were developed and implemented. Experience with restoration projects elsewhere strongly suggests that carefully targeted incremental actions within an active adaptive management framework, supported by appropriate administrative and funding structures, are likely to provide a way to overcome the technical, budgetary, and political difficulties that currently are delaying some restoration efforts in the Everglades.

To accelerate restoration of the natural system and break through current constraints on restoration progress, many future investments in restoration in the South Florida ecosystem could profitably employ an incremental adaptive restoration approach. An IAR approach makes investments in restoration that are significant enough to secure environmental benefits while also resolving important scientific uncertainties about how the natural system will respond to management interventions. An IAR approach is not simply a reshuffling of priorities in the MISP. Instead, it reflects an incremental approach using steps that are large enough to provide some restoration and address critical scientific uncertainties but generally smaller than the CERP projects or project components themselves, since the purpose of IAR is to take actions that promote learning that can guide the remainder of the project design. The improved understanding that results from an IAR approach will provide the foundation for more rapidly moving forward with restoration. Without appropriate application of an IAR approach, valuable opportunities for learning would be lost, and subsequent actions would be likely to achieve fewer or smaller environmental benefits than they would if they had built upon previous knowledge. IAR is likely to be of particular value in devising management strategies for dealing with complex ecosystem restoration projects for which probable ecosystem responses are poorly known and, hence, difficult to predict (e.g., the role of flows, including extreme events, in establishing and maintaining tree islands and ridge-and-slough vegetation). An IAR approach would also help address current constraints on restoration progress, including Savings Clause requirements, water reservation obligations, water quality considerations, and stakeholder disagreements.

An IAR approach would support the innovative adaptive management program now being developed for the CERP. IAR can be used in combination with a rigorous monitoring and assessment program to test hypotheses, thereby yielding valuable information that can expedite future decision making. A significant advantage of IAR over the present CERP adaptive management approach is that there may be early restoration benefits, as major restoration projects proceed incrementally in ways that enhance learning, improve efficiency of future actions, and potentially reduce long-term costs.

The existing authorization and budgeting process can be modified to accommodate the IAR process. To facilitate the IAR process and better support an adaptive management approach to the restoration effort, a modified programmatic authorization process would be needed that allows for the continuing reformulation and automatic authorization of subsequent next-added investment increments, subject to an overall budget cap set by Congress. This budgeting authority would still require securing individual appropriations for each new investment increment. This would constitute a variant of the current CERP programmatic authorization of groups of projects, where a project implementation report is required before the final authorization of a project is secured and funding can be requested.

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Acronyms

AFB	alternative formulation briefing
AHF	Airborne Height Finder
AM	adaptive management
ASA	Assistant Secretary of the Army
ASPRS	American Society of Photogrammetry and Remote Sensing
ASR	aquifer storage and recovery
ATLSS	Across Trophic Level System Simulation
BEST	Board on Environmental Studies and Toxicology
BMP	best management practice
C	canal
CAR	Coordination Act Report
CEM	conceptual ecological model
CERP	Comprehensive Everglades Restoration Plan
CESI	Critical Ecosystem Studies Initiative
CFR	Code of Federal Regulations
CISRERP	Committee on Independent Scientific Review of Everglades Restoration Progress
CROGEE	Committee on the Restoration of the Greater Everglades Ecosystem
C&SF	Central and Southern Florida
CSOP	Combined Structural and Operational Plan
CW	Civil Works
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DE	district engineer

DEM	Digital Elevation Model
DEP	Department of Environmental Protection
DMSTA	Dynamic Model for Storm Water Treatment Area
DOI	U.S. Department of the Interior
DQO	data quality objective
EAA	Everglades Agricultural Area
ECP	Everglades Construction Project
EDEN	Everglades Depth Estimation Network
ELM	Everglades Landscape Model
ENP	Everglades National Park
FAU	Florida Atlantic University
FBAMS	Florida Bay and Adjacent Marine Ecosystems Science
FDEP	Florida Department of Environmental Protection
FGCU	Florida Gulf Coast University
FIATT	Florida Invasive Animals Task Team
FIU	Florida International University
FSM	feasibility scoping meeting
FWC	Florida Fish and Wildlife Conservation Commission
FY	fiscal year
GAO	Government Accountability Office
GIS	geographic information system
HAED	high-accuracy elevation data
HMDT	high-resolution multi-data source topography
HSI	Habitat Suitability Index
IAR	Incremental Adaptive Restoration
IOP	Interim Operational Plan
IPR	in-progress review
IRL	Indian River Lagoon
IRL-S	Indian River Lagoon-South
ISOP	Interim Structural and Operational Plan
kg	kilogram
L	levee
LiDAR	Light Detection and Ranging

LILA	Loxahatchee Impoundment Landscape Assessment
LOER	Lake Okeechobee and Estuary Recovery
MAP	Monitoring and Assessment Plan
MCACES	Micro-Computer Aided Cost Engineering System
mg	milligrams
MISP	Master Implementation Sequencing Plan
MOU	Memorandum of Understanding
MT	metric ton
NEPA	National Environmental Policy Act
NESS	Northeastern Shark River Slough
NEWTT	Noxious and Exotic Weed Task Team
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	National Research Council
NSM	Natural Systems Model
NSRSM	Natural System Regional Simulation Model
NWR	National Wildlife Refuge
OMB	Office of Management and Budget
P	phosphorus
PAH	polycyclic aromatic hydrocarbon
PAL	planning aid letter
PBA	Palm Beach Aggregates
PCB	polychlorinated biphenyl
PDT	Project Delivery Team
PI	principal investigator
PIR	project implementation report
P.L.	Public Law
PM	performance measure
PMP	project management plan
ppb	parts per billion
ppm	parts per million
PSTA	periphyton stormwater treatment area
QASR	Quality Assurance Systems Requirement
RECOVER	Restoration Coordination and Verification

REMER	Regional Engineering Model for Ecosystem Restoration
ROD	Record of Decision
S	structure
SAV	submerged aquatic vegetation
SCCF	Sanibel-Captiva Conservation Foundation
SCG	Science Coordination Group
SCT	Science Coordination Team
SEI	Sustainable Ecosystems Institute
SESI	Spatially Explicit Species Index
SFERTF	South Florida Ecosystem Restoration Task Force
SFRSM	South Florida Regional Simulation Model
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SHOALS	Scanning Hydrographic Operational Airborne LiDAR Survey
SICS	Southern Inland and Coastal Systems
SMA	square mile area
SPOT	System-wide Planning and Operations Team
SRS	Shark River Slough
SSG	Science Subgroup
STA	stormwater treatment area
TIME	Tides and Inflows in the Mangrove Ecotone
TP	total phosphorus
TS	Taylor Slough
UF	University of Florida
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAM	Watershed Assessment Model
WCA	Water Conservation Area
WMA	Wildlife Management Area
WPA	Water Preservation Area
WRDA	Water Resources Development Act
WSS	West Shark Slough
WSTB	Water Science and Technology Board
WY	water year

Glossary

8.5-square-mile area—The 8.5-square-mile area (SMA) is a low-lying, partially developed area near the northeast corner of Everglades National Park, west of the L-31 North canal. Flood protection was to have been provided under the original 1989 Mod Waters legislation, but years of subsequent study and negotiations with property owners resulted in a compromise in which a flood protection levee is to be built around approximately two-thirds of the 8.5 SMA while providing for purchase of approximately one-third of the private property and 12 homes in the western portion.

Acceler8—An expedited course of action for achieving Everglades restoration. Through Accler8, the state of Florida intends to implement 11 components of the CERP and 3 additional non-CERP components.

Across Trophic Level System Simulation (ATLSS)—A modeling system that uses topographic data to convert the 2 × 2 mile landscape of the regional hydrological models to a 500 × 500 m landscape to which various ecological models are applied. These range from highly parameterized, mechanistic individual-based models (e.g., EVERKITE, SIMSPAR) to simpler, habitat-suitability models (Spatially-Explicit Species Index, SESI; and Habitat Suitability Index, HSI). The objectives of the ATLSS project are to utilize the outputs of systems models to drive a variety of models that attempt to compare and contrast the relative impacts of alternative hydrologic scenarios on the biotic components of South Florida.

Active adaptive management—Adaptive management is designed to generate information that can be used to improve the planning and operation of projects. Active adaptive management begins with an analysis of the most serious gaps in understanding about the system and examines or develops several plausible explanations or models of the system's response to management actions. Practitioners then design and conduct experiments to remove the maximum possible amount of uncertainty about the system response. Experimental results are used to revise the models and better predict the outcomes of management options. New experiments are designed and performed if needed. Active adaptive management is based on the assumption that early investment in knowledge generation will reduce the likelihood of making inappropriate and potentially damaging management decisions.

Adaptive management (AM)—The application of scientific information and explicit feedback mechanisms to refine and improve future management decisions.

Airborne Height Finder (AHF)—A helicopter-based instrument developed by the U.S. Geological Survey that uses global positioning system technology and a high-tech version of the surveyor's plumb bob to measure terrain surface elevation above and under water. The AHF system distinguishes itself from remote-sensing technologies in its ability to physically penetrate vegetation and murky water, providing measurement of the underlying topographic surface.

Aquifer storage and recovery (ASR)—A technology for storage of water in a suitable aquifer when excess water is available and recovery from the same aquifer when the water is needed to meet peak emergency or long-term water demands. Wells are used to pump water in and out of the aquifer.

Best management practices (BMPs)—Effective, practical methods that prevent or reduce the movement of sediment, nutrients, pesticides, and other pollutants resulting from agricultural, industrial, or other societal activities from the land to surface or groundwater or that optimize water use.

Central and Southern Florida (C&SF) Project for Flood Control and Other Purposes—A multipurpose project, first authorized by Congress in 1948 to provide flood control, water supply protection, water quality protection, and natural resource protection.

Comprehensive Everglades Restoration Plan (CERP)—The plan for the restoration of the greater Everglades ecosystem authorized by Congress in 2000.

Conceptual ecological models—Nonquantitative planning tools that identify the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the biological attributes or indicators of these ecological responses.

Critical Projects—Projects determined to be critical to the restoration of the South Florida ecosystem that were authorized in 1996 prior to the CERP. These projects are comparatively small and were undertaken by the U.S. Army Corps of Engineers and South Florida Water Management District. They are being implemented along with the CERP projects.

Decomp—Short title for Water Conservation Area 3 Decompartmentalization and Sheet Flow Enhancement—Part 1 project.

Digital Elevation Model (DEM)—DEM data are arrays of regularly spaced elevation values referenced horizontally either to a Universal Transverse Mercator projection or to a geographic coordinate system. The grid cells are spaced at regular intervals along south to north profiles that are ordered from west to east. DEMs are derived from hypsographic data (contour lines) and/or photogrammetric methods using USGS 7.5-minute, 15-minute, 2-arc-second (30- by 60-minute), and 1-degree (1:250,000-scale) topographic quadrangle maps.

Dynamic Model for Stormwater Treatment Area (DMSTA)—Model that simulates dynamics of hydrology and phosphorus, predicts changes in water quality, and is used for the design of STAs for the restoration and protection of the Everglades.

Empirical model—A simplified representation of a system or phenomenon that is based on experience or experimentation.

Estuary—The portion of the Earth's coastal zone where sea water, fresh water, land, and atmosphere interact.

Everglades—The present areas of sawgrass, marl prairie, and other wetlands south of Lake Okeechobee. Also called the Everglades ecosystem or the remnant Everglades ecosystem.

Everglades Agricultural Area (EAA)—Land in the northern Everglades south of Lake Okeechobee that was drained for agricultural use.

Everglades Construction Project—Twelve interrelated construction projects located between Lake Okeechobee and the Everglades. Six stormwater treatment areas (STAs, constructed wetlands) totaling over 44,000 acres are the cornerstone of the project. The STAs rely on physical and biological processes to reduce the level of total phosphorous entering the Everglades to an interim goal of 50 parts per billion.

Everglades Depth Estimation Network (EDEN)—A USGS surface-water hydrological monitoring network in support of the MAP that is intended to provide the hydrologic data necessary to integrate hydrologic and biological responses to the CERP during MAP performance measurement assessment and evaluation for the Greater Everglades module.

Everglades Landscape Model (ELM)—Model used to predict the landscape response to different water management scenarios. ELM consists of a set of integrated modules to understand ecosystem dynamics at a regional scale and simulates the biogeochemical processes associated with hydrology, nutrients, soil formation, and vegetation succession. Its main components include hydrology, water quality, soils, periphyton, and vegetation.

Everglades National Park Protection and Expansion Act (1989)—Federal legislation that added approximately 107,000 acres of land to Everglades National Park and authorized restoration of more natural water flows to northeast Shark River Slough through construction of the Modified Water Deliveries Project.

Everglades Protection Area—As defined in the Everglades Forever Act, the Everglades Protection Area is comprised of Water Conservation Areas 1 (also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge), 2A, 2B, 3A, 3B; and the Everglades National Park.

Everglades watershed—The drainage that encompasses the Everglades ecosystem but also includes the Kissimmee River watershed and other smaller watersheds north of Lake Okeechobee that utimately supply water to the Everglades ecosystem.

Exotic species—An introduced species not native to the place where it is found.

Extirpated species—A species that has become extinct in a given area.

Flow—The volume of water passing a given point per unit of time, including in-stream flow requirements, minimum flow, and peak flow. "Flow" is used generically within the text to mean the movement of volumes of water across the landscape and incorporates the concepts of volumetric flow rate (e.g., cubic feet per second), velocity, and direction. Volumetric flow rate may be estimated for large averaging times, such as acre-feet per year, as in the South Florida Water Management Model and the Natural Systems Model, and also on a short-term ("instantaneous") basis by other models, as discussed in Chapter 4.

Flux—The rate of transfer of fluid, particles, or energy across a given surface.

Foundation projects—Non-CERP activities.

Geographic information system (GIS)—A map-based data storage and retrieval system.

Guidance memoranda—In accordance with the programmatic regulations, six program-wide guidance memoranda have been drafted that establish additional procedures to achieve the goals and purposes of the CERP. The subjects for the guidance memoranda include project implementation reports, Savings Clause requirements, identifying water needed to achieve the benefits of the plan, operating manuals, and assessment activities for adaptive management.

Habitat Suitability Index (HSI)—Tool used to define, in relative terms, the quality of the habitat for various plant and animal species. HSIs can be used as the first approximation toward quantifying the relationships identified in various conceptual ecological models.

Hydroperiod—Annual temporal pattern of water levels.

Interim goal—A means by which the restoration success of the Plan may be evaluated throughout the implementation process.

Interim target—A means by which the success of the Plan in providing for water-related needs of the region, including water supply and flood protection, may be evaluated throughout the implementation process.

Invasive species—Species of plants or animals, both native and exotic, that aggressively invade habitats and cause multiple ecological changes.

Light Detection and Ranging (LiDAR)—A technology that employs an airborne scanning laser rangefinder to produce detailed and accurate topographic surveys.

Marl—A type of wetland soil high in clay and carbonates. Hydroperiod is a critical determinant of marl formation.

Master Implementation Sequencing Plan (MISP)—Specifies the sequence in which CERP projects are planned, designed, and constructed.

MIKE SHE/MIKE 11—A physically based, spatially distributed, finite-difference, integrated surface-water and groundwater model. It can simulate the entire land phase of the hydrologic cycle and evaluate surface-water impact from groundwater withdrawal.

MODBRANCH—A hydrologic model that combines a widely used groundwater model (MODFLOW) with a one-dimensional model for canals and structures (BRANCH).

Natural system—According to WRDA 2000, all land and water managed by the federal government or the state within the South Florida ecosystem, including water conservation areas, sovereign submerged land, Everglades National Park, Biscayne National Park, Big Cypress National Preserve, other federal or state (including a political subdivision of a state) land that is designated and managed for conservation purposes, and any tribal land that is designated and managed for conservation purposes, as approved by the tribe.

Natural System Model (NSM)—Model that simulates hydropatterns before canals, levees, dikes, and pumps were built. The NSM mimics frequency, duration, depth, and spatial extent of water inundation under pre-management (i.e., natural) hydrologic conditions. In many cases, those pre-management water levels are used as a target for hydrologic restoration assuming that restoration of the hydrologic response that existed prior to drainage of the system would lead to restoration of natural habitats and biota.

Original Everglades—The pre-drainage Everglades, or that which existed prior to the construction of drainage canals beginning in the late 1800s.

Parts per billion (ppb)—A measure of concentration equivalent to microgram of solute per liter of solution.

Parts per million (ppm)—A measure of concentration equivalent to milligram of solute per liter of solution.

Passive adaptive management—Adaptive management by which a preferred course of action is selected based on existing information and understanding. Outcomes are monitored and evaluated and subsequent decisions (e.g., adjustments in design or operations, the design of subsequent projects, etc.) are adjusted based on improved understanding.

Performance measure—A quantifiable indicator of ecosystem response to changes in environmental conditions.

Periphyton—A biological community of algae, bacteria, fungi, protists, and other microorganisms. In the Everglades, periphyton grows on top of the soil surface, attached to the stems of rooted vegetation, and in the water column or at the water surface, sometimes in association with other floating vegetation.

Programmatic Regulations—Procedural framework and specific requirements called for in section 601(h)(3) of WRDA 2000. The programmatic regulations are intended to guide implementation of the CERP and to ensure that the goals and purposes of the CERP are achieved. The final rule for the Programmatic Regulations (33 CFR §385) was issued in November 2003.

Project Delivery Team (PDT)—An interdisciplinary group that includes representatives from the implementing agencies. PDTs develop the products necessary to deliver the project.

Project Implementation Report (PIR)—A decision document that bridges the gap between the conceptual design contained in the Comprehensive Plan and the detailed design necessary to proceed to construction.

Project management plan (PMP)—A document that establishes the project's scope, schedule, costs, funding requirements, and technical performance requirements (including the various functional area's performance and quality criteria) and that will be used to produce and deliver the products that comprise the project.

RECOVER—The Restoration Coordination and Verification Program (RECOVER) is an arm of the CERP responsible for linking science and the tools of science to a set of systemwide planning, evaluation, and assessment tasks. RECOVER's objectives are to evaluate and assess CERP performance; refine and improve the CERP during the implementation period; and ensure that a system-wide perspective is maintained throughout the restoration program. RECOVER conducts scientific and technical evaluations and assessments for improving CERP's ability to restore, preserve, and protect the South Florida ecosystem while providing for the region's other water-related needs. RECOVER communicates and coordinates the results of these evaluations and assessments.

Ridge—Elevated areas of sawgrass habitat that rise above the foot-and-a-half deeper sloughs. A ridge may be submerged or above the water surface.

Savings Clause—Provision of WRDA 2000 that is designed to ensure that an existing legal source of water (e.g., agricultural or urban water supply, water supply for Everglades National Park, water supply for fish and wildlife) is not eliminated or transferred until a replacement source of water of comparable quantity and quality, as was available on the date of enactment of WRDA 2000, is available and that existing levels of flood protection are not reduced.

Sawgrass plain—An unbroken expanse of dense, tall (up to 10 feet) sawgrass that originally covered most of the northern Everglades. Most of the sawgrass plain area has been replaced by agricultural crops, mainly sugar cane, but some tall sawgrass remains in the Water Conservation Areas.

Science Coordination Group (SCG)—The SCG supports the South Florida Ecosystem Restoration Task Force in its efforts to coordinate the scientific aspects of restoration of the South Florida ecosystem. The SCG is primarily tasked with continually documenting and supporting the programmatic-level science and other research through updates and implementation of the Task Force's Plan for Coordinating Science. The SCG includes both senior managers and scientists appointed by the Task Force.

Sheet flow—Water movement as a broad front with shallow, uniform depth.

Slough—A depression associated with swamps and marshlands as part of a bayou, inlet, or backwater; contains areas of slightly deeper water and a slow current; can be thought of as the broad, shallow rivers of the Everglades.

South Florida ecosystem—An area consisting of the lands and waters within the boundary of the South Florida Water Management District, including the built environment, the Everglades, the Florida Keys, and the contiguous near-shore coastal waters of South Florida (also known as Greater Everglades ecosystem).

South Florida Ecosystem Restoration Task Force (SFERTF or Task Force)— The Task Force was established by the WRDA of 1996 to coordinate policies, programs, and science activities among the many restoration partners in South Florida. Its 14 members include the secretaries of Interior (chair), Commerce, Army, Agriculture, and Transportation; the Attorney General; and the Administrator of the Environmental Protection Agency; or their designees. One member each is appointed by the Secretary of the Interior from the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida. The Secretary of the Interior also appoints, based on recommendations of the governor of Florida, two representatives of the state of Florida, one representative of the SFWMD, and two representatives of local Florida governments.

South Florida Regional Simulation Model (SFRSM)—A finite-volume-based model capable of simulating multidimensional and fully integrated groundwater and surface-water flow. This model is intended to eventually replace the SFWMM.

South Florida Water Management Model (SFWMM)—A model that simulates hydrology and water systems (widely accepted as the best available tool for analyzing structural and/or operational changes to the complex water management system in South Florida at the regional scale).

Southern Inland and Coastal Systems numerical model (SICS)—Numerical model that simulates hydrologic conditions for the Taylor Slough area.

Spatially Explicit Species Index (SESI)—A set of models designed to assess the relative potential for breeding and/or foraging success of modeled species across the greater Everglades landscape under various proposed hydrologic scenarios.

Stormwater Treatment Area (STA)—A human constructed wetland area to treat urban and agricultural runoff water before it is discharged to the natural areas.

Submerged aquatic vegetation (SAV)—Plants that grow completely below the water surface.

Tides and Inflows in the Mangrove Ecotone (TIME) model—Numerical model being developed by the U.S. Geological Survey to investigate the interaction of overland sheet flow and dynamic tidal forces, including flow exchanges and salinity fluxes between the surface- and groundwater systems, in and along the mangrove-dominated transition zone between the Everglades wetlands and adjacent coastal-marine ecosystems in south Florida. The TIME model domain has an eastern boundary at the L-31N, L-31W, and C-111 canals; a southern boundary across northern Florida Bay from Key Largo to Cape Sable; a western boundary along the Gulf coast from Cape Sable to Everglades City; and a northern boundary along Tamiami Trail. TIME has a spatial scale of 500 x 500 m.

Total phosphorus (TP)—Sum of phosphorus in dissolved and particulate forms.

Tree island—Patch of forest in the Everglades marsh occurring in the central peatlands and the peripheral marl prairies of the southern and southeastern Everglades; on higher ground than ridges; sizes range from as small as one-hundredth of an acre to hundreds of acres.

WAMVIEW—A GIS-based watershed hydrology/water quality model developed to allow engineers and planners to assess the water quality of both surface and groundwater based on land use, soils, climate, and other factors.

Water Conservation Areas (WCAs)—Everglades marshland areas that were modified for use as storage to prevent flooding, to irrigate agriculture land and recharge well fields, to supply water for Everglades National Park, and for general water conservation. The Water Conservation Areas WCA-1, WCA-2A, WCA-2B, WCA-3A, and WCA-3B comprise five surface-water management basins in the Everglades; bounded by the Everglades Agricultural Area on the north and the Everglades National Park basin on the south, the WCAs are confined by levees and water control structures that regulate the inflows and outflows to each one of them. Restoration of more natural water levels and flows to the WCAs is a main objective of the CERP.

Water Reservations—According to WRDA 2000, the state shall, under state law, make sufficient reservations of water provided by each CERP project for the natural system in accordance with the Project Implementation Report for that project and consistent with the Plan before water made available by a project is permitted for a consumptive use or otherwise made unavailable.

Water Resources Development Act (WRDA) of 2000—Legislation that authorized the Comprehensive Everglades Restoration Plan as a framework for modifying the Central and Southern Florida Project to increase future water supplies, with the appropriate quality, timing, and distribution, for environmental purposes so as to achieve a restored Everglades natural system as much as possible, while at the same time meeting other water-related needs of the ecosystem.

Water year—Time convention used as a basis for processing stream flow and other hydrologic data. In the Northern Hemisphere, the water year begins October 1 and ends September 30; in the Southern Hemisphere, it begins July 1 and ends June 30. The water year is designated by the calendar year in which it ends.

Wetlands—Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Yellow Book—Common name for the *Central and Southern Florida Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement* (USACE and SFWMD, 1999), which laid out the Comprehensive Everglades Restoration Plan.

Appendixes

Appendix A

2005 Report to Congress Past and Future Accomplishments Tables[1]

[1]Accomplishment tables are found in Appendix B of DOI and USACE (2005).

FOUNDATION PROJECTS

Foundation Project Accomplishments to Date
Construction Activities:
Kissimmee River Restoration • S65 Addition (Spillway) • C35/36 Enlargement • Reach 1 Backfilling • S65 A Tieback Levee Degradation • US Highway 98 Bridge Relocation and Highway Modifications • S65A Road/Guard Rail Installation • Avon Park Fence/Levee Degradation (West)

Everglades & South Florida Ecosystem Restoration/Critical Projects
• Florida Keys Carrying Capacity Study
• East Coast Canal Structures
  o S-380 Structure on C-4
• Western C-11 Water Quality
  o Pump Station S-9A
  o S-381 Divide Structure
• Seminole Big Cypress
  o Conveyance Canal System
  o Canal Pump stations
• Southern CREW
  o Kehl Canal Weir
• Ten Mile Creek WPA – 80 to 90% Complete
• Lake Okeechobee Water Retention and Phosphorus Removal
  • Taylor Creek STA – 80% Complete
  • Nubbin Slough STA – 60% Complete
• Western Tamiami Trail Culverts - 43% Complete

Everglades Construction Project • All Stormwater Treatment Areas (STAs) constructed with effective treatment area of 36,098 acres
Modified Water Deliveries to ENP Project • S-355A & S-355B Structures construction • S-356 Pump Station construction • Degradation of 4 miles of L67 extension • Elevation of Tiger Tail Camp • Real Estate Acquisition – 8 ½ Square Mile Area (SMA) (Complete or in Final Acquisition Process)
Modifications to C-111 Project • S-332B Pump Station construction • S-332C Pump Station construction • S-332D Pump Station construction • S-332 Pump Station construction • Taylor Slough Bridge • C-109 canal plugs • Detention areas S-332B north & west • Detention area S-332C • Detention area S-332D
C-51/STA-1E • STA-1E construction completed

Foundation Project Accomplishments to Date – Continued
Planning & Design Activities:
Biscayne Bay Feasibility Study • Phase 1 hydrodynamic/salinity model and associated surface and groundwater model of the study area.

Foundation Project Accomplishments in Next Five Years
Construction Activities:
Kissimmee River Restoration • S84 Addition (Spillway) • S65D Additions (Spillway) • Monitoring wells installation • S65B Radio Tower • C36/37 Improvement (Terminated) • S83 Addition (Spillways) • CSX Railroad Bridge Over Historic Channel • S68 Modification • Istokpoga Canal Improvement • Basinger Grove Levee • Reach 4 Backfilling Phases I & II – Includes Avon Park Fence • River Acres Flood Protection Levees, Bridge, and Canals • Pool D Oxbows & Berms • Reach 2 Backfilling (2010)

Everglades & South Florida Ecosystem Restoration/Critical Projects
• Seminole Big Cypress
    ○ Basins 1, 2, 3, & 4
    ○ Inverted siphons across West Feeder Canal
• Southern CREW
    ○ Removal of Man-Made Features
• Lake Okeechobee Water Retention and Phosphorus Removal
    ○ Taylor Creek
    ○ Nubbin Slough
• Ten Mile Creek Water Preserve Area
• Lake Trafford

Everglades Construction Project • Enhancements complete in 2006
Modified Water Deliveries to ENP • S-357 Pump Station construction • STA • Seepage canal/levee for 8.5 SMA • Conveyance features in L67A • L67C and L29 levees and canals • Modifications to Tamiami Trail • Combined Structural & Operating Plan (CSOP) • Real Estate Acquisition – 8 ½ Square Mile Area (SMA) (Completion of Final Acquisition Process)
Modifications to C-111 Project • S-332A Pump Station construction • Permanent S-332B and S-332C structures • Discharge canals for S-332A, B, C, & D • S-332 connector canal • Levees from detention areas to 8.5 SMA STA • Culverts to connect C-111 to S-332 • Back fill of L31W borrow canal • C-111 plugs and mods to existing C-111 berms • Overflow weir to L31W tieback • Combined Structural & Operating Plan (CSOP)
STA-1E • STA-1E operational • Periphyton Stormwater Treatment Area (PSTA) Operational

Foundation Project Accomplishments in Next Five Years – Continued
Planning & Design Activities:
Biscayne Bay Feasibility Study • Phase 2 water quality model • Phase 3 biological model, including plant and animal communities.
C-7, C-8, C-9 – Awaiting Funding

CERP PROJECTS

CERP Project Accomplishments to Date
Planning & Design Activities:
Project Implementation Reports Completed (* = authorized in WRDA 2000 subject to PIR approval by Congressional Committees) • Indian River Lagoon South (* C-44) • Picayune Strand Restoration
Project Implementation Reports Initiated (* = authorized in WRDA 2000 subject to PIR approval by Congressional Committees) • Acme Basin B Discharge • Biscayne Bay Coastal Wetlands • Broward County WPA(* only C-9, C-11, & WCA 3A/3B Levee Seepage Management) • C-111 Spreader Canal* • C-43 Basin Storage Reservoir – Part 1 • Everglades Agricultural Storage Reservoirs – Phase 1* • Lake Okeechobee Watershed (* only Taylor Creek Nubbin Slough) • Melaleuca and Other Exotic Plants • North Palm Beach County - Part 1 • Site 1 Impoundment* • Strazzulla Wetlands • WCA 3 Decomp & Sheetflow Enhancement Part 1 (* only Eastern Tamiami Trail/Fill Miami Canal, & North New River) • Winsberg Farms Wetlands Restoration

Pilot Project Design Reports Completed
• Aquifer Storage and Recovery (ASR) Pilots
  ○ Caloosahatchee (C-43) ASR
  ○ Hillsboro ASR
  ○ Lake Okeechobee ASR

Pilot Project Design Reports and Regional Studies In Progress • L-31N Seepage Management • Master Recreation Plan
Feasibility and Regional Studies In Progress • CERP ASR Regional Study • Florida Bay/Florida Keys Feasibility Study • Comprehensive Integrated Water Quality Feasibility Study • Southwest Florida Feasibility Study
Project Management Plans In Progress • Lakes Park Restoration

*Note: * = authorized project.*

CERP Project Accomplishments in Next Five Years

Construction Activities:

Construction To Be Completed in Next Five Years

- Acme Basin B Discharge
- Biscayne Bay Coastal Wetlands
- Broward County WPA
- C-111 Spreader Canal
- Caloosahatchee (C-43) ASR Pilot
- Everglades Agricultural Area Storage Reservoirs – Part 1, Phase 1
- Hillsboro ASR Pilot
- Indian River Lagoon South
    - C-44 Reservoir
    - Natural Area Phase 1 Acquisition
- Lakes Park Restoration
- L-31N Seepage Management Pilot
- Lake Okeechobee ASR Pilot
- Melaleuca and Other Exotic Plants (Rearing and release of biological agents.)
- Picayune Strand Restoration
- Site 1 Impoundment
- Winsberg Farms Wetlands Restoration
- Henderson Creek/Belle Meade Restoration
- C-4 Eastern Structure
- Everglades National Park Seepage Management
- WPA Conveyance
- Broward Secondary Canal System

Construction to Begin in Next Five Years

- C-43 Basin Storage Reservoir – Part 1

Project Implementation Reports To Be Completed

- Acme Basin B Discharge
- Biscayne Bay Coastal Wetlands
- Broward County WPA
- Indian River Lagoon North
- C-111 Spreader Canal
- C-43 Basin Storage Reservoir – Part 1
- Everglades Agricultural Area Storage Reservoirs – Phase 1
- Lakes Park Restoration
- Lake Okeechobee Watershed
- Melaleuca and Other Exotic Plants
- North Palm Beach County - Part 1
- Site 1 Impoundment
- Strazzulla Wetlands
- WCA 3 Decomp & Sheetflow Enhancement Part 1
- Winsberg Farms Wetlands Restoration

Pilot Project Design Reports and Regional Studies To be Completed

- L-31N Seepage Management

Feasibility and Regional Studies To Be Completed

- ASR Regional Study (will complete 1 year after ASR Pilots)
- Florida Bay/Florida Keys Feasibility Study
- Comprehensive Integrated Water Quality Feasibility Study
- Southwest Florida Feasibility Study

Appendix B

Master Implementation Sequencing Plan

Comparison of Restudy and MISP 1.0 Construction Completion Dates

As of: 6 April 2005

Component/ Project Name	Construction Completion Dates: Comp Plan (April 1999)	MISP Phase 1	MISP Streamlined (Current)
Caloosahatchee (C-43) River ASR Pilot	Oct-02	Sep-06	2006
Hillsboro ASR Pilot Project	Oct-02	Dec-06	2006
Melaleuca Eradication and Other Exotic Plants (PIR)	Sep-11	Nov-13	2007
Winsberg Farm Wetlands Restoration	Dec-05	Jul-14	2008
L-31N (30) Seepage Management Pilot	Oct-02	Jul-08	2008
Lake Okeechobee ASR Pilot	Dec-01	Sep-08	2007
Biscayne Bay Coastal Wetlands (Phase 1)	May-18	May-11	2008
Picayune Strand (Southern Golden Gate Estates) Hydrologic Restoration	Jun-05	2009	2009
Indian River Lagoon - South*			
- C-44 Reservoir*	Jun-07	Oct-09	2009
- Natural Areas Real Estate Acquisition (Phase 1)		Band 5	2009
Broward County WPA			
- C-9 Impoundment*	Sep-07	Jul-11	2009
- C-11 Impoundment*	Sep-05	Jul-11	2009
- WCA 3A-3B Levee Seepage Management*	Sep-08	Jul-10	2008
Acme Basin B Discharge	Sep-08	Jul-09	2007
Site 1 Impoundment*	Sep-07	Dec-09	2009
C-111 Spreader Canal	Jul-08	Dec-10	2009
North Palm Beach County - Part 1			
- C-51 and L-8 Basin Reservoir, Phase 1 (PBA)	201[illegible]	2008	2008
EAA Storage Reservoir			
- Part 1, Phase 1*	Sep-08	Dec-08	2009
Lake Okeechobee Watershed			
- Lake Istopoga Regulation Schedule	Dec-01	2008	2008
Modify Rotenberger Wildlife Management Area Operation Plan		Jul-09	2009
Lakes Park Restoration	Jun-04	Dec-14	2009
C-43 Basin Storage Reservoir	Mar-12	Band 2	2010

Band 1 (2005-2010)

Grey Shading = Construction by SFWMD
* = Initially Authorized Project

Comparison of Restudy and MISP 1.0 Construction Completion Dates — As of: 5 April 2005

Component/ Project Name	Comp Plan (April 1999)	MISP Phase 1	MISP Streamlined (current)	
Indian River Lagoon – South				Band 2 (2010-2015)
- C25 Reservoir and Northfork/Southfork Basin	May-10	Band 7	Band 2	
- C-23/24 STA		May-16	Band 2	
- C-23/24 North	May-05	Mar-17	Band 2	
- C-23/24 South		Mar-17	Band 2	
- Natural Areas Real Estate Acquisition (Phase 2)		Band 5	Band 2	
Strazzulla Wetlands	Oct-07	Apr-10	Band 2	
ASR Regional Study		Band 2	Band 2	
EAA Storage Reservoir				
- Part 1, Phase 2*			Band 2	
North Palm Beach County - Part 1				
- Lake Worth Lagoon Restoration	Mar-11	Band 2	Band 2	
- Pal-Mar/Corbett Hydropattern Restoration		Band 2	Band 2	
- C-17 Backpumping	Oct-08	Band 3	Band 2	
- C-51 Backpumping and Treatment	Oct-08	Band 3	Band 2	
- L-8 Basin Modifications	Sep-11	Band 2	Band 2	
Florida Keys Tidal Restoration	Aug-05	Band 3	Band 2	
Lake Okeechobee Watershed				
- Tributary Sediment Dredging	Sep-05	Band 2	Band 2	
- Water Quality Treatment Facilities	Sep-10	Band 2	Band 2	
- North of Lake Okeechobee Storage	Sep-15	Band 2	Band 2	
- Taylor Creek/ Nubbin Slough*	Jan-05	Sep-11	Band 2	
Henderson Creek/ Belle Meade Restoration	Dec-05	Band 3	Band 2	
Modify Holey Land Wildlife Management Area Operation Plan		Band 2	Band 2	
C-4 Eastern Structure	Jul-05	Band 2	Band 2	
Everglades National Park Seepage Management (Phase 1)	Oct-10	Band 2	Band 2	
Biscayne Bay Coastal Wetlands (Phase 2)	May-10	Band 2	Band 2	
WCA 3 Decompartmentalization and Sheetflow Enhancement				
- Physical Models	N/A	N/A	Band 2	
- North New River Improvements*	Jan-05	Band 3	Band 2	
WPA Conveyance				
- Dade-Broward Levee and Canal		Band 2	Band 2	
Broward Secondary Canal System	Jun-05	Band 3	Band 2	

Comparison of Restudy and MISP 1.0 Construction Completion Dates — As of 8-Apr-2005

Component/ Project Name	Comp Plan (April 1999)	MISP Phase 1	MISP Streamlined (current)	
Flows to Northwest and Central WCA 3A				Band 3 (2015-2020)
- G-404 Pump Station Modifications	Mar-05	Band 3	Band 3	
- Flows to NW and Central WCA 3A	Apr-05	Band 3	Band 3	
Miccosukkee Water Management Plan	Band 1	Band 3	Band 3	
Indian River Lagoon - South				
- Natural Areas Real Estate Acquisition (Phase 3)		Band 5	Band 3	
EAA Storage Reservoir				
- Part 2	Dec-15	Band 3	Band 3	
WPA Conveyance				
- North Lake Belt Storage Area (Turnpike Deliveries)	Sep-06	Band 3	Band 3	
Palm Beach County Agricultural Reserve Reservoir - Part 1	Aug-13	Band 3	Band 3	
Palm Beach County Agricultural Reserve ASR - Part 2		Band 4	Band 3	
Wastewater Reuse Pilot				
- South Miami Dade Reuse Pilot	Sep-05	Band 3	Band 3	
WCA 3 Decompartilization and Sheetflow Enhancement				
- Miami Canal		Band 3	Band 3	
- Canal and Levee Modifications in WCA 3		Band 3	Band 3	
- WCA 3A & 3B Flows to CLB	Feb-16	Band 3	Band 3	
- Eastern / Western TT			Band 3	
Everglades National Park Seepage Management (Phase 2)	Dec-13	Band 3	Band 3	
Lake Belt In-Ground Reservoir Technology Pilot Project	Dec-05	Band 3	Band 3	
Flows to Eastern WCA	Feb-17	Band 3	Band 3	
Seminole Tribe Water Conservation Plan	Jun-06	Band 3	Band 3	
North Palm Beach County - Part 1				
- C-51 and L-8 Basin Reservoir, Phase 2	Sep-11	Band 3	Band 3	
North Palm Beach County - Part 2				
- L-8 Basin ASR		Band 3	Band 3	
- C-51 Regional ASR	Sep-13	Band 4	Band 3	
Caloosahatchee Backpumping with STA	Sep-15	Band 4	Band 3	
Loxahatchee National Wildlife Refuge Internal Canal Structures	Jul-03	Band 4	Band 3	
Lake Okeechobee ASR				
- Lake Okeechobee ASR - Part 1	Jun-26	Band 4	Band 3	
C-43 Basin ASR	Mar-12	Band 3	Band 3	

Grey Shading = Construction by SFWMD
* = Initially Authorized Project

Comparison of Restudy and MISP 1.0 Construction Completion Dates

As of 8 April 2005

Component/ Project Name	Comp Plan (April 1999)	MISP Phase 1	MISP Streamlined (current)	
Big Cypress/ L-28 Interceptor	Sep-16	Band 4	Band 4	Band 4 (2020-2025)
Indian River Lagoon - South				
- Natural Areas (Complete Construction)		Band 5	Band 4	
- Muck Remediation		Band 5	Band 4	
Restoration of Pineland & Hardwood in C-111 Basin	Mar-36	Band 4	Band 4	
South Miami-Dade County Reuse	Jun-20	Band 4	Band 4	
West Miami-Dade County Reuse	Jun-20	Band 4	Band 4	
Lake Okeechobee ASR				
- Lake Okeechobee ASR - Part 2		Band 5	Band 4	
Hillsboro ASR	Oct-14	Band 4	Band 4	
WCA 2B Flows to Everglades National Park				
- WCA 2B Flows to CLB (L-30 Improvements)		Band 4	Band 4	
- WCA 2B Flows to CLB		Band 5	Band 4	
Lake Okeechobee ASR				Band 5 (2025-2030)
- Lake Okeechobee ASR - Part 3		Band 5	Band 5	
North Lake Belt Storage Area - Phase 1	Feb-21	Band 5	Band 5	
Central Lake Belt Storage Area - Phase 1	Feb-21	Band 5	Band 5	
North Lake Belt Storage Area - Phase 2	Jun-36	Band 7	Band 7	Band 7 (2035-2040)
Central Lake Belt Storage Area - Phase 2	Dec-36	Band 7	Band 7	

Grey Shading = Construction by SFWMD
* = Initially Authorized Project