Chapter 7: Update on RECOVER Implementation and Monitoring for the Comprehensive Everglades Restoration Plan

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SUMMARY

RECOVER (Restoration Coordination and Verification) is an interagency, interdisciplinary team sponsored by the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (District or SFWMD). The role of RECOVER is to organize and apply scientific and technical information in ways that are most effective in supporting the objectives of the Comprehensive Everglades Restoration Plan (CERP), and to ensure that CERP's systemwide goals and purposes are achieved.

RECOVER applies science and the tools of science to three broad mission areas. RECOVER's three mission areas are as follows:

- **Assessment:** Measure (through monitoring) and interpret responses in natural and human systems as CERP projects are brought on line
- **Evaluation:** Work with the Project Delivery Teams (PDTs) to evaluate (through predictive modeling) and maximize the contribution made by each project to the systemwide performance of CERP
- **Planning and Integration:** Identify potential improvements in the design and operation of CERP, consistent with plan objectives, and strive for consensus regarding scientific and technical aspects of the plan

RECOVER's three mission areas are the primary means of improving CERP systemwide performance as implementation of individual CERP projects proceeds. The evaluation process (1) incorporates the Comprehensive Plan approved by the Water Resources Development Act of 2000 (WRDA 2000) and conceptual ecological models into a set of systemwide evaluation performance measures, (2) uses this set of performance measures to evaluate (or predict) systemwide performance of CERP and to support individual CERP projects in development of project management plans and project implementation reports, and (3) assists in refinement of project designs and operations. The assessment process (1) develops systemwide assessment performance measures based on conceptual ecological models, (2) develops a monitoring and assessment plan based on these models and performance measures, (3) uses results of monitoring and supporting research described in the plan to assess the success of CERP implementation through issuance of integrated assessment reports, and (4) assists in refining CERP design and

operation. The planning and integration process (1) refines models and performance measures, (2) performs CERP update modeling and contingency planning, and (3) provides options for management approval to refine CERP projects or operation.

These missions provide RECOVER with the organizational framework for meeting its overall objectives of predicting and measuring CERP performance, refining and improving CERP during the implementation period, and ensuring that a systemwide perspective is maintained throughout the restoration program.

Assessment, evaluation, and planning and integration activities will encompass all CERP projects, pilot projects, and critical projects, as appropriate. RECOVER may also evaluate other non-CERP projects that can potentially affect CERP's ability to achieve its goals and purposes. RECOVER will function throughout the entire duration of the CERP process, continuously seeking ways to improve the plan. Evaluation and assessment activities, as well as data from cause-effect research and from new technologies, will shape planning and integration efforts toward this goal.

RECOVER is developing an adaptive management program for CERP that will better prepare CERP to anticipate and respond to future uncertainties. The adaptive management program will provide a feedback mechanism for assessing whether responses by systems being restored are matching restoration objectives. These assessments will be used to determine when and how implementation of the plan could be improved where objectives are not being met. The ultimate role of adaptive management in CERP is to have an ongoing, scientifically-based process for substantially increasing the probability that the plan will succeed. Key principles of adaptive management being incorporated in the CERP program are (1) anticipation, (2) learning, (3) communication, and (4) adjustment.

The Total System Conceptual Ecological Model has been created as a planning tool for selecting the most appropriate set of total system performance measures for CERP. The total system model is designed to show the key ecosystem stressors working at multi-landscape scales in South Florida and the best biological indicators of these stressors.

Several projects currently being undertaken by RECOVER will allow tracking of CERP performance. The CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research has been published (RECOVER, 2004a) and is currently being implemented. Integrative assessment protocols are presently being developed, and will be published as Part 2. This plan establishes the framework for measuring systemwide responses (Part 1) and for assessing how well CERP is meeting its goals and objectives (Part 2). As part of this process, assessment performance measures and a process for establishing interim goals and interim targets have been developed. Both assessment and evaluation performance measures have been published in the Draft CERP Systemwide Performance Measures Report (RECOVER, 2004b), and the final report is expected to be published in late 2004.

The Initial CERP Update (ICU) remains under way in response to environmental changes and new information gained since the release of the CERP feasibility report (USACE and SFWMD, 1999). The ICU will result in an improved prediction of plan performance, a revised description of existing conditions and of the future-without-project condition. Moreover, this information will be provided to the individual PDTs as they begin project-level formulation and evaluation.

More detailed information regarding the RECOVER program of CERP is contained in the Draft Management Plan for RECOVER (FY2004–FY2006)[1] (USACE and SFWMD, 2003). and in the 2002–2004 Everglades Consolidated Reports (ECRs) (SFWMD, 2002; 2003; and 2004)[2]. This chapter focuses on RECOVER activities, organized by its mission areas, from September 2003 through July 2004.

RECOVER ACTIVITIES

The following sections provide an update on RECOVER activities since the publication of the 2004 Everglades Consolidated Report (ECR). They are broken down into four categories: RECOVER-wide, Evaluation, Assessment, and Planning and Integration. The activities listed under the RECOVER-wide section fall under two or more mission areas.

RECOVER-WIDE

Conceptual Ecological Models

Eleven conceptual ecological models that represent South Florida's major wetland physiographic regions are being prepared for publication in a special issue of *Wetlands*. Draft regional models were published in Appendix A of the CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research (RECOVER, 2004a) [3]. Models have been developed for the following regions: Everglades Ridge and Slough, Southern Marl Prairies, Everglades Mangrove Estuaries, Big Cypress Regional Ecosystem, Biscayne Bay, Florida Bay, Lake Okeechobee, Caloosahatchee Estuary, St. Lucie Estuary and Southern Indian River Lagoon, Loxahatchee watershed, and Lake Worth Lagoon. The models have served as the basis for development of natural system performance measures used in RECOVER's evaluation and assessment missions. As new information becomes available, models will be revised or new models developed, and the sets of evaluation and assessment systemwide performance measures will be revised and expanded.

A conceptual ecological model addressing the total South Florida system has also been developed and will be published with the regional models. The Total System Conceptual Ecological Model focuses on the bigger picture, picking up where the regional models leave off and integrating the major, systemwide working hypotheses common to several or all of the regional conceptual ecological models. It identifies the working hypotheses that explain the major ecological changes that have occurred at the larger scale of the South Florida ecosystem. It also addresses major stressors and ecological effects that, because they are operating at such a large

[1] Draft Management Plan is online at http://www.evergladesplan.org/pm/recover/recover_mgmt_plan.cfm.

[2] RECOVER chapters in the 2002, 2003, and 2004 ECRs are respectively available online as follows:

http://www.sfwmd.gov/org/ema/everglades/consolidated_02/Chapters/Ch7.pdf
http://www.sfwmd.gov/org/ema/everglades/consolidated_03/ecr2003/chapters/ch7b.pdf
http://www.sfwmd.gov/org/ema/everglades/consolidated_04/final/chapters/ch7.pdf

[3] CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research is available online at http://www.evergladesplan.org/pm/recover/recover_map_2004.cfm.

scale, have not been adequately characterized by the regional models. The model looks at the interactions among the regional models and at the upstream and downstream effects.

CERP Systemwide Performance Measures

RECOVER has developed a set of performance measures that will be used to predict, measure, and assist in assessing CERP's systemwide progress and success. CERP performance measures identify systemwide hydrological, biological, and water quality indicators that are expected to be responsive to CERP implementation. The performance measures were developed in large part from conceptual ecological models and from a review of performance measures used in the Central and Southern Florida (C&SF) Project Comprehensive Review Study (Restudy) (USACE and SFWMD, 1999). For the natural system, performance measures are principally derived from the conceptual ecological models discussed above. For urban and agricultural water supply and flood protection objectives, performance measures are based on current federal and state law and policy. The set of measures is have been presented in the Draft CERP Systemwide Performance Measures document (RECOVER, 2004b), which was distributed for general review in June 2004. RECOVER utilizes two categories of systemwide performance measures: evaluation (predictive) and assessment measures. Summaries of the assessment and evaluation performance measures are presented in Appendix 7-1 and 7-2, respectively. A more detailed discussion of revisions and additions to each set of measures is provided under the *Assessment* and *Evaluation* sections in this chapter.

Adaptive Management Program

RECOVER has the responsibility to coordinate the development and implementation of a systemwide Adaptive Management Program in support of CERP. The purpose of the Adaptive Management Program is to create a set of measurable restoration objectives for CERP that are consistent with CERP goals and to assess how well CERP meets these objectives during and following its implementation. The program also aims to identify opportunities to improve CERP's design and operation based on uncertainty analyses, assessments of its performance and on new information acquired through cause-effect research and monitoring.

INTEGRATED ASSESSMENT PROTOCOL

The second part of the CERP Monitoring and Assessment Plan (see below), detailing how the assessment of CERP's progress will be conducted, is currently being developed by RECOVER's Integrative Assessment Team. Participants on this team are members of RECOVER's Adaptive Assessment and Water Quality Teams. The subteam has developed a report, Assessing the Response of the Everglades Ecosystem to Implementation of the Comprehensive Everglades Restoration Plan (RECOVER, 2004c)[4], as part of the future development of the RECOVER Monitoring and Assessment Plan: Part 2 Assessment Process. This report has also been used to

[4] Assessing the Response of the Everglades Ecosystem to Implementation of the Comprehensive Everglades Restoration Plan can be found on USACE's Website at ftp://ftp.saj.usace.army.mil/pub/uploads/k3epjmm3/PDFforGMTaskTeam/GM%204AppendixA061404Task%20Team.pdf.

develop a Draft Assessment Guidance Memorandum (USACE and SFWMD, 2004)[5], which "presents strategies for (1) establishing reference (baseline) conditions in the system, (2) determining the ability to detect changes in the parameters of interest, (3) assessing ecosystem performance at a hierarchy of scales, (4) assessing hypotheses, (5) incorporating assessments of indicators of interim goals and interim targets, (6) making adaptive changes in the overall assessment process, and (7) evaluating if corrective actions to improve CERP performance should be considered." Additionally, the Draft Assessment Guidance Memorandum provides a framework for assessment reporting mechanisms, including the preparation of the technical report as specified in the Programmatic Regulations (Section 385.31(b)(4); DOD, 2003).

Interim Goals and Interim Targets

WRDA 2000 directs that the Programmatic Regulations (DOD, 2003) establish a process "to ensure the protection of the natural system consistent with the goals and purposes of the Plan…" [Section 601 (h)(C)(i)(III)]. The Programmatic Regulations further require that progress toward providing for "other water-related needs" also be evaluated. The vehicle for these assurances is the establishment of quantitative interim goals and interim targets through which the plan's success may be evaluated incrementally as CERP implementation proceeds.

In April 2004, RECOVER provided draft recommendations for both interim goals and interim targets (RECOVER, 2004d and 2004e). These two documents contained documentation sheets for each indicator chosen to represent an interim goal or target, the prediction methodology for each indicator, and how each indicator will be assessed in order to determine CERP's progress towards meeting restoration and other goals. The final recommended indicators for the interim goals and interim targets are presented in **Tables 7-1** and **7-2**, respectively. RECOVER also developed a series of six questions regarding the adequacy and predictability of the indicators for presentation to a peer review panel. This initial panel discussion took place in May 2004; the most common criticism from the panel was that the writers did not "get the story right" and substantial revisions were necessary. Revisions to the documents have been taking place during summer 2004, while work has proceeded with the modeling at five-year increments necessary to predict the goals and targets. After the modeling is completed in fall 2004 and predictions are subsequently made, it is expected that a second meeting of the peer review panel will convene.

ASSESSMENT

Performance Measures

New assessment systemwide performance measures have been proposed for nutrient loads in inflows to the Greater Everglades, mercury bioaccumulation, and Everglades snail kite (*Rosthrhamus sociabilis plumbeus*) habitat and nesting success. The Lake Okeechobee stage performance measures have been updated based on new information. A summary of all of CERP systemwide assessment performance measures is presented in Appendix 7-1.

[5] The draft Assessment Guidance Memorandum can be found on the USACE's Website at ftp://ftp.saj.usace.army.mil/pub/uploads/k3epjmm3/PDFforGMTaskTeam/GM%204AssessmentDraft051804%20Task%20Team.pdf.

Table 7-1. List of recommended Comprehensive Everglades Restoration Plan (CERP) interim goal indicators by group.

Group 1: Hydrologic Indicators
G1.1 Volume – Quantity and Distribution
G1.2 Sheetflow in Greater Everglades Wetlands
G1.3 Hydropattern in Greater Everglades Wetlands
G1.4 Salinity Patterns in Florida and Biscayne Bays
G1.5 Water Levels in Lake Okeechobee
Group 2: Water Quality Indicators
G2.1 Lake Okeechobee Phosphorus
G2.2 Lake Okeechobee Algal Blooms
G2.3 Greater Everglades Wetlands Total Phosphorus
G2.4 Periphyton Mat Cover, Structure, and Composition
G2.5 Florida Bay Algal Blooms
Group 3: Biological Indicators
G3.1 Recovery of Threatened and Endangered Species and Supporting Habitats - Snail Kite
G3.2 Ridge and Slough Pattern
G3.3 Everglades Tree Islands
G3.4 Spatial Extent of Cattail Habitat
G3.5 Submerged Aquatic Vegetation in Southern Estuaries
G3.6 Juvenile Pink Shrimp Densities in Florida and Biscayne Bays
G3.7 Submerged Aquatic Vegetation in Northern Estuaries
G3.8 Aquatic Fauna Regional Populations in Greater Everglades Wetlands
G3.9 Systemwide Wading Bird Nesting Patterns
G3.10 Recovery of Threatened and Endangered Species and Supporting Habitats - American Crocodile
G3.11 Systemwide American Alligator Distribution and Abundance
G3.12 Lake Okeechobee Ecological Communities – Submerged Aquatic Vegetation
G3.13 American Oysters in Estuaries

Table 7-2. List of recommended CERP interim target indicators.

All indicators will be developed into interim targets using established predictive methods
T1.1 Volume – Quantity and Distribution
T1.2 Water Supply for the Lower East Coast Service Area
T1.3 Water Supply for the Lake Okeechobee Service Area
T1.4 Protect the Biscayne Aquifer from Saltwater Intrusion
T1.5 Protect the Southern Portion of the Biscayne Aquifer from Saltwater Intrusion
T1.6 Flood Control: Root Zone Groundwater Levels in South Miami-Dade Agricultural Area East of L-1N
T1.7 Flood Control: Groundwater Stages for Miami-Dade, Broward, Palm Beach and Seminole Tribe Surface Water Management Basins
T1.8 Flood Control: Flood Water Removal Rate for the Everglades Agricultural Area

Monitoring and Assessment Plan

The CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research (MAP) (RECOVER, 2004a) was published in January 2004, and is currently being implemented. **Table 7-3** lists projects that have been implemented to begin gathering data to establish a pre-CERP reference state by 2010. Some of these are existing projects being conducted throughout the District, but are now being used in RECOVER's systemwide monitoring and assessment effort. Collection of critical biological data has begun for key indicator species that are critical linkages and attributes in the conceptual ecological models. Statistical analysis and results from the first five years of monitoring and associated studies will allow RECOVER to fine tune the long-term monitoring to be able to best assess the effects of CERP on the ecosystem through 2050. Some of these projects are summarized in the following subsections. The newly implemented projects are described below; the existing projects are not described. Further information on the coastal ecosystems discussed below is also presented in Chapter 12 of the *2005 South Florida Environmental Report – Volume I.*

GREATER EVERGLADES STRATIFIED RANDOM DESIGN

A statistically sound sampling design is necessary to establish baseline aquatic fauna population structure and to detect change over time. An overall master experimental design is being developed for aquatic fauna and periphyton sampling in emergent marsh ecosystems. A stratified random sampling design will be used for emergent marsh ecosystems to detect current status and future changes in aquatic populations. In this design, the greater Everglades is divided into a series of landscape subunits. Within each subunit, the design recommends selection of primary sampling units (PSUs) that be selected based upon availability and location of sparse emergent freshwater marsh within each landscape subunit. After the PSUs are selected, throw traps will be randomly taken within the appropriate habitat of each PSU.

A pilot study to test the stratified random sampling design by sampling fish using throw traps was implemented in late 2003. The results of this study, which concluded in March 2004, illustrate that the stratified random design using the throw trap method would be successful in open marsh ecosystems, but not in forested wetland ecosystems such as mangrove or cypress dominated wetlands. This finding has led to a new reprioritization of future research efforts. A methodology for sampling aquatic fauna and periphyton in forested ecosystems is currently being developed.

TRANSECT AND SENTINEL SITE DESIGN

Landscape/vegetation monitoring components are being implemented to supplement existing vegetation maps. The five-year vegetation maps will capture changes in vegetation type (category), especially when changes occur at large spatial extents. However, changes in the number and size of bayheads require supplemental sampling at a well-defined subset of the area. Changes in composition (e.g., from 45 to 30 percent *Muhlenbergia*) within vegetation types or classes are not captured by mapping vegetation at any spatial resolution. Such changes can be important themselves, or can be early indicators of slower change in community type. Species composition is best monitored in permanent vegetation plots along transects, with cover or abundance estimated for each species in each plot. Given the effort to collect compositional data, soil nutrient data should be taken at the same locations to allow species-specific nutrient

relationships to be assessed for interpreting potential causation if monitoring detects change.

Table 7-3. Monitoring and Assessment Plan items implemented in Fiscal Years 2003 and 2004.

Project Title
GREATER EVERGLADES WETLANDS MODULE
Greater Everglades Stratified Random Design
Transect and Sentinel Sampling Design
Coastal Gradients of Flow, Salinity and Nutrients
Tidal Creek Geomorphic Survey in Southwest Everglades
Greater Everglades Regional Aquatic Fauna Baseline Characterization
Dry Season Fish Concentration Studies
Crayfish Population Dynamics and Hydrological Influences
Greater Everglades Aquatic Fauna Populations and Periphyton Mat Cover and Composition
Systematic Reconnaissance Flights Wading Bird Distribution Surveys Synthesis, 1985–2001
Greater Everglades Transect Sulfate/Porewater *
Everglades Soil Mapping (Regional Distribution of Soil Nutrients) *
Loxahatchee Impoundment Landscape Assessment *
Greater Everglades Landscape Pattern - Ridge, Slough, and Tree Island Elevations *
SOUTHERN ESTUARIES MODULE
Submerged Aquatic Vegetation Mapping in Florida and Biscayne Bays
Southern Estuaries Salinity Monitoring Network
Oyster Monitoring Network for South Florida Estuaries
South Florida Fish Habitat Assessment Network
Southern Estuaries Dissolved Organic Matter Fate and Effect
Northeast Florida Bay Water Quality Trends
NORTHERN ESTUARIES MODULE
Caloosahatchee Submerged Aquatic Vegetation Monitoring
Caloosahatchee Estuary Submerged Aquatic Mapping from Aerial Photography
Caloosahatchee Estuary/Charlotte Harbor Juvenile Fisheries Monitoring
Charlotte Harbor Research
Macro-benthic Monitoring St. Lucie Estuary and Southern Indian River Lagoon
Oyster Monitoring Network for South Florida Estuaries
Southern Indian River Lagoon Seagrass and Macro-algae Monitoring
Indian River Lagoon and Loxahatchee Estuary Seagrass Photography and Mapping
Water Quality Monitoring in the Northern Estuaries
LAKE OKEECHOBEE MODULE
Lake Okeechobee Taxonomic Support Services for Phytoplankton and Zooplankton *
Lake Okeechobee Submerged Aquatic Vegetation Sediment, Periphyton, and Plants *
Regional Hydrology Monitoring Network Water Conservation Area 1 Elevations *
Regional Hydrology Monitoring Network Optimization *
Evapotranspiration Remote Sensing *
SOUTH HYDROLOGY MONITORING NETWORK MODULE
Regional Hydrology Monitoring Network Optimization Study *

* Represents an existing project.

Open issues include the number, size, and location of permanent plots. Locations may be arrayed spatially, across hydroperiod gradients, or across nutrient gradients.

COASTAL GRADIENTS OF FLOW AND WATER QUALITY

The Coastal Gradients of Flow and Water Quality project included the installation and instrumentation of ten new flow and three new nutrient monitoring stations. These stations complimented an existing U.S. Geological Survey (USGS) monitoring network by filling in critical gaps. The areas chosen for instrumentation will be influenced by the restoration of sheetflow as CERP proceeds; therefore, the data provided by these stations will enable the creation of a reference state. The total cost of the project was cooperatively cost-shared by the USGS and the SFWMD. Data from these stations is also being cooperatively shared via the South Florida Information Access (SOFIA) site. Future funding for the station maintenance and operations will be cost shared by the USGS and the USACE.

TIDAL CREEK GEOMORPHIC SURVEY IN SOUTHWEST EVERGLADES

The Tidal Creek Geomorphic Survey in Southwest Everglades project's objective is to test technology used to define bathymetry of tidal creeks in southwest Everglades. The tidal creeks selected for initial bathymetric survey include Shark River, and Lostman's, Harney, and Trout Creeks. This project is anticipated to be completed using state-of-the-art technology including SANDS (Shallow and Nearshore Depth Survey) and EAARL (Experimental Advanced Airborne Research). The goal is to establish a reference point that will be used to measure change in tidal creek channels after CERP is implemented. This project is being completed with a cooperative agreement with the USGS.

GREATER EVERGLADES REGIONAL AQUATIC FAUNA BASELINE CHARACTERIZATION

The Greater Everglades Regional Aquatic Fauna Baseline Characterization tested the in-field practicality of the stratified random design that was completed for the MAP. Boundaries and scope of landscape subregions proposed for the MAP were evaluated for feasibility of sampling. Test sampling was conducted at a subset of potential monitoring sites that have not previously been visited to estimate inter-sample variance for analysis of statistical power; and an initial draft manual of standard operating procedures for fish monitoring was completed. This project resulted in a redrawing of the landscape subunits where aquatic fauna could be evaluated using throw traps and in the initiation of a new research effort by the USGS to determine appropriate sampling methods to assess fish populations in forested wetlands.

DRY SEASON FISH CONCENTRATION STUDIES

A study to test a patch-prey availability hypothesis (RECOVER, 2004a) was initiated with the onset of the 2003–2004 dry season. This effort evaluates the availability of forage fishes and other prey in drying pools of water, and how wading birds utilize these drying pools on a landscape scale.

CRAYFISH POPULATION DYNAMICS AND HYDROLOGICAL INFLUENCES

Through indirect results of research and monitoring on wading birds and fish, crayfish are now recognized as critical ecosystem components in the Greater Everglades, although little is known about their basic life history characteristics or relationship to the hydrology of the Everglades. Given that they are a major research component of the Everglades, a statistically sound method of crayfish population sampling is needed. A study to determine efficiencies of various trap methods for native crayfish species was completed in December 2003. The study found that throw traps were the most unbiased and efficient methods to sample native populations. Currently, another study is being conducted to determine baseline crayfish populations and their life history linkages with hydrology, and their role in wading bird nesting success.

GREATER EVERGLADES AQUATIC FAUNA POPULATIONS AND PERIPHYTON MAT COVER AND COMPOSITION

Wet season marsh fish and macroinvertebrates population and periphyton production and community composition data are being gathered across the Greater Everglades ecosystem. The current condition of these populations will be established allowing scientists to detect changes and trends in aquatic fauna and periphyton population structures during CERP implementation. Aquatic fauna and periphyton will be sampled at sites selected using a stratified random design. Information gathered about the population dynamics of these aquatic fauna and periphyton communities will be used (1) as input for predictive models, and (2) to interpret the relationship between wading birds and aquatic fauna populations and the periphyton community structure and composition. Understanding this relationship between the upper, primary and secondary trophic levels will be used to assess CERP's performance.

SYSTEMATIC RECONNAISSANCE FLIGHTS WADING BIRD DISTRIBUTION SURVEYS SYNTHESIS, 1985–2001

Systematic Reconnaissance Flights (SRFs) are being conducted to (1) determine the relative contribution of short- and long-term effects of hydrologic stressors and landscape variables on the variation and trends in wading bird feeding patterns and population sizes observed over the past 17 years, (2) develop a wading bird performance measure for CERP based on relationships between wading bird spatial distributions and annual nesting effort, and (3) evaluate the SRF as a tool for wading bird monitoring. The main challenge of this project is to capture how wading birds use a dynamic landscape with key variables that are changing at different time scales and their association with nesting patterns.

SUBMERGED AQUATIC VEGETATION MAPPING IN FLORIDA BAY

Mapping of submerged aquatic vegetation (SAV) patches is a critical measurement for estuarine health. Seagrass communities act as habitat for many estuarine species, especially for many fish and invertebrates in their critical larval stages. Therefore, seagrass community composition and spatial extent is an indicator of estuarine productivity. The Florida Marine Research Institute, under a cooperative agreement with the SFWMD, digitized, georectified, and performed patch metric analyses on seagrass photography from the early 1990s, and attempted to take photos in 2003 for comparison. However, murky water conditions limited photographic capabilities during that time. It is anticipated that this photography for both Biscayne Bay and Florida Bay will be completed in fall 2004. Subsequently, digitizing and georectification of 1940s

Florida Bay photography will be performed for analyses of pre-drainage conditions in Florida Bay's seagrass communities.

SOUTHERN ESTUARIES SALINITY MONITORING NETWORK

Data gaps were identified within the salinity monitoring networks in both Florida and Biscayne Bays. RECOVER provided funding through a cooperative agreement with Biscayne National Park to purchase additional salinity meters for deployment throughout Biscayne Bay. In Florida Bay, meters are being installed at three areas for monitoring purposes. Importantly, there is a monitoring station at West Lake, a key water body on the saltwater-freshwater interface. Additionally, quarterly salinity monitoring measurements are going to be collected for the first year of sampling to determine salinity variability throughout this lake.

OYSTER MONITORING IN SOUTHEAST FLORIDA ESTUARIES

The main objective of this project is to implement a long-term monitoring program for American oysters (*Crassostrea virginica*) in Southeast Florida. Four aspects of oyster ecology will be monitored: (1) spatial and size distribution patterns of adult oysters, (2) distribution and frequency patterns of oyster diseases resulting from infection by pathogens [*Perkinsus marinus* ("dermo") and *Haplosporidium nelsoni* (MSX)], (3) oyster reproduction and recruitment, and (4) juvenile oyster growth and survival. Oyster beds provide important habitat for numerous organisms and are strong indicators of a healthy estuary. The change in spatial extent and health of oyster beds in Southeast Florida estuaries are a key performance measure that will help assess CERP's success. Data generated and contained in project reports will be analyzed to determine if the health and spatial extent of oysters is improving with time. Maps of oyster location, density, and health will also be a key product.

SOUTH FLORIDA FISHERIES HABITAT ASSESSMENT

The goal of the South Florida Fisheries Habitat Assessment is to provide information for spatial assessment and resolution of interannual variability in seagrass and macro-algal communities and to establish a baseline to monitor responses of these communities to water management alterations associated with CERP activities. The status and trends of seagrass distribution, abundance, and reproduction will be documented. Process-oriented data such as photosynthetic quantum yields and epiphyte loads will be provided. Resource managers will be able to use these data to address ecosystem response issues on a real-time basis, and to weigh alternative restoration options. Specific objectives of the project are to (1) develop a basic understanding of the relationships among salinity, water quality, and seagrass species distribution and abundance in South Florida, (2) provide data to separate anthropogenically induced changes from natural system variation, and (3) verify model predictions on species and ecosystem-level responses to system perturbations.

SOUTHERN ESTUARIES DISSOLVED ORGANIC MATTER FATE AND EFFECT

Everglades restoration has generally focused on the loading, fate, and effects of phosphorus because the Everglades are known to be limited by phosphorus availability. However, primary production in estuaries and other coastal marine ecosystems generally is commonly limited by the availability of nitrogen, and this may be the case in western and central Florida Bay. One hypothesis of concern to the SFWMD is that nitrogen loading to the bay from the Everglades may increase with increasing freshwater flow causing stimulation of algal blooms (Brand, 2002;

CROGEE, 2002). Some evidence is consistent with this hypothesis. Ongoing research (as part of RECOVER) is being conducted to measure the fate and effect of nitrogen from the Everglades in Florida Bay. Water quality modeling (part of CERP's Florida Bay and Florida Keys Feasibility Study) will utilize results from this research to assess CERP impacts on Florida Bay water quality and provide restoration recommendations to CERP.

CALOOSAHATCHEE ESTUARY SUBMERGED AQUATIC VEGETATION MONITORING

The premise of CERP is that restoring hydrology in the Caloosahatchee Estuary will improve spatial and structural characteristics of submerged plant communities. SAV beds provide important habitat for numerous organisms and are indicators of a healthy estuary. The objective of SAV monitoring in the Caloosahatchee Estuary is to determine if the restoration of beneficial patterns of freshwater inflow, salinity, and water quality to the Caloosahatchee Estuary will achieve the expected distribution, community structure, and viability of SAV beds. This monitoring will provide the scientific basis for quantifying the success of these projects. During the first year of the project, it is anticipated that SAV will be monitored in the upper and lower Caloosahatchee River and San Carlos Bay.

CALOOSAHATCHEE ESTUARY SUBMERGED AQUATIC VEGETATION MAPPING FROM AERIAL PHOTOGRAPHY

SAV in the Caloosahatchee Estuary is being monitored through the use of mapping from aerial photography. The first mapping was completed in 1999, and another survey was done in 2003. Geographic Information System (GIS) maps are produced from the interpretation of these photos. Subsequent mapping approximately every two years will allow evaluation of SAV acreage trends and distribution changes.

CALOOSAHATCHEE RIVER/CHARLOTTE HARBOR JUVENILE FISHERIES MONITORING

The main objective of the Caloosahatchee River/Charlotte Harbor juvenile fisheries monitoring program is to (1) address the critical need for effective assessment techniques for an array of species and sizes of fish and selected invertebrates, (2) provide timely information for use in management plans, and (3) monitor trends in the relative abundance of fishes in a variety of estuarine and marine systems throughout South Florida. In addition to the primary goals of describing long-term trends in fishery abundance and size distribution related to fishery management, this data has been useful for preparing species inventories for major estuaries throughout Florida, documenting habitat and dietary needs for a variety of estuarine fish and invertebrates, displaying geographic information on fish distribution and primary nursery areas, and assessing the implications of water resource management to estuarine fish communities. Expansion of this holistic, multi-gear, long-term monitoring program into Southern Charlotte Harbor will provide South Florida resource managers with high quality information on fish communities that may be useful when gauging the effects of natural and anthropogenic disturbances, restoration projects affecting fish habitat, and changes in water quality and quantity.

CHARLOTTE HARBOR RESEARCH

The SFWMD, in collaboration with the Mote Marine Laboratory, will be conducting research needed to understand the effect of river flow on significant ecological resources and processes.

The Caloosahatchee River and Estuary (CRE) Collaborative Research Project coincides with a Mote Marine Laboratory five-year study of Charlotte Harbor, funded by the Mote Scientific Foundation and other private and public sources. The research being funded by the SFWMD expands Mote Marine Laboratory's study and extends it to the southern harbor. The objective of the first year of this work is to design the final research plan. This will include reconnaissance, expansion, and refinement of the Caloosahatchee Estuary Conceptual Ecological Model (RECOVER, 2004a), detailed identification of information needs, bibliographic updates and applications, preliminary field sampling and measurement, and development of a first year report. The objective of the overall CRE Collaborative Research Plan is to determine and empirically evaluate causal relationships of river flow to the distribution, abundance, and/or condition of selected valued ecosystem components.

MACRO-BENTHIC MONITORING ST. LUCIE ESTUARY AND SOUTHERN INDIAN RIVER LAGOON

The main objectives of the macro-benthic monitoring project for St. Lucie Estuary (SLE) and Southern Indian River Lagoon (SIRL) are to (1) evaluate the present health status of these water bodies as baseline data, (2) record and follow long-term changes in these ecosystems, (3) attribute causative factors to observed changes (i.e., freshwater runoff/release, natural successions and oscillations, climate change, other anthropogenic impacts), (4) pinpoint and evaluate anthropogenic disturbances, and (5) provide reference data for possible intensive short-term local monitoring programs.

Environmental monitoring determines the chemicals present in an ecosystem, but it does not identify the effects, especially long-term effects, on the ecosystem by those chemicals that are present (Spellerberg, 1994). Therefore, biological monitoring is generally regarded as one of the most effective tools in detecting natural successions/changes and anthropogenic disturbances in the environment, especially in marine systems. Benthic infaunal communities are primarily stationary, and therefore are continuously exposed to changes in the environment; this is in contrast to motile animal communities that can migrate out of an area during times of disturbance, while later returning to the (temporarily) impacted system. This is one of the main reasons why benthic infaunal monitoring is commonly regarded as one of the best tools for evaluation the health and long-term changes within the marine environment.

SOUTHERN INDIAN RIVER LAGOON SEAGRASS AND MACRO-ALGAE MONITORING

Seagrass and macro-algae will be monitored in the SIRL near the mouth of the St. Lucie River to document seasonal changes in seagrass and associated macro-algae (epiphytes, attached algae, and drift algae). Data collected will be used to better understand (1) the natural seasonal variability of seagrass and macro-algae in the study area, and (2) the response of the seagrass community to freshwater discharge. Additionally, water quality data will be collected to evaluate potential links between water quality and trends in seagrass and algae.

Seagrasses are a prominent feature of the SIRL, and are considered to be good indicators of ecosystem health. Seagrass monitoring data provides valuable information for assessing the health of the lagoon and for making water management decisions regarding the impacts of freshwater releases on marine resources. Freshwater releases into the St. Lucie River ultimately discharge over seagrass beds in the SIRL.

The dominant seagrass species in the SIRL are *Halodule wrightii* and *Syringodium filiforme* (Morris et al., 2000). Of these two species, *Syringodium* appears to be the most sensitive to declines in salinity (URS Greiner, Inc., 1999). Monitoring conducted in *Syringodium* dominated beds may provide earlier warning of freshwater and associated nutrient stresses than monitoring conducted in beds dominated by other species. Macro-algae within the seagrass beds will also be evaluated as potential indicators of excess nutrients.

This study will document changes in seagrass percent cover, shoot counts, percent occurrence, species composition, canopy height, and reproductive status at monthly intervals for at least one year. Additionally, density of epiphytes on the seagrass blades, and percent cover and occurrence of attached and drift macro-algae will be monitored. Salinity, light, and other water quality parameters will be collected within and adjacent to the seagrass beds for evaluating relationships between water quality and seagrass/algae.

INDIAN RIVER LAGOON AND LOXAHATCHEE ESTUARY SEAGRASS PHOTOGRAPHY AND MAPPING

Seagrass photography and mapping is performed every other year in the Indian River Lagoon and Loxahatchee estuaries to evaluate the long-term changes in the distribution and abundance of seagrasses. Traditional aerial photography is acquired at the end of the dry season when water clarity is at its best. The photography is then ground-truthed and GIS maps are produced. This mapping is an important way to quickly assess one of the most important estuarine indicators in this region.

WATER QUALITY MONITORING IN THE NORTHERN ESTUARIES

Water quality monitoring in the northern estuaries is intended to (1) document and evaluated changes in nutrient and pollutant loads transported to the Caloosahatchee, St. Lucie, and Loxahatchee River estuaries, and the Indian River and Lake Worth lagoons, and (2) document water quality trends of the estuarine and lagoon waters that are anticipated to occur as a result of upstream CERP projects. Water quality is currently being collected in all of these downstream receiving water bodies as well as at the major coastal salinity structure that are part of the original C&SF Project.

NORTHEAST FLORIDA BAY WATER QUALITY TRENDS

The water quality monitoring program for Florida Bay and the adjacent southwest Florida estuaries and coast is evaluating status, quantify changes, and documenting trends in water quality as a result of CERP implementation. During Water Year 2004 (WY2004) (May 1, 2003 through April 30, 2004), Florida Bay hydrologic conditions were near long-term averages with regard to rainfall, freshwater flow into the bay, and salinity. Water quality conditions have undergone a decade-long period of improvement with decreasing concentrations of total nitrogen, total phosphorus, chlorophyll *a*, and decreasing turbidity. In 2004, each of these parameters had values well below the long-term average. Since 1996, a similar trend of decreasing nutrient concentrations in water flowing into the bay also has occurred. During this period, nutrient and chlorophyll concentrations generally have been highest in the central bay.

EVALUATION

Performance Measures

All of the systemwide evaluation performance measures that are dependent on the South Florida Water Management Model (SFWMM), the Natural System Model (NSM), and the Lake Okeechobee Water Quality Model (LOWQM) have been updated to incorporate results from new versions of these models, which include expansion of the period of record simulated.[6] An ecological landscape model is needed to evaluate systemwide response of projects during the plan formulation and evaluation phases of the Project Implementation Report process. A number of modeling approaches will be considered including the Everglades Water Quality Model, a phosphorus deposition model, the Everglades Landscape Model (ELM), or new models or methods will be developed to evaluate changes to water quality.

The major RECOVER revisions and additions to evaluate performance measures are summarized as follows:

- In addition to grouping performance measures to evaluate Greater Everglades wetlands hydrology, the interpretation of performance relative to their targets was altered. Instead of meeting the target (NSM or 2000 existing condition) at discrete locations, an envelope or range of targets was developed for each landscape type based on modeling results for the entire landscape. The envelope for the hydrologic target is intended to capture some of the uncertainty of model results as well as scientific underpinnings of the target. New topographic data and land use classifications incorporated in model updates prompted RECOVER to refine locations of indicator regions used to evaluate impacts to the Greater Everglades wetlands.
- For two of the northern estuaries, Caloosahatchee and St. Lucie, the number of events outside of the salinity envelope was revised to accommodate the longer period of record in the SFWMM, version 5.0.
- For Biscayne Bay, salinity envelopes were identified for most contributing basins. Seasonal flow targets were created for Miami River and South Bay, while Snake Creek's target was revised. The salinity envelopes are based on estimated requirements of target communities or organisms. Regression analyses were used to relate salinity to flows from selected coastal control structures.
- For Florida Bay, new regression analyses relating salinity to water stages in Everglades National Park were improved by focusing on predictor gauges located nearest to each basin and incorporating additional environmental variables.

[6] The SFWMM was reviewed in 1988, the NSM in 1997, and the LOWQM in 1994 and 2004.

- Water supply performance measures were revised to focus on regionally significant water restrictions. Two additional measures were added to evaluate the severity of restrictions, as measured by duration of water restriction events.
- The performance measure for flood protection in the South Miami-Dade Agricultural Area was updated to incorporate calibration and validation results from the new version of the SFWMM (version 5.0). The target is based on 1983–1993 stage hydrographs of seven selected cells.

All accepted and proposed evaluation performance measures are presented online at http://www.evergladesplan.org/pm/recover/ret_perf_measures.cfm. Also, all CERP systemwide evaluation performance measures that were published in the Draft CERP Systemwide Performance Measures (RECOVER, 2004b) document are summarized in Appendix 7-2.

Regional Evaluation and Report Process

Development of systemwide performance measures is an important part of establishing the scientific basis for refining and improving CERP during the implementation period. One of the ways that the systemwide perspective can influence the design of CERP components is to take a look at the project-specific performance measures developed by Project Delivery Teams (PDTs). As goals, objectives, and performance measures are prepared for each project, a RECOVER team conducts a review for consistency with systemwide performance measures. RECOVER has been able to form standing teams with members from various agencies and technical disciplines. Orienting each team to a geographic area increases the likelihood that the same team will look at projects that are linked not only by proximity but also shared restoration goals. In this way, RECOVER can ensure consistency across projects and increase the opportunities for sharing lessons learned in a timely way.

Steps for conducting a performance measure review include the submittal by the project managers of documents describing project goals, objectives, and draft performance measures. The documents are distributed electronically to the review team and a briefing meeting is scheduled. Team leaders assemble comments and coordinate development of a draft report with the review team and the project team. Each report includes a table of project and corresponding CERP goals and objectives, a summary of consistency review findings and an appendix with more detailed comments on each performance measure. The final report is posted to CERP's Website at http://www.evergladesplan.org. The steps in the RECOVER review process are described in the RECOVER Review of Project-Level Performance Measures Standard Operating Procedure (RECOVER, 2004f).[7]

Comments on project-specific reviews have addressed variances in terminology (e.g., watershed versus systemwide) to inconsistencies in methodologies for evaluating phosphorus inputs to Lake Okeechobee. RECOVER review of performance measures has been completed for these projects and studies: Everglades Agricultural Area Storage Reservoirs, Lake Okeechobee Watershed Project, Acme Basin B Project, Biscayne Coastal Wetlands Project, Florida Bay/Florida Keys Feasibility Study, C-111 Spreader Canal Project, and the Combined Structural and Operational Plan for Modified Water Deliveries and the C-111 Canal Projects.

[7] RECOVER Review of Project-Level Performance Measures Standard Operating Procedure document is available at http://www.evergladesplan.org/pm/recover/recover_docs/ret/012604_ret_pm_review_prot.pdf.

The next step for these projects will be the screening and evaluation of an array of alternatives. RECOVER will contribute to the selection of a project plan through application of RECOVER performance measures to evaluate the systemwide performance and benefits of each alternative. Acme Basin B and the Lake Okeechobee Watershed projects, and several Water Preserve Area components, are expected to be initially addressed in the RECOVER alternatives evaluation.

PLANNING AND INTEGRATION

CERP implementation will take place over an estimated 30-year period. The magnitude of CERP, as well as direction from the U.S. Congress and the Florida Legislature, necessitate that a process to incorporate changing conditions, new information, and other factors that may affect CERP performance be established. As more detail becomes available from CERP feasibility studies and PIRs, the integration function of RECOVER will incorporate this information into the overall prediction of CERP's progress.

Initial CERP Update

In the 2004 Everglades Consolidated Report (SFWMD, 2004), it was reported that an effort known as the Initial CERP Update (ICU) would be a first step in assuring that new technical information is integrated into CERP's implementation. The purpose of the ICU has been to update the model simulation from the version used in the Restudy (SFWMM version 3.5) to the new model version (version 5.4), and to incorporate new information into the model that improves its accuracy (e.g., topography, evapotranspiration, land use, etc.). Projected future public water supply demands reflecting 2000 census results and agricultural demands based on future land use were also used to update the model inputs. The public water supply projected demands are greater than 19 percent than those used in the Restudy (note that actual demands grew 12 percent over the period from 1995 to 2000), while agricultural demands decreased slightly by 9 percent. The ICU has developed a new simulation of the 2000 existing condition (September 2003), and a new 2050 future-without-project condition (December 2003). In simulating an updated 2050 future-with-project condition, the challenge has been to best reflect the intentions of the Restudy while not reformulating or changing the plan. The results of two model simulations, available as of April 2004, are available online at http://modeling.cerpzone.org/cerp_recover/pmviewer/pmviewer.jsp. These results present the future-with-project condition, and include (1) CERP 1, which reflects the updated public water supply demands, and (2) CERP 0, which is a sensitivity analysis reflecting Restudy-like public water supply demands.

RECOVER's Regional Evaluation Team (RET), in their analyses of the CERP 0/CERP 1 model runs, identified five areas of plan performance that did not meet Restudy performance. A small group of planners, scientists, engineers, and modelers formed a Special Analysis Team (SpAT) to investigate operational fine-tuning to the CERP 1 run in an attempt to boost performance. The SpAT team agreed to limit its efforts to the original project footprints and to stay within the structural capacities identified in the Restudy. SpAT efforts addressed to varying degrees each of the five areas of poor performance identified by the RET, demonstrating that improvements to systemwide plan performance could be achieved. The RET is currently awaiting policy guidance on how to proceed to a final, updated CERP model simulation.

RECOVER Liaisons to Project Delivery Teams

The RECOVER liaison role was created to improve communication between the RECOVER systemwide perspective and the planning and design of CERP components by PDTs. RECOVER liaisons spent much of the first year tracking the progress of individual components as PDTs developed goals and objectives and performance measures to evaluate project alternatives. Projects were tracked by attending team meetings, participating in quarterly meetings of the SFWMD and USACE project managers, and monitoring project review meetings of the CERP Design Coordination Team.

Liaisons familiarized themselves with RECOVER products and resources by attending meetings of the active RECOVER teams: RECOVER Leadership Group, Regional Evaluation Team, Adaptive Assessment Team, Water Quality Team, and Comprehensive Plan Review Team. These teams have developed performance measures, a monitoring and assessment plan, updates to CERP modeling scenarios, and interim goals and interim targets for the RECOVER program.

Several tools have been developed by RECOVER liaisons to coordinate effectively with project implementation. Work breakdown structures had already been standardized for the Project Management Plan and Project Implementation Report processes. These templates were used to identify milestones that would require some type of RECOVER product or service, i.e., the use of a base condition developed by RECOVER, the review of project specific performance measures, evaluation of the systemwide effects of project alternatives, and review of project monitoring and operating plans.

A master calendar has been developed to track the dates when each project will approach a particular milestone, thus allowing RECOVER to project interactions for each upcoming year. The master calendar anticipated project needs far enough in advance to allow interdisciplinary, interagency teams to be formed to conduct project reviews. Often, the same team was available to review several projects that were related by geography or restoration goal, improving the likelihood that RECOVER input would be consistent and cumulative from one project to another.

Protocols are currently being developed to guide RECOVER-project interactions at each milestone. For example, the procedures for conducting the review of project performance measures (1) indicate when the review will begin, (2) describe the materials to be prepared, (3) request a review team briefing, (4) identify points of contact, (5) provide a sample report outline, and (6) display the steps and timeframe for completion of the RECOVER report. During the last year, RECOVER has used this protocol to complete the review of performance measures for seven CERP projects.

Next year, it is expected that many projects will be preparing a range of alternatives that will be used to develop one plan to be recommended for design and construction. Project-specific monitoring plans may also be in the planning stage. Protocols for RECOVER evaluation of project alternatives and review of monitoring plans have been drafted and close to completion.

These protocols and links to other RECOVER resources have been collected on RECOVER's Website at http://www.evergladesplan.org/pm/recover/recover_rap.cfm. The information is intended to be used by project managers and others who may be more familiar with CERP projects than the RECOVER program. In order to be user-friendly to the project audience, the layout of this Website mirrors the phases of project implementation (e.g., Project Management Plan, Project Implementation Report, Project Monitoring Plan, etc.).

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