REstoration COordination and VERification (RECOVER)
Evaluation Team, Regional Evaluation Report

TRANSMITTAL LETTER

April 5, 2006,

Project Managers and Planning Technical Leads
Biscayne Bay Coastal Wetland Project
Comprehensive Everglades Restoration Plan

Dear Project Team Managers and Planning Technical Leads,

RECOVER has completed its regional evaluation of the Biscayne Bay Coastal Wetland Project (BBCW) alternative plans and our final report is attached.

RECOVER's evaluation of project alternatives fulfills the following requirements as prescribed by the Programmatic Regulations:

1. Support project teams to achieve consistency with the CERP's goals and objectives;
2. Document the performance of the project alternative plans using RECOVER approved system-wide performance measures, project performance measures (when appropriate), and best professional judgment. RECOVER determines the ability of each alternative plan to meet the targets established for each performance measure and describes the resulting effects upon the natural system. When appropriate, RECOVER evaluations include a qualitative analysis on how the project fulfills CERP goals and objectives;
3. Suggest improvements to the project, which if pursued could improve project performance or enhance benefits to the natural system;
4. Provide insight, if possible, and alert the project teams of any inconsistent modeling assumptions for the project as originally modeled in the CERP.

Recommendations discussed within the RECOVER regional evaluation report generally fall into one of three categories:

1. Recommendations that can easily be incorporated into the plan formulation process;
2. Recommendations that are more conceptual in nature, which the Project Team may select to incorporate into preliminary designs to improve project performance; and
3. Recommendations that are crucial to the project, but cannot be addressed prior to the AFB meeting.

Concerning the latter category, RECOVER provided its regional evaluation to satisfy the need for timely reporting, while bringing forward as much science as possible. As a result, this report may not constitute the entirety of RECOVER's review as specified in the Programmatic Regulations. Therefore, RECOVER may provide additional information supporting and refining the original regional evaluation, with the expectation that those additional evaluation comments be considered by the project team.

The following list highlights RECOVER's comments to the project team.

- Both spreader canal path length and potential natural areas restored provide important water quality benefits that should be considered by the project team

- Current project nitrate estimates underestimate potential water quality benefits
- The BBCW project should consider interactions with the C-111 spreader canal project to enhance rehydration of the Model Lands. This includes the potential for a hybrid alternative (see section 4.2.6)
- Reservoir and STA operations should be conducted to minimize dry down in the project area thereby minimizing oxidation of sediments and corresponding potentially high sediment nutrient fluxes
- Additional water quality and biological tools/models which will yield performance measures should be developed both at the system and project level for this area of the system.
- When the project monitoring plan is developed it should incorporate both short and long-term response water quality and biological indicators and the data should be collected in a manor that could generate additional evaluation and assessment tools
- The planning process is iterative and should be treated that way. Normally a couple of rounds of modeling are needed to optimize the alternatives. RECOVER recommends that future projects incorporate these iterations into the planning process.
- This Biscayne Bay area could use additional water to achieve restoration targets. The ET recommends that future system-wide planning and adaptive management efforts incorporate a review of the system to determine if additional water is available for Biscayne Bay for both the BBCW and the C-111 spreader canal projects.

Best regards,

Evaluation Team Chairs
(Orlando Ramos-Ginés, Kim Chuirazzi, and Steve Traxler)

Biscayne Bay Coastal Wetlands (BBCW) Project
System-wide Evaluation Report
Prepared by RECOVER

1.0 Introduction and Purpose of the Evaluation

The Biscayne Bay Coastal Wetlands (BBCW) Project Team has identified their final array of alternative plans and requested that Restoration Coordination and Verification (RECOVER) conduct a system-wide evaluation of the alternative plans being considered. 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 or Comprehensive Plan). One of the primary missions of RECOVER is to work with the project team to evaluate and maximize the contribution made by each project to the system-wide performance of the CERP. The RECOVER Evaluation Team (ET) is charged with the responsibility of conducting system-wide evaluations (previously termed regional evaluations).

The ET is an interagency and interdisciplinary scientific and technical team charged with developing and using performance measures for evaluating alternative plans developed for Project Implementation Reports (PIRs). The purpose of the ET evaluation is to ensure that alternative plans are consistent with the goals and purposes of the CERP. For its evaluations, the ET has developed a suite of approximately 40 ecological performance measures and 8 water supply and flood protection performance measures. Output from the South Florida Water Management Model (SFWMM version 5.4), which is the primary hydrologic simulation model for the CERP, is used to produce performance measure output. The SFWMM is a regional-scale model that provides simulations of hydrologic conditions at a 2-mile by 2-mile spatial resolution. Because of the large-scale resolution of the model and the relatively small hydrologic influence of some CERP projects, ET performance measures may not always reveal differences in system-wide performance of project alternative plans. In these cases, RECOVER uses other scientific information to evaluate the potential performance of project alternatives on the system.

The purposes of regional evaluations are to (1) inform the project team of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures, project performance measures, and best professional judgment; (3) identify improvements for project performance that would improve its regional performance, and (4) provide decision-makers required information regarding regional performance expectations of specific projects.

The type of RECOVER evaluations may vary depending on the applied tools, new information that may have become available, the project's relationship to the Central and South Florida (C&SF) Project, or the project implementation schedule. In the case of hydrologically isolated projects, RECOVER may not be able to rely on regional modeling results for their evaluations. For these projects, the scope of RECOVER's evaluations may be limited to reviewing project-level model results and applying best professional judgment.

2.0 Project Background and General Description of Alternative Plans

2.1 Project Goals and Objectives

The BBCW Project is part of the CERP as authorized by the Water Resources Development Act (WRDA) 2000 (U.S. Congress 2000). The goal of the BBCW Project is to restore or enhance freshwater wetlands, tidal wetlands, and nearshore bay habitat. The objectives of this project, as identified in the BBCW Feasibility Scoping Meeting Document (USACE and SFWMD 2004) are as follows:

- Reestablish productive nursery habitat along the shoreline.
- Redistribute freshwater flow to minimize point source discharges to improve freshwater and estuarine habitat.
- Restore and improve quantity, quality, timing, and distribution of fresh water to the bay, including Biscayne National Park.
- Preserve and restore the spatial extent of natural coastal glades habitat.
- Reestablish connectivity between Biscayne coastal wetlands, C-111 Basin, Model Lands, and adjacent basins.

2.2 Project Background

In the pre-drainage Everglades, water flowed to Biscayne Bay through near-surface groundwater, overland flow through sloughs, freshwater upwellings in the bay, and overland sheet flow (Ruiz and Ross 2004). Groundwater levels have been lowered by several feet since the 1920s in order to provide flood protection to nearby populated areas. Lower groundwater levels have resulted in substantial decreases in groundwater flow into Biscayne Bay. Stormwater runoff in canals has replaced the much more gradual dispersal of water provided by overland sheet flow. These canals now discharge at a few points along the shoreline increasing the intensity of freshwater discharges and precluding stormwater flows through coastal wetlands. Levee 31 East (L31E) was constructed about 30 years ago near the coast of southern Biscayne Bay to help control the damaging effects of salt water intrusion on the Biscayne Aquifer. A drainage system is currently operated to provide flood protection drainage for agricultural land uses, and to maintain adequate freshwater supply for groundwater withdrawals by private and public wells.

The issues and opportunities for restoration in southern Miami-Dade County have been discussed for many years. This project began to take form under the Biscayne Bay Surface Water Improvement and Management (SWIM) Plan administered by the South Florida Water Management District (SFWMD). Certain issues and solutions were proposed in the early 1980s and investigated under Miami-Dade County's Biscayne Bay Management Plan. The SFWMD has been operating a pilot project, L-31E Culvert and Weir Project, in the study area and conducting research for several years. Much of the land in the project area remains open, therefore restoring and using wetlands near the coast is recommended to slow runoff and redistribute flow away from the canal outfalls into a more natural estuarine system. The major benefits of restoring more natural drainage would be to restore estuarine conditions, as well as improve inland freshwater habitats. Other benefits may include improved water quality and enhanced water supply protection.

The CERP includes a brief conceptual description of the BBCW Project. It was identified as an “Other Project Element”, meaning that the effect of the proposed project could not be modeled with the SFWMM. The SFWMM was designed to predict and quantify broad, regional changes in hydrology in the inland portions of South Florida. The hydrologic impact of the BBCW Project is near the minimum spatial resolution of the SFWMM, and lies along the southeastern boundary of the model domain, increasing model uncertainty and reducing the utility of model results. Consequently, the BBCW Project Team used a combination of regional model output and best professional judgment to evaluate their suite of project alternatives. RECOVER also used this limited model output to the extent feasible, as well as best professional judgment to review the project’s analysis of local benefits and to provide the system-wide perspective of the performance of proposed alternative plans.

2.3 General Description of Alternative Plans

The BBCW Project identified their final array of five project alternative plans. Alternative plans being considered include management measures such as stormwater treatment areas (STAs), reservoirs, and spreader canals. The five alternatives that make up the final suite of alternative plans are as follows:

- Alternative E
- Alternative J
- Alternative M2
- Alternative Q
- Yellow Book (YB) Alternative

Documentation for the management measures associated with each alternative plan was provided by the BBCW Project Team and can be found in Appendix A of this report.

3.0 Evaluation Methodology and Information Considered

This section outlines the methodology used by RECOVER to conduct its system-wide (regional) evaluation of alternative plans. It also describes the modeling and technical information considered by RECOVER to evaluate the potential system-wide effects of the BBCW Project. RECOVER’s analyses of the information and its evaluation of the implications to the system are presented in later sections of this report.

3.1 Methodology

Because the BBCW Project is essentially outside the spatial resolution and domain of the SFWMM, the Watershed Systems of 1-D Stream-River Networks, 2-D Overland Regimes, and 3-D Subsurface Media (WASH123D) and TABS-Multi-Dimensional Sediments (TABS-MDS) sub-regional models were used by the project team to simulate canal, groundwater, and surface water flows in the project footprint. Some model output data from these sub-regional models warranted further investigation, prompting the project team to consider additional available data, GIS tools, and best professional judgment to describe potential performance of the alternative plans at the project area. The BBCW Project Team provided RECOVER with the following information for consideration during the system-wide evaluation of alternative plans:

- WASH123D and TABS-MDS output for an average water year (1998-1999)
- Ecological Benefits Analysis Methodology (Appendix B)
- "Quantifying Ecological Benefits and Evaluating Alternatives for the Biscayne Bay Coastal Wetlands Project" Draft Report

RECOVER typically uses CERP system-wide performance measures to evaluate alternative plan performance; however, these performance measures are dependent on SFWMM output. Because the project area is on the boundary of the SFWMM domain and because at this boundary the SFWMM does not perform as expected, RECOVER evaluated the alternative plans performance using the following methodology:

- RECOVER reviewed salinity output from the TABS-MDS sub-regional model for each alternative, and where feasible compared results to the CERP system-wide performance targets established for different regions of Biscayne Bay.
- RECOVER reviewed WASH123D hydrologic output to determine if there were any expected benefits or impacts to the wetlands and freshwater marshes upstream of the project. Due to concerns over modeling RECOVER did not use this output for analysis. Rather, the review team provided comments on model formulation to help future model efforts.
- RECOVER reviewed the ecological benefits analysis methodology and matrix provided by the project team (Appendix B and C) and provided any additional considerations or expected benefits/impacts of each alternative plan for the Project Team to consider.
- RECOVER reviewed the management features information to qualitatively determine the project effects on water quality, water supply, flood protection, and saltwater intrusion.
- RECOVER reviewed the modeling assumptions and proposed changes to the alternative plans, and/or operational features that may improve alternative plan performance. The Project Team should consider the proposed changes when refining their tentative selected plan (TSP).

3.2 Hydrologic Modeling Considered

RECOVER reviewed the WASH123D and TABS-MDS model results. As noted earlier RECOVER did not use the WASH123D output due to concerns over model conceptualization and formulation. Where possible, TABS-MDS output was compared to RECOVER salinity targets.

3.3 Water Quality Information Considered

Because RECOVER currently lacks existing water quality tools for the region within which the project is located, RECOVER considered non-model hydrologic information that could be assessed in term of their potential water quality effects on the system. Such information included structural flows, frequency of STA drydowns, creation/restoration of natural areas, and canal operations. Additionally, RECOVER has considered non-model information for water quality parameters evaluated by the project team as presented in the ecological benefits analysis matrix.

3.4 Additional Pending Modeling Results

Additional model results may be pursued by the BBCW Project Team. When available, RECOVER will review these additional model results and provide modified and/or additional comments to the BBCW Project Team on alternative plan performance, where appropriate.

4.0 Consistency of Project Goals and Objectives and System-wide Performance of Alternatives Plans

4.1 Project Goals and Objectives - Consistency with the Comprehensive Plan

The planning objectives developed for the BBCW Project are generally consistent with the objectives of the Comprehensive Plan (USACE and SFWMD 1999). The planning goal of this project is to restore or enhance freshwater wetlands, tidal wetlands, and nearshore bay habitat. It will primarily contribute to CERP environmental benefits to Biscayne Bay by improving the quantity, quality, timing and distribution of freshwater deliveries to the bay. The planning objectives for this project were developed using both the broad CERP goals and objectives and the more defined regional and site-specific restoration objectives. The five objectives developed for the BBCW Project presented below (Table 1) directly correspond to specific CERP objective(s) contained in the Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (USACE and SFWMD 1999).

Table 1. Project and CERP objectives

Project Objective	Corresponding CERP Objective(s)
Reestablish productive nursery habitat along the shoreline.	Improve habitat and functional quality. Improve native plant and animal species abundance and diversity.
Redistribute freshwater flow to minimize point source discharges to improve freshwater and estuarine habitat.	Improve habitat and functional quality. Improve native plant and animal species abundance and diversity.

Restore and improve quantity, quality, timing, and distribution of fresh water to the bay, including Biscayne National Park.	Improve habitat and functional quality. Improve native plant and animal species abundance and diversity.
Preserve and restore the spatial extent of natural coastal glades habitat.	Increase spatial extent.
Reestablish connectivity between Biscayne coastal wetlands, C-111 Basin, Model Lands, and adjacent basins.	Increase availability of fresh water. Improve habitat and functional quality. Increase spatial extent.

4.2 System-wide Performance of Alternative Plans

The following sections summarize performance of the project alternatives using the methodology described in Section 3.1 of this report. Given the underlying issues with the model tools used by the project team, RECOVER decided to provide additional, relevant evaluation on how the models were conceptualized for the project area. RECOVER identified major concerns with how models were conceptualized to represent the hydrologic system in the project area. The comments made by RECOVER on the conceptualization are intended to help with future project model refinement efforts. RECOVER opted to use physical/structural and operational features of the project, or any other available information, to provide a system-wide evaluation of the alternative plans.

4.2.1 Review and Evaluation of WASH 123D Hydrologic Model and TABS-MDS Model Conceptualization and Output

The hydrologic system for the wetlands portion of the project area was simulated using the WASH123D model. The model's western boundary condition utilizes output from the SFWMM southeastern boundary, as modeled under Alt7R5 (SFWMM v5.4.1). The WASH123D model is a fully coupled groundwater/surface water model. Output from the eastern boundary of the WASH123D model provides input data to the TABS-MDS model. The TABS-MDS model is the hydrodynamic model that is used by the project team to quantify the salinity based performance measures in the nearshore bay region of the project area. Although both models have been used successfully to simulate natural environments, their conceptualization and construction to represent the hydrologic system in the BBCW project area is of continued concern to the Project Team and to RECOVER.

The BBCW Project team members brought concerns to the Engineering Research and Development Center (ERDC) of the US Army Corps of Engineers (USACE) concerning how the WASH123D model represents/simulates the hydrologic system in the project area. ERDC has attempted to rectify these issues. However, as currently constructed, the model continues to show unrealistic flows in some basins. For example, historical data and SFWMM output, including the future with and without CERP, indicate that the C-103 Canal provides a relatively large fraction of water to the bay, varying from about 17 to 33 percent of the total surface flows for 1998-1999 (average rainfall conditions). WASH123D output indicates that percentage of total surface flows through C-103 Canal for existing conditions, future without CERP, and the

Yellow Book alternative is only 6, 1, and 0.01 percent, respectively. The opposite trend appears to be true for the C-100 basin, which has too much flow compared to historical conditions.

Also of concern are the differences observed between WASH123D output and that of a USGS regional groundwater model that includes the project area. WASH123D indicates very high groundwater fluxes to the bay and a very large percentage (approximately about 70 to 80 percent) of the total fresh water entering the bay arrives as groundwater. Groundwater flux across the project area, according to the WASH123D output, is on the order of 700,000 acre-feet per year. In contrast, the USGS Regional Groundwater Model indicates that the groundwater discharge rate along the entire western bay coastline is probably only about 6 percent of the measured surface water discharge (Langevin 2001). The USGS model suggests that nearly 100 percent of the fresh groundwater discharge to the bay occurs through the northern half of the bay, north of the C-100 Canal. The coastal lowlands south of C-100 Canal prevent the water table from rising high enough to drive groundwater to the bay and almost all of the BBCW Project area lies south of the C-100 Canal.

The WASH123D simulations of surface flows and the large groundwater transfer from the eastern model boundary to the western boundary of the TABS-MDS model explains the much lower than expected salinity values along the coast as simulated by TABS-MDS model. This led the project team to believe that the performance of project alternatives is unreasonably high for salinity-based performance measures for virtually all alternatives. RECOVER has similar concerns over the western boundary conditions provided to TABS-MDS by WASH123D.

According to ERDC modelers, the concerns with the WASH123D output stem from a combination of the western boundary conditions obtained from the SFWMM CERP0 simulations (v5.4) and the fact that the SFWMD often did not follow the operating rules for water control structures in the model domain. The latest version of the WASH123D simulation includes adjustments to the opening and closing triggers of the water control structures in the model domain in an attempt to “work around” the above identified issues. These latest adjustments have produced more reasonable groundwater flows to Biscayne Bay along the coastline in the C-100 and C-103 basins; however, the simulated groundwater flows remain much higher than estimated groundwater flows. Because of these apparent problems with the constructed WASH123D model for the project area, the BBCW Project Team has been reluctant to include results from this model in its benefits analysis and evaluations of the alternative plans. The IMC also provided review of previous WASH123D model version for the Biscayne Bay project area and has agreed with project team concerns (December 2004 and October 2005). RECOVER concurs. In the current state, the constructed model does not reasonably represent the hydrologic system of the project area.

In an effort to utilize output from the TABS-MDS model constructed for Biscayne Bay, ERDC recently conducted additional runs of the model using the latest WASH123D output for the TABS western boundary condition, reducing groundwater flux data from the WASH123D outputs by 300,000 acre-feet/year for all alternative plans prior to being input to TABS-MDS. This adjustment provides more reasonable total freshwater input to the TABS-MDS model, which results in more realistic performance of the alternative plans as compared with salinity performance measures. It also provides more realistic differences between alternatives. At the time this report was prepared, these latest TABS-MDS data were being included in the multi-criteria decision matrix agreed-upon by the project team. RECOVER expects to review this new output and any additional model results and will provide comments to the project team where relevant.

4.2.2 Evaluation of Ecological Effects

Background

Historically, the Biscayne Bay coastal wetlands and nearshore areas supported a diverse assemblage of estuarine faunal communities, including oyster reefs, estuarine fish and crocodiles. The remains of oyster reefs have been found in association with remnant coastal creeks that once dispersed fresh water to the bay through coastal wetlands (Meeder et al. 1999). Historic photographs, satellite imagery and soil analyses show that, prior to construction of the South Dade Conveyance System, estuarine conditions in lower Biscayne Bay were maintained by the flow of fresh water through the series of creeks within the project area (Meeder et al. 1999). As many as 48 historic creek beds have been identified between Shoal and Convoy Points (Meeder et al. 2001). Major creeks drained surface water passing through the transverse glades of the coastal ridge and were distinct from the shorter, more numerous tidal creeks and creeks that originated at local springs. Redfish and other species of sciaenids that rely upon estuarine areas were "abundant at all seasons" during the late nineteenth century (Smith 1896). Prior to the early part of the twentieth century, Miami-Dade County was at the core of the American crocodile geographic range in the United States (Kushlan and Mazzotti 1989) and coastal wetlands along the western shore of Biscayne Bay provided important crocodilian habitat.

Estuarine fishes and shellfish have precipitously declined in abundance due to the loss of estuarine habitat along the bay's southwestern edge (Serafy et al. 2001). The diversity of estuarine species is very low in southern Biscayne Bay today. Historic oyster beds are presently inactive due to habitat changes associated with the loss of freshwater discharge into the wetlands through creek systems. Attempts to restore red drum to the bay through stocking failed largely because juveniles were released into areas that were no longer consistently estuarine (Serafy et al. 1996).

Abrupt canal-driven salinity fluctuations are damaging to aquatic plants and fish populations (Montague and Ley 1993, Serafy et al. 1997). In the southwestern part Biscayne Bay, the salinity of marine waters, downstream of canal water control structures, usually 30-35 parts per thousand (ppt), frequently drops 20 ppt within 60 minutes and returns almost as rapidly (Chin and Wang 1987). As the system is currently operated, these dramatic salinity fluctuations can occur several times per day during the wet season (June - October) when water is released through control gates. The higher salinities that now characterize the western bay and adjacent wetlands have severely reduced the suitability of this area for juvenile crocodiles, which require relatively low salinities for proper growth and development.

Salinity requirements for oysters, estuarine fishes and crocodiles are very similar. For oysters, ideal salinity ranges in South Florida are 5-15 ppt during the wet season and 10-19 ppt during the dry season (RCOVER 2006) 5-15 ppt from June through October, with higher salinities during the remainder of the year. Ideal salinity for juvenile crocodiles is 0-20 ppt in the mangrove wetlands and coastal creeks during the wet season and several months into the dry season (approximately June through January; Mazzotti et al. 2002).

Evaluation

The combination of storage, STA treatment capacity and spreader canals is expected to help address project goals by providing flexibility in distributing water at more appropriate spatial and temporal distributions.

The RECOVER performance measure SE-6 for South Biscayne Bay provides estimates from Meeder et al. (2002) that 321,912 and 145,595 acre-feet of water in the wet season and dry season, respectively, is required to reestablish and maintain the freshwater wetlands and establish a positive salinity gradient, with an average bottom salinity of 20 ppt, 500 meters into the bay from the shoreline during the wet season and 250 meters into the bay from the shoreline during the dry season. If the project is successful at providing sufficient fresh water at the appropriate temporal and spatial scales, reestablishing a broader, more stable polyhaline zone in shallow waters further offshore should provide more suitable nursery habitat for pink shrimp. Shrimp densities in the northern part of the restoration area (between Shoal Point and Black Point) appear robust. However, shrimp densities in the southern area (between Black and Convoy points) are very low, possibly because of the widely fluctuating salinities that now prevail in the southern area.

An analysis of the RECOVER performance measures for Biscayne Bay, using the project information provided and available to us, shows that maximum benefits could be obtained when the performance measure targets are met through the delivery of adequate quantities of water. The Initial CERP Update (RECOVER 2005b) reported that the modeled CERP alternative (CERPA) provides approximately 60% of the wet season flow and 77% of the dry season flow required to meet the target for the BBCW area. The CERP Monitoring and Assessment Plan (MAP) (RECOVER 2004) and the Draft 2005 Assessment Strategy for the Monitoring and Assessment Plan (RECOVER 2005a) contain hypotheses and supporting research directly addressing nearshore community structure. As research on the MAP elements continues, community response within the project area will be better understood and developed.

4.2.3 Evaluation of Water Quality Effects

Water Quality Approach by Project Team

In the estimation of benefits, the project team focused on the various proposed STAs upstream of the spreader canals and estimated water quality benefits based upon load reduction expected from the STAs. This was based on projected future land uses, estimates of rainfall, runoff coefficients, estimates of possible implementation of best management practices (BMPs), and changes in runoff due to project components. These calculations produced runoff volumes and concentrations necessary for benefits quantification. They were obtained for the existing conditions, the future with project conditions and for each of the alternative plans. Estimates of the expected quality of water to reach the proposed spreader canals and, ultimately, the wetlands were derived from first order wetland decay equations for total phosphorus and nitrate. The project team did not estimate other water quality benefits beyond nitrate load reduction.

RECOVER Analysis

RECOVER recommends the project team consider the following approach in quantifying additional water quality benefits. The project's forecast of future water quality conditions herein presented assumes planned land use changes and BMP implementation. However, RECOVER cautions that those are current plans that may not necessarily be implemented in the future. The project team estimates of (existing) concentrations of total phosphorus characterized existing Miami-Dade Department of Environmental Resource Management (DERM) water quality data accurately (Table 2). The estimates of existing nitrate concentrations, however, significantly underestimated DERM water quality data (Table 3) (http://www.sfwmd.gov/org/ema/envmon/wqm/bisc/biscs.html). The predicted future water quality conditions are significantly lower than existing conditions (Table 2 and 3).

Table 2. Total phosphorus concentrations in mg/l (DERM water quality stations)

			Predicted Future Total Phosphorus Concentration:		
Canal	**Existing DERM**	**Predicted Existing based on Land Use**	**Future Based upon Land Use**	**Less BMPs + STAs**	**Future Estimated**
C-102	0.007 (PR03)	0.007	0.007	Not estimated	Not estimated
C-103	0.007 (MW04)	0.007	0.007	Not estimated	Not estimated

Table 3. Nitrate + nitrite-N concentrations in mg/l (DERM water quality stations)

			Predicted Total Nitrate Concentration:		
Canal	**Existing DERM**	**Predicted Existing based on Land Use**	**Future Based upon Land Use**	**Less BMPs + STAs**	**Future Estimated**
C-102	1.49 (PR01) to 4.017 (PR03)	0.8	1.0595	0.4786	0.5809
C-103	2.2 (MW04)	0.67	0.8774	0.2115	0.6659

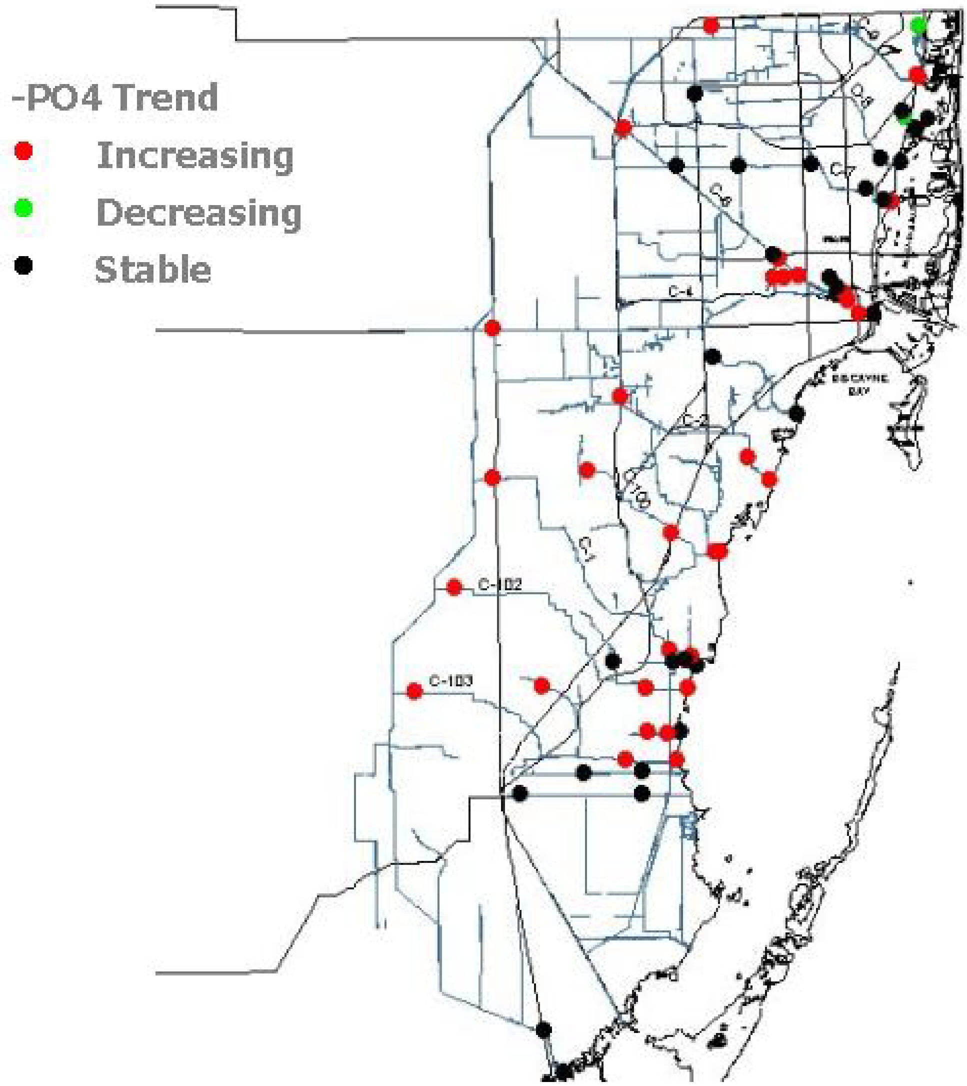

Figure 1. **DERM data on TPO4 trends in BBCW Project area**

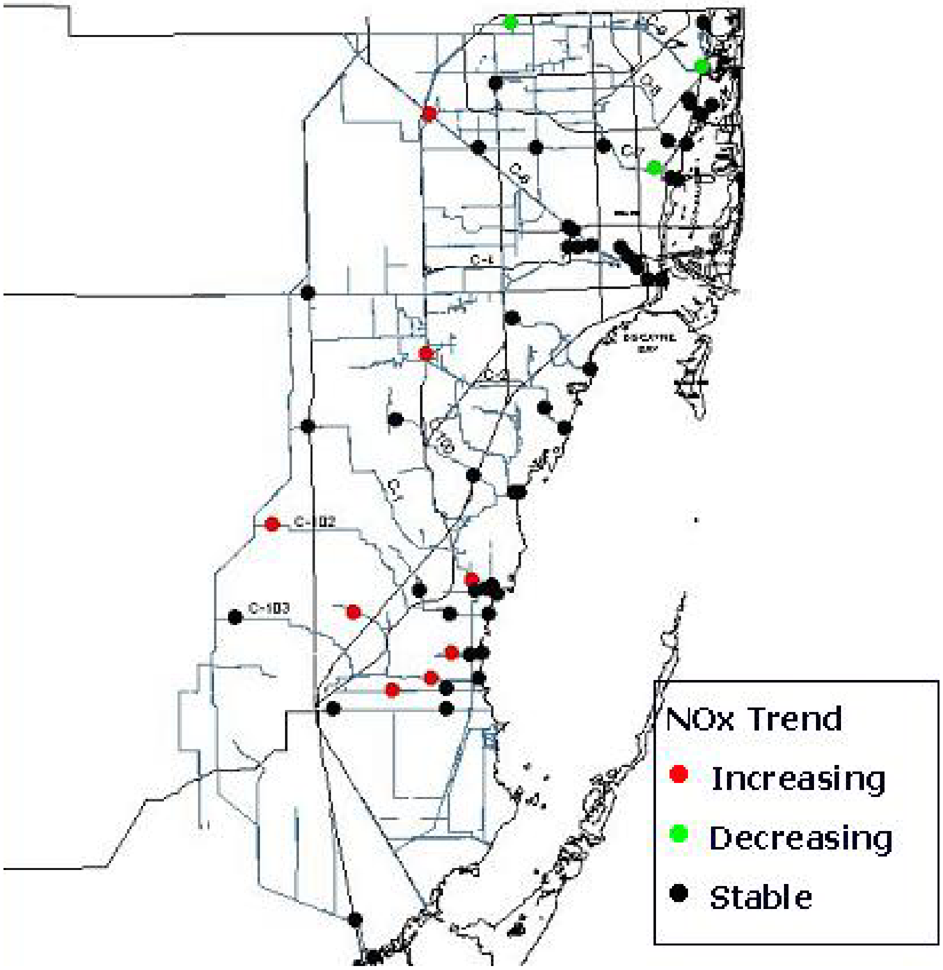

Figure 2. **DERM data on NOx (nitrate/nitrite) trends in the BBCW Project area**

The project WQ estimates forecast future conditions as stable for total phosphorus and improving for nitrate. These estimates do not include the effect of using Reuse water which will likely have different (higher) concentrations than canal water estimates. Dade Environmental Resource Management (DERM) forecasts TPO4 conditions in the area degrading and nitrate/ nitrite conditions degrading or stable (Figures 1 and 2) (Miami-Dade DERM, Natural Resource Division, Numeric Nutrient Criteria Technical Advisory Committee presentation February 19, 2004). The project team's optimistic forecast reduces the potential WQ benefits obtained by the project alternatives. RECOVER recommends that the project consider projected nitrate and phosphorus concentrations provided by Miami-Dade DERM.

The project also has significant water quality benefits in addition to those offered by the STAs. Canal path length itself and the potential for various spreader canals to help rehydrate and restore significant areas of wetlands may produce benefits that exceed that of the STAs by an order of magnitude. RECOVER suggests that water quality benefits provided by the spreader canal and rehydrated natural areas, which are beyond those provided by the proposed STAs, be included in the benefits quantification by the project team

Rehydrating Natural Areas

Increased spatial extent of natural areas by rehydrating inland marshes and estuarine habitats not only directly benefits biota by restoring previously degraded habitats, but also provides important water quality benefits not previously included by the project team in its benefits quantification. The ability to maintain more natural timing and distribution of water in the coastal wetlands allows periphyton and other native vegetation to flourish. This provides additional phosphorus uptake capacity beyond that of the proposed STAs. Increasing the spatial extent of natural areas along with available carbon production (CO_2) also leads to increased denitrification, thereby benefiting the system further. In a study conducted by Rudnick et al. (1999) on the Taylor Slough, dissolved inorganic nitrogen (DIN) decreased from 240 µg l^{-1}(17 mM) to 36 µg l^{-1} (2.6 mM) along a 3 kilometer flow path. Although this was a peat based system and some of the project area is more of a mineral-based (marl) system, similar (slightly lower) denitrification benefits can be expected. Rehydrating the Model Lands through coordination of C-111 and BBCW Projects can potentially provide long-term water quality and habitat benefits.

The project will offer substantial water quality benefits to the downstream areas of the project footprint. This will affect loads conveyed to southern Biscayne Bay. The rapid loading that occurs via the C-1, C-102, and C-103 Canals will be spread across a flow path several miles long (http://www.sfwmd.gov/org/ema/envmon/wqm/bisc/biscs.html). This will likely provide significant system-wide benefit to the Southern Estuaries. This will improve the status of or conditions for several Southern Estuaries performance measure indicators including nutrient concentrations, nutrient loading, algal blooms, water clarity, and toxins.

STAs and Reservoirs

The current alternatives provide flexibility in STA and reservoir design and operations that can maximize benefits for water quality or potential for restored or enhanced natural areas. STAs can be extremely efficient if designed and operated to promote periphyton and emergent and submergent vegetation, as well as particulate settling. The 2,997 and 3,615 acres proposed under alternatives E and J, respectively, provide important acreage for phosphorus reduction. Similarly, alternatives E and J provide the most storage flexibility to optimize the timing of water deliveries. The potential to make water available in the dry season can help reduce nutrient fluxes associate with sediment oxidation. These alternatives provide more STA acreage than the Yellow Book design. Additionally, the Yellow Book design did not call for reservoir construction. The project team recognizes the water quality benefits provided by the STAs and reservoirs. RECOVER stresses the importance of adaptive management to help projects obtain their objectives (and goals) in the face of current uncertainties.

Spreader Canal

The spreader canals are key features of the restoration provided by this project. Spreader canals distribute water across flow paths, providing significant areas of inundation, which translates into restored or enhanced wetlands. The current alternatives provide flexibility and demonstrate a range of benefits by using spreader canals. The differences in spreader canal length amongst the alternatives provide variation in the flow path. Considering inundated acreages with hydroperiod between 0.5- to 3.5 -feet stage could provide an indication of this benefit. Given 1999-2000 was a statistically dry period, it would be reasonable to expect that the acreage determined was a conservative estimate of the wetland restoration/creation capacity of the proposed spreader canals. During dry periods, water stages would be at or near their lowest and the foot print created by spreader canals would be at or near its smallest. The flow path from the spreader canal to the mangrove areas is approximately 3.5 miles (18,000 feet). The range of wetlands created (compared to the without project condition) during the 1999-2000 dry period varied from 2,192 to 4,420 acres for alternatives J and Q, respectively (Table 4).

An idealized 5,000-foot spreader over the 18,000-foot flow path would potentially create about 2,100 acres of wetlands. This is consistent with the range of inundated acreages is presented Table 4. Accordingly, load reduction would vary between alternatives due to differences in spreader canal length. Water quality effects due to the spreaders would be magnified as these wetlands are less likely to endure dry out. Project components would not dry out and additional inundated areas would be available to provide relief to nutrient loading to southern Biscayne and Florida Bay. The PDT recognized the importance of the spreader canals in relation to connectivity and spatial extent, but RECOVER recommends noting the potential water quality benefits associated with the spreader canal and the rehydration of natural areas.

Table 4. Water quality flow paths and wetlands

Alternative	Deering and Black Creek	South and Florida City Canal	Wetlands South of Florida City Canal	Total Inundation Acreages	Net Difference between Future Without Project and Alternatives
Yellow Book	0	702	4,699	9,988	2,287
Future Without Project	0	371	4,348	7,701	0
E	0	797	5,332	10,222	2,521
J	0	371	4,798	9,893	2,192
M	0	1,076	4,563	11,395	3,694
Q	0	837	4,028	12,121	4,420

4.2.4 Evaluation of Effects on Water Supply, Flood Damage Reduction, and Saltwater Intrusion

Background

The BBCW Project is located directly above the Biscayne aquifer, which covers most of Miami-Dade and Broward Counties. Water in the Biscayne aquifer is unconfined and the aquifer has high hydrologic conductivity, exceeding 300,000 feet/day in eastern Miami-Dade County (Fish and Stewart 1991). Consequently, water levels respond rapidly to recharge or groundwater withdrawals, including drainage and recharge from canals, recharge from rainfall, evapotranspiration, and pumpage from supply wells (Sonenshein 1995). The large reservoirs and STAs planned in some of the project alternatives, and the more stable flow of fresh water to the coast especially during the dry season, are expected to deter saltwater intrusion in southeastern Miami-Dade County. The ability to deliver water to the coast during the dry season is likely dependent upon several assumptions, including the availability of reuse water.

Under predrainage conditions, large volumes of low dissolved-solids water formed seasonally and flowed eastward forcing the saltwater-freshwater interface toward the coast. Since the development of canal and flood protection systems in South Florida, the saltwater-freshwater interface has moved westward. Saltwater intrusion has been a concern in Miami-Dade County; coastal well fields began showing evidence of increasing salinity more than 65 years ago. A history of saltwater intrusion in Miami-Dade County through 1984 is reported by Klein and Waller (1985). In 1995, Sonenshein (1995) placed the saltwater-freshwater interface line west of the BBCW Project footprint (Figure 3).

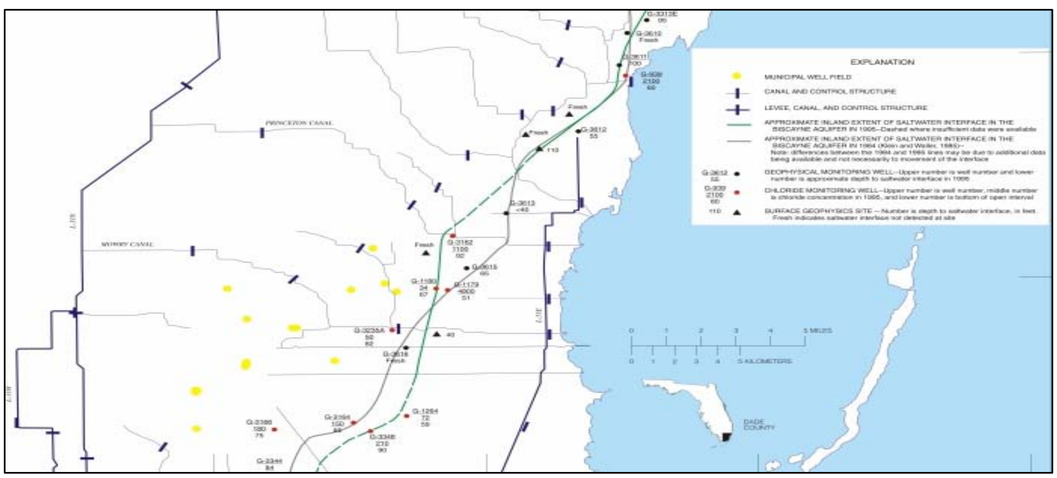

Figure 3. Saltwater-freshwater interface in 1984 (gray) and 1995 (green)

Evaluation

The problem of saltwater intrusion in the BBCW area has a seasonal component that the project is, in part, expected to address. Recharge by rainfall is greatest during the wet season, from June to November, and recharge by canal seepage is greatest during the dry season, from December to May. Consequently, average water levels and the water-level gradients are lower in the dry season than in the wet season. In southeastern Miami-Dade County, water level declines during the dry season range from 0.5 to 1 foot. Within Everglades National Park and along Tamiami Trail, declines range from 0.7 to 1.6 feet. The largest declines, about 2-3 feet, occur from the area east of Everglades National Park to just east of Krome Avenue (Fish and Stewart 1991). It is expected that the BBCW Project will aid in maintaining freshwater flow to the coast during the dry season through water storage features like reservoirs and STAs, thereby potentially providing necessary aquifer recharge to limit further saltwater intrusion during this time period. An evaluation of the alternatives considered for the BBCW Project shows that alternatives E and J would provide the most storage to supplement dry season flows and improve aquifer recharge during this time of the year. While inter-basin operation of the reservoirs and STAs (including supplemental reuse water) will ultimately determine the success in restricting movement of the saltwater-freshwater interface, these two alternatives provide the most potential for providing a nearly constant supply of fresh water to the coast during both the wet and dry seasons in the northern and central regions of the project.

Table 5. Acreages of reservoirs and STAs to be provided by each alternative

	Existing Condition	2050 Without Project Condition	Yellow Book	E	J	M	Q
Reservoir (acre-feet)	0	0	0	32,270	3,000	0	0
STA (acre-feet)	0	80	2,327	2,997	3,615	80	80

4.2.5 Evaluation of Effects on Spatial Extent and Habitat Connectivity

Background

Spatial extent is one of the defining characteristics of the Everglades ecosystem. Worldwide losses of wetlands to agriculture and other development have left behind poor water quality, loss of wetland species, loss of recreational and commercial opportunities, increased salinities, and lowered productivity in downstream estuaries and bays. In the Everglades ecosystem, half of the spatial extent of wetlands was lost by the time the USACE and the SFWMD began to take a second look at the C&SF Project impacts.

In addition to a large spatial extent, the connectedness of Everglades wetlands is critical to the ability of the comparatively nutrient-poor system to support the tremendous abundance of biota it was naturally capable of supporting. Smaller, more isolated wetlands of various types, including short-hydroperiod wetlands, provide critical support for the Everglades from the sidelines by providing additional habitat for many Everglades species, particularly birds.

Additionally, these habitats have been disproportionately impacted by development compared to remaining habitat types, ultimately degrading needed buffer zones.

During the Restudy, increasing the spatial extent and connectivity of wetlands was described as a “precursor” to restoring the Everglades ecosystem (USACE and SFWMD 1999). Wetland restoration adjacent to all projects was expected to increase the overall acreage of wetlands throughout the system. This would not only increase the amount of habitat available to wetland species, but provide free water storage and improve water quality. The Biscayne Bay coastal wetlands in particular are important for reconnecting overland flow with the marine ecosystem. If all the planned water is delivered to the area, a series of stable potentially year-long freshwater habitats will be created to provide nursery grounds for estuarine fish. The establishment of these stable freshwater environments is consistent with the CERP goal of increasing the spatial extent of natural habitat, increasing the connectivity, and improving species abundance and diversity.

Evaluation

An evaluation of the BBCW alternatives shows that Alternative E provides the most opportunity to establish connectivity with approximately 47 miles of levees, roadways, and canals removed. Alternatives J and Q also provide substantial reductions in the miles of roadways, canals, and levees over the future without project condition. RECOVER agrees with the project team’s decision to use spreader canal length and removal of levees, canals and roadways as a means to estimate project benefits (spatial extent and connectivity).

Table 6. Miles of levees, canals and roadways removed by each alternative

	Existing Condition	2050 Without Project Condition	Yellow Book	E	J	M	Q
Miles Levees, Canals, and Roadways Removed	0	0	10.66	36.73	28.53	5.28	21.05
Miles L31N Removed	0.01	2.24	3.05	10.57	3.31	5.28	5.28
Total	0.01	2.24	13.71	47.30	31.82	10.56	26.33

Improved spatial extent is more difficult to quantify, since land related to each alternative has not yet been determined by the project team. Given South Florida’s projected population growth, however, any lands not included in the project alternatives or maintained as public lands will likely be developed consistent with surrounding land use patterns. Those implementing CERP must make a concerted effort to recognize and, where possible, protect the wetlands within and between project boundaries throughout the South Florida ecosystem. Otherwise, the cumulative effect of losses, each of which may appear small and isolated to single projects, will likely accumulate over time and add up to serious losses for the system as a whole. Spatial extent has been one of the characteristics of the greater Everglades ecosystem that has proven difficult to quantify.

4.2.6 Interaction with Other Projects

The BBCW and the C-111 Spreader Canal Projects overlap in their goals and the area (and habitat types) they are expected to affect. Because CERP was formulated as a set of interactive, interdependent projects, optimizing the linkages between these projects will likely result in increased performance. At this point, some alternatives can provide linkages between the projects. Maximum operation flexibility for the region will provide the projects the most opportunity to optimize ecological benefits and create project linkages where possible. By formulating and operating projects in a complementary fashion, there will be greater potential to create and sustain the freshwater head to rehydrate larger acreage in the Model Lands, to increase freshwater discharge to the estuaries, and to increase spatial connectivity in the areas. As noted earlier in the report, rehydrating natural areas not only provides habitat benefits, but also provides corresponding water quality benefits.

The BBCW Alternative J would interact better with the central alignment of C-111 Spreader Canal or a more northern variation of this alignment. Depending on which alternative is selected, the Model Lands may miss out on potential acreage of rehydration. Exploration of a hybrid alternative including the flexibility provided by features in either Alternatives E or J, combined with the spreader canal to the south in alternative Q likely has the greatest potential to actualize and optimize the desired benefits. It is important to note that both the C-111 Spreader and the BBCW Projects need additional, clean water either from the system or from some other means such as reuse water cleaned to a proper level. Because of the interaction and interdependency of the two projects, BBCW and C-111 Spreader Canal should have a combined project-level monitoring plan developed that compliments the MAP, but goes into greater detail to determine success and shortcomings in the projects future and effected habitats and indicators.

5.0 Ability of Project Alternatives to Address Planning and Scientific Uncertainties (CERP Adaptive Management)

As with other ecosystem restoration projects throughout the nation, every potential restoration action carries with it an amount of uncertainty and risk. There are five key principles that are fundamental to this approach:

1. Anticipating possible contingencies during planning and exploring qualitatively different options for responding
2. Employing science-based approaches to build knowledge over time, including development of “safe-to-fail” project designs and assessment procedures
3. Designing “robust” projects that can be adapted to uncertain or changing future conditions
4. Building shared understanding through collaboration and conflict resolution

5. Reconciling competing objectives to benefit both nature and society

The first three key principles as they relate to the BBCW Project are addressed in the following two subsections. Although the project team has already identified uncertainties and formulated plans to address and alleviate these uncertainties, they should consider some additional uncertainties mentioned throughout this report. In general, uncertainties related to large-scale restoration can be categorized as scientific uncertainties and planning uncertainties.

5.1 Scientific Uncertainty

Scientific uncertainty is the uncertainty regarding the environmental response corresponding to a specific action. With regard to the BBCW Project, there is little uncertainty that decreased salinities in Biscayne Bay will improve populations of desirable indicator species including submerged aquatic vegetation, oysters, estuarine fishes, and crocodiles. CERP system-wide performance measures for Biscayne Bay detail the expected freshwater flows required to reach these salinity targets during both the wet season and dry season. RECOVER finds that the project team has addressed some of the uncertainties, but the project team also needs to consider those additional uncertainties presented in this report.

5.2 Planning Uncertainties

Planning uncertainties for the BBCW Project center on the amount of water that can be made available that will directly affect the potential level of restoration accomplished by the project. In Restudy modeling, the C-111 Spreader Project and Modified Water Deliveries to Everglades National Park (MODWATERS) Project redirected flows from Biscayne Bay. To compensate for this decrease in freshwater deliveries, wastewater reuse was added to the CERP to provide supplemental flows to the bay. At this time, however, significant uncertainty remains regarding (1) the volumes of freshwater flows delivered to the BBCW Project, and (2) the timing and availability of wastewater reuse as a CERP component to provide supplemental water, of reasonable quality, to Biscayne Bay. The Initial CERP Update conducted by RECOVER in 2005 (RECOVER 2005b) showed that the modeled CERP alternative (CERPA) provides approximately 60 percent of the wet season flow and 77 percent of the dry season flow required to meet the target. The future without CERP (2050B3) only supplies approximately 41 percent of the wet season or dry season target.

5.2.1 Water Available to BBCW Project

The volumes of water identified for BBCW Project during the Restudy were inadequate to meet restoration goals for the bay. Although Congress authorized Alternative D13R, it allowed for updates of the plan to “seek continuous improvement…based on new information, improved modeling, new technology, and changed circumstances” (Senate Report No.106-362). Given this adaptive management approach, it will be the responsibility of the System Planning and Operation Team (SPOT), in coordination with the BBCW Project Team, to address whether additional water can be made available through existing CERP projects and whether such water could be delivered to the BBCW Project to address the Restudy performance shortfall. Because these are long-term activities related to system-wide performance, solutions cannot be proposed before selection of a TSP by the Project Team.

The BBCW Project Team needs to consider the best means of accomplishing restoration of Biscayne Bay given different inflow volumes when comparing alternatives. Alternatives E and J provide the most flexibility in moving and storing water for wet/dry season operational flexibility. While Alternative Q provides for inter-basin transfers of water, it does not have the storage capacity to regulate and equalize water flows into the bay. RECOVER suggests a hybrid alternative be considered in the final alternative plan design.

Table 7. Water availability scores for alternatives

	Existing Condition	2050 Without Project Condition	Yellow Book	E	J	M	Q
Inter-basin Transfer Capability	1	1	4	5	4	2	5
Lined Canal(s)	0	0	1	0	0	1	2
Reservoirs to the West	0	0	0	6	4	0	0

5.2.2 Supplemental Wastewater Reuse

The two wastewater reuse facilities proposed in the BBCW area are the West Miami-Dade Reuse Facility and the South Miami-Dade Reuse Facility, which are expected to produce 100 and 131 million gallons per day, respectively. The South Miami-Dade Reuse Facility would provide supplemental water to Biscayne Bay via groundwater recharge adjacent to the project, and therefore provide saltwater intrusion benefits. The West Miami-Dade Reuse Facility, however, is planned primarily to contribute water to the Bird Drive Recharge Area which is well west of Biscayne Bay. This project will potentially provide some project benefit through groundwater flow. The West Reuse project is planned far in the future with full 100 MGD capacity being in 2050.

A sensitivity analysis conducted by the SFWMD and presented at the Greater Everglades Ecosystem Restoration Conference in 2000 investigated what impacts would occur if wastewater reuse components were removed from D13R (Santee et. al. 2000). The sensitivity analysis found that removal of the West Miami-Dade Reuse water resulted in approximately 20,000 acre-feet reduction to flows in Biscayne Bay over D13R and additional water supply cutbacks (5-6 months) in all Lower East Coast Service Areas (LECSAs). Removal of the South Miami-Dade Reuse Facility resulted in an approximately 120,000 acre-feet flow reduction of flows to Biscayne Bay over D13R, and additional water supply cutbacks (10 months) in LECSA 3. From these results, it can be inferred that the presence of wastewater reuse to supplement flows to Biscayne Bay significantly influences the ability of the project to meet restoration goals, and the ability of the region to meet water supply needs. As with the water availability issue, it is incumbent upon the BBCW Project Team to consider how their alternative plans will operate until wastewater reuse is available to provide supplemental water to the bay. It is important to recognize that reuse will not be fully implemented in the early stages of CERP and therefore the associated water quality and hydrologic benefits will not be actualized during this time.

Alternatives E and J provide the most storage and operational flexibility, as previously discussed; however, until wastewater reuse is utilized, fewer water quality improvements may be possible under these alternatives. The supplemental water supplied by reuse, especially during the dry season, would keep reservoirs and STAs from drying down, thereby increasing nutrient assimilation and reducing potential nutrient fluxes. Although reuse provides needed water for seasonal hydration, reuse water brings along with it a water quality expense (Table 8).

Table 8. Table 8 is an excerpt from the Final Report South Dade Advanced Wastewater Treatment Alternatives. The table provides examples of effluent concentrations required for different levels of reuse treatment, as well as average effluent concentrations for the South Dade Waste Water Treatment Project* from 1999-2004. (CDM 2004)

Parameter	Reuse	Wetlands Application	Class III / OFW
Total Suspended Solids (mg/ L)	5[1]	5	3.5
CBOB-BOD5 (mg/ L)	20[2]	5	
Total Nitrogen (mg/l as nitrogen)		3	0.27
Total Phosphorous (mg/L as phosphorus)	1.09*	1	0.005
Fecal Coliform (# /100 ml)	<1.0	<1.0	<1.0
Total Ammonia-Nirogen (mg/L)			0.02 –0.05
Nitrite/Nitrate-Nitrogen (mg/L)	.87*		0.01 mg/L
Total Kjeldahl Nitrogen (mg/L)	17.55*		0.22 mg/L
Ortho-Phosphorus (mg/L)			0.002 mg/L
Dissolved Oxygen (mg/L)			5.0-7.3
Turbidity (NTU)			0.5 NTU
Salinity			Shall not change salinity in test site by more than 5 ppt
pH			6.5-7.5[3]
Heavy Metals			See Table 3.4 (citation)
EPOC			Lowest possible levels[4]
Cryptosporidium and Giardia			Lowest possible levels[4]

[1]Single sample maximum
[2]Annual average
[3]Appropriate limits for pH in the estuarine zone will require further evaluation
[4]Even though, currently there are no established numerical criteria or anti-degradation targets for these parameters, available information shall be gathered on removal efficiency of various treatment technologies and detectable levels after advanced treatment for these parameters for comparative assessment. In practical terms, the objective would be to identify the technology that reduces such contaminants to the lowest level.

6.0 Opportunities for Alternative Plan Improvements and Other Considerations

RECOVER provides insight, if possible, and alerts the project team to any inconsistent modeling assumptions for the project. As part of the responsibilities given to RECOVER, this section presents suggested improvements to the alternative plans, which, where possible, are intended to improve the project's performance or enhance benefits to the natural system. These suggested improvements to the alternative plans should be considered by the project during the design of the final plan or reevaluation of alternative plans. The project manager or designee is required to notify RECOVER in writing if any of these suggested improvements to the alternative plans were incorporated in the final design. Additionally, RECOVER provides suggestions on how the project may analyze data or modeling output that may provide the project with greater system-wide benefits than recognized under the current analysis. The following bulleted list highlights opportunities for alternative plan improvement as well as notes alternative benefit not recognized by the project team:

- Both spreader canal path length and potential natural areas restored provide important water quality benefits that should be considered by the project team
- Current project nitrate estimates underestimate potential water quality benefits
- The BBCW project should consider interactions with the C-111 spreader canal project to enhance rehydration of the Model Lands. This includes the potential for a hybrid alternative (see section 4.2.6)
- Reservoir and STA operations should be conducted to minimize dry down in the project area thereby minimizing oxidation of sediments and corresponding potentially high sediment nutrient fluxes
- Additional water quality and biological tools/models which will yield performance measures should be developed both at the system and project level for this area of the system.
- When the project monitoring plan is developed it should incorporate both short and long-term response water quality and biological indicators and the data should be collected in a manor that could generate additional evaluation and assessment tools
- The planning process is iterative and should be treated that way. Normally a couple of rounds of modeling ~~is~~are needed to optimize the alternatives. RECOVER recommends that future projects incorporate these iterations into the planning process.

- This Biscayne Bay area could use additional water to achieve restoration targets. The ET recommends that future system-wide planning and adaptive management efforts incorporate a review of the system to determine if additional water is available for Biscayne Bay for both this and the C-111 spreader canal projects.

7.0 Conclusions

RECOVER's review of relevant project-level and system-wide information mentioned in the report indicates that the project is likely to meet the following goals:

- Redistribute freshwater flow to minimize point source discharges to improve freshwater and estuarine habitat
- Preserve and restore the spatial extent of natural coastal glades habitat
- Potentially restore and improve quantity, quality, timing, and distribution of fresh water to the Biscayne Bay, including Biscayne National Park
- Aid in reestablishing connectivity between Biscayne coastal wetlands, C-111 basin, Model Lands, and adjacent basins
- Potentially help reestablish productive nursery habitat along the shoreline

Redistributing current canal flow through spreader canals will provide benefits by minimizing point source discharges. This will minimize the number of extreme salinity fluctuations occurring in the estuarine habitat. Redistribution of canal flow will also benefit the system by helping to restore previously hydrologically-isolated habitats as well as help restore previously desiccated habitats.

As noted in the report, the level of benefits achieved will be directly related to the ability to rehydrate natural areas. These natural areas have the potential to provide water quality benefits to both the freshwater marshes and the coastal estuaries. The reuse assumption and issues associated with reuse will need to be addressed. This is not only an issue at the BBCW Project level but for other projects, such as the C-111 Spreader Canal Project, as well. This is included in the regional evaluation to recognize constraints on the planning assumptions. The SPOT team is currently working on issues surrounding availability of water for the BBCW and C-111 Spreader Canal Projects.

As noted in the section 4.2.2 "Evaluation of Ecological Benefits", water deliveries to Biscayne Bay will help ameliorate the effect of high salinities. Maintenance of lower salinities via these freshwater deliveries is critical to reducing the effect of *Perkinus marinus* predation effects on oysters. Freshwater deliveries similarly moderate the effect of high salinities on neonate *Crocodylus acutus* and effect survival.

In addition to the water quality benefits provided by rehydration, STA and reservoir operational flexibility will provide the project the ability to respond to changes in land use and corresponding water availability and water quality. These benefits will be leveraged by the wetlands created by spreader canals in the southerly flow path. Alternatives E and J provide the most flexibility in design and operations and both provide benefits beyond the Yellow Book and

Base (existing) alternatives. A hybridized alternative, such as Alternatives E or J with the south spreader from Alternative Q, will likely help attain the greatest benefits. If the project team pursues this option, RECOVER will review any additional project materials.

The RECOVER evaluation team recognizes that the project team has requested additional modeling runs that have not yet been run by ERDC. RECOVER expects to review this additional output and will provide the project with additional comments where necessary. In addition to the system-wide evaluation of the BBCW Project, RECOVER also evaluated the benefits matrix used by the project. Appendices A and B contain the alternative structural information and multi-criteria decision matrix summary, respectively, considered by the RECOVER ET review team.

RECOVER's comments are not bound by many of the same constraints (including costs) that the project team faces. RECOVER understands the balanced view the project team undertakes when developing their alternatives and in many instances may have already screened out some of the recommendations made by RECOVER.

RECOVER's recent adoption of the "values triangle" recognizes the need to balance science, timely reporting, and inclusiveness. For this RECOVER evaluation, significant efforts were undertaken to satisfy the need for timely reporting while bringing forward as much science as possible. This report may not constitute the entirety of RECOVER's review of this project as specified in the Programmatic Regulations (DOD 2003). RECOVER may provide the project additional information supporting and refining the original evaluation.

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9.0 Appendix A. BBCW Alternative Matrix for All Alternatives, December 2005

Alternative Management Measure	Yellow Book	Alternative M2	Alternative Q	Alternative E	Alternative J
Reservoir (acres)	N/A	(1) DA-C1 375 ac-ft	N/A	(5) Reservoirs @ 35,925 ac-ft	(5) Reservoirs @ 32,450 ac-ft
STA in acre-feet (acres @ depth)	(4) STAs @ 13,950 acre-feet	(1) STA – C1 Lennar flow way 600 acre-feet (?)	(1) FW-C1 Lennar flow way@ 600 acre-feet	(5) STAs @ 8370 acre-feet	(5)STAs @ 8991acre-feet
Pump(s)/sizes (cfs)	(10) Pumps = 1550 cfs	(2) Pumps = 640 cfs	(10) Pumps = 1480 cfs	(10) Pumps = 2045 cfs	(8) Pumps = 1395 cfs
Levees (feet/cyd)	(1) L-C1 4 miles long	(1)L-C1 4 miles long	(4) levees @ 29,500 feet long	(2) levees 8,000+ ..?	(1) L-C1 3-feet height x 8000-feet length
Canals (feet/cyd)	(5) new canals	(5) new canals	(4) new canals	(7)new canals/bypass canals	(5) new canals
Spreader canals	(4) spreader canals	(3) spreader canals	(4) spreader canals	(2) spreaders	(2) spreaders
Plugs vs. backfilling canals	(23) plugs Backfill mosquito ditches Backfill North Canal	(1) plug	(22) plugs Plug mosquito ditches an let fill naturally	(2) plugs Backfill mosquito ditches Backfill L-31E	(3) plugs Backfill mosquito ditches Backfill L-31E Remove Tallahassee Road 200-foot sections removed every 1000 feet
Culverts weirs & pipes	(56)+ culverts (1) weir	(2) culverts?	(7) culverts? (1) weir	(10+) culverts (1) weir (3) pipes	(17) culverts (1) weir
Unique measures					

Comment [k1]: what does this stand for?

Comment [k2]: same as spreader canals?

10.0 Appendix B. BBCW Multi-criteria Decision Method

Ecological benefits were determined by combining some components of the TABS-MDS model output with a suite of evaluation metrics that did not rely on model output. This method, referred to as the Multi-criteria Decision Method (MCDM), evaluated benefits for each of the three project sub-regions and within three ecological zones. The MCDM performance measures and evaluation metrics address each of the original five project objectives as defined above. An additional objective was added to underline the importance of restoring the nearshore area, and is referred to as: "Restore nearshore salinity regimes."

The team utilized 15 performance measures and 19 evaluation metrics to address the six project objectives. For each performance measure, there is at least one evaluation metric by which the performance measure is scored. Of these, only one performance measure relies on output from the TABS-MDS model. The others are based primarily on best professional ~~judgement~~judgment by the team regarding how management measures or operations inherent to a given alternative would improve habitat. Some of the evaluation metrics employ Geographic Information System (GIS) measurements to determine scores. Each alternative was scored for all 19 evaluation metrics in each of the 3 geographic sub-regions of the project, and within each of the three ecological zones into which the project can be divided. It should be noted that not all project objectives apply to a given ecological zone. For the nearshore zone, objectives 1, 2, 3, and 6 are applicable. For the salt water wetlands zone, objectives 1, 2, 3, and 5 are applicable. For the freshwater wetlands, objectives 2, 3, 4, and 5 are applicable.

Numeric targets for evaluation metrics were established whenever possible. For these metrics, the scores were converted to percent target achieved to compare and contrast between and among evaluation metrics. Establishing targets for some metrics was not possible. In these cases, scores were normalized against the alternative with the highest score. Normalizing or converting scores to percent target achieved resulted in transforming scores to a scale of 0 to 1, which allows evaluation metrics to be averaged to produce an ecological benefits index for each ecological zone. These indices can then be applied to the total spatial extent of each zone to produce habitat units.

The following outlines the evaluation matrix and describes how each performance measure and evaluation metric relates to the project objective (i.e., how the metrics benefit habitat):

I. Reestablish shoreline nursery habitat.

A. Performance Measure - Linear extent of coastal spreaders (1 evaluation metric). This performance measure assumes that the ability to restore nearshore habitat to an appropriate salinity regime is a function of the capability to redistribute water along as much of the shoreline as possible (i.e., the longer the coastal spreaders, the more nearshore habitat will be restored).

II. Objective - Redistribute freshwater to improve habitat.

Performance Measure - Reduce direct canal discharge (1 evaluation metric). This performance measure assumes that diverting water from canals into the wetlands improves habitat by reducing harmful point source discharges to the nearshore areas and rehydrates the wetlands into which the water is diverted.

Performance Measure – Flexibility to move water (3 evaluation metrics). The flexibility to move water in the project area is assumed to be a function of: 1) the capability to transfer water between project sub-regions, 2) the use of lined canals to eliminate seepage of water to be transferred, and 3) the capability to store water for use when needed (i.e., availability of water during the dry season).

Evaluation Metric – Inter-region transfer capability. This metric is evaluated by qualitatively scoring the transfer capability on a scale of 0 to 3 for each region (0 = no transfer capability, 1 = little transfer capability, 2 = moderate, 3 = high).

Evaluation Metric – Lined canals (seepage reduction). This metric assumes that lined canals provide better capability to transfer water than unlined canals because no water will be lost to seepage.

Evaluation Metric – Reservoirs. This metric assumes that the larger the reservoir, the better the capability to transfer water, and thus is scored based on the relative sizes of reservoirs by alternative and region.

C. Performance Measure – Hydrate freshwater wetlands (1 evaluation metric). The performance measure assumes that the ability to restore freshwater wetlands is based at least partly on the capability to redistribute water into as much of the freshwater wetland habitat as possible (i.e., the longer the freshwater spreaders, the more freshwater wetland habitat will be restored).

III. Objective – Restore and Improve Quality and Timing of Freshwater to the Bay

Performance Measure – Reduce nutrient concentration (2 evaluation metrics). Water quality is evaluated based on the presence or absence of reservoirs and STAs, and on the volume of water diverted into those features.

1. Evaluation Metric – Reduce nitrogen concentrations. This metric is scored using a spreadsheet model that is driven by Kadlec (2004) equations for nitrate removal by STAs and wetlands.

2. Evaluation Metric – Reduce phosphorus concentrations. Reduction in phosphorus is calculated in a similar manner, except removal efficiencies were estimated for different flow paths rather than using the Kadlec equations for nitrate.

Performance Measure – Storage Capacity (2 evaluation metrics). The ability to store water is assumed to provide the capability to improve the timing of freshwater delivery to the bay. For this analysis, reservoirs and STAs are considered the only storage features. The greater that storage capacity, the higher the score.

1. Evaluation Metric – Reservoirs.

2. Evaluation Metric – STAs.

IV. Objective – Preserve and Restore Coastal Glades Habitat

A. Performance Measures – Reduction in Exotic Vegetation (1 evaluation metric). This metric assumes that displacement of non-native vegetation by STAs or reservoirs improves coastal glade habitat.

B. Performance Measure – Reduction in Good Quality Habitat (1 evaluation metric). This metric assumes that displace of high quality wetlands by STAs or reservoirs contribute to the degradation of coastal glades habitat.

C. Performance Measure – Spatial Extent of Existing Public Wetlands Restored (1 evaluation metric). This metric assumes that the greater the area ~~restoired~~restored that is already in public hands, the better.

V. Objective – Reestablish Water Basin and Wetland Connectivity.

A. Performance Measure – Length of Obstructions Removed (1 evaluation metric). This metric assumes that removal of physical obstructions, like roads and levees, will increase wetland and basin connectivity.

B. Performance Measure – Increase Connection between Fresh and Salt Water Wetlands (1 evaluation metric). This metric assumes that removal of L-31E will increase the connectivity between salt and freshwater wetlands.

VI. Objective – Nearshore Salinity

A. Performance Measure – Storage Available (1 evaluation metric). This measure assumes that the greater the storage capacity, the more likely that the desired salinity target will be maintained.

B. Performance Measure – Use of Additional Water for Environmental Benefit (Reuse) (1 evaluation metric). This metric gives credit to all alternatives relative to Future Without Project provided by waste water reuse.

C. Performance Measure – Ability to Redistribute Water in the Coastal Zone (1 evaluation metric, incorporates TABS-MDS output). This metric assumes that the ability to distribute water to the nearshore area is a function of the volume of water diverted from canals and the proportional length of the coastal spreader (i.e., combines I.A. and II.A. above).

D. Performance Measure – Ability to Establish Ecologically Desirable Salinity Ranges (TABS-MDS output, 1 evaluation metric). This metric relies on the scoring of Performance Measure 3.A.2 by the TBS-MDS model.

The team considered several options for weighting the evaluation metrics and performance measures, prior to applying ecological benefits indices to the acreages in the various ecological zones of the project. However, treating the evaluation metrics with equal weighting provided the best separation between alternatives. This also eliminated the need to justify weighting. After scoring, all evaluation metrics applicable to a given ecological zone were averaged to provide a single index value that could then be applied to the acreage within that zone.

Using the evaluation method described above, the project alternatives were ranked according to the habitat units of ecological lift provided above the future without project condition as follows:

1. Alternative E 39,314 HUs
2. Alternative J 27,845
3. Alternative Q 24,003
4. Yellow Book 22,399
5. Alternative M 12,330

Literature Cited

Kadlec, R. H. 2004. Constructed wetlands to remove nitrate. Wetland Management Services, 6995 Westbourne Drive, Chelsea, MI 48118, USA