Annex D
Adaptive Management and Monitoring Plans for the Central Everglades Planning Project Post Authorization Change Report (CEPP PACR)

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Introduction to Annex D: the CEPP PACR Adaptive Management and Monitoring Plans

The Central Everglades Planning Project Post Authorization Change Report (CEPP PACR) Annex D contains four plans: the adaptive management plan required by the U.S. Army Corps of Engineers (USACE) implementation guidance for the Water Resources Development Act (WRDA) 2007 Section 2039[1], the 2003 Programmatic Regulations for the Comprehensive Everglades Restoration Plan (CERP) and CERP Guidance Memorandum 56[2], and monitoring plans required to address various laws, regulations, and permits necessary to implement the CEPP PACR. The items identified in this annex are based on knowledge formed from extensive scientific work on Everglades ecology and restoration, some initiated several decades ago, as well as USACE guidance and regulatory agency permit requirements all of which were used to design the CEPP and the CEPP PACR adaptive management and monitoring plans. In particular, the long-term, system-wide monitoring and modeling conducted by CERP's interagency science group (the REstoration COordination and VERification group, or RECOVER) informed the planning of the CEPP PACR and the development of the adaptive management plan. *The overall objective of the adaptive management and monitoring plans in this annex is to: (1) identify the primary areas were restoration efforts will benefit from monitoring and assessment and specify the monitoring and assessment resources needed; (2) define how the monitoring and assessment can be used to refine CEPP PACR implementation to improve restoration performance in the face of inevitable uncertainties, using existing knowledge complimented by CEPP PACR monitoring and assessment, and (3) meet regulatory and permit objectives to understand whether constraints are avoided and/or minimized.*

The monitoring plans contained in Annex D were guided in part by two objectives. First, they needed to be complete from a TSP perspective by providing all monitoring required to address specific needs. Second, they must be integrated with other Everglades monitoring to take advantage of existing monitoring efforts, knowledge, and information and thereby leverage dollars committed and spent elsewhere to avoid redundancies and insure cost-effectiveness. These two objectives have been accomplished in the adaptive management plan, hydrometeorological monitoring plan, water quality monitoring plan, and the ecological monitoring plan. It is expected that document reviews and future reassessments of the TSP monitoring needs will identify additional monitoring to address regulatory and consultation needs, as well as additional efficiencies that can be gained. Where possible, monitoring described here relies on existing monitoring resources including physical instrumentation, stations, locations, servicing, and analysis efforts funded by RECOVER, CERP sponsors, and partner agencies. Therefore, the monitoring requirements described and budgeted in the CEPP PACR monitoring plan are limited to the additional, marginal increase in monitoring resources and analysis efforts needed to address TSP-specific questions. The TSP monitoring plan relies on other monitoring to keep its monitoring costs to a minimum

Part 1: Adaptive Management Plan – The first section, the Adaptive Management Plan (**Annex D, Part 1**), provides the strategies to address prioritized project uncertainties that will be faced as the TSP progresses toward achieving restoration goals and objectives while remaining within constraints. Each strategy follows a scientific approach that uses performance measures, monitoring, triggers and/or thresholds to

[1] USACE. 2009. USACE HQ Implementation Guidance on Section 2039 of Water Resources Development Act. http://cw-environment.usace.army.mil/pdfs/09sep2-wrda-monitor.pdf

[2] USACE and SFWMD. 2011. CERP Guidance Memorandum 56: Integration of Adaptive Management into Program and Project Management. http://www.cerpzone.org/documents/cgm/CGM 56 Adaptive Management.pdf

inform restoration progress. Suggestions for informing future increments of CERP that were discussed by the adaptive management team during the development of the CEPP Adaptive Management Plan have been included, but demarcated to show that they are not expected to be authorized as part of the CEPP PACR Plan. Rather, these are described here to record current understanding of needs that may be considered in the future to further improve restoration.

The management options included in the CEPP PACR Adaptive Management Plan can be described as the following:

- *Informing CEPP PACR Implementation* - results of monitoring a project component may inform next phase of project component construction sequencing,
- *Inform Project Operations* - results inform project operations or system operating manuals,
- *CEPP PACR Adaptive Management Contingency Options* – monitoring results may suggest a need to implement additional restoration actions, called adaptive management options, pending all required and applicable coordination, policies, and permitting.

Management option summary matrices (MOMs) are provided as a quick reference to the adaptive management options and to link monitoring, triggers and thresholds, and the management options. The descriptions and summary matrices are intended to inform decision-makers, and the public on potential actions to improve restoration performance. ***Implementation of adaptive management options is not automatic; the options are suggestions that capture current understanding of potential future issues and solutions. While the Adaptive Management Plan and its suggested options are considered part of the CEPP PACR Tentatively Selected Plan (TSP), all applicable policies, permitting, and coordination requirements apply to implementing Adaptive Management Options.***

The monitoring identified in this plan is considered part of the adaptive management strategies, as per the 2003 Programmatic Regulations for the Comprehensive Everglades Restoration Plan (DOD 2003), the CERP Guidance Memorandum #56 (CGM 56; USACE and SFWMD 2011), and the USACE CERP Adaptive Management Integration Guide (RECOVER 2011b), and the CERP Program-level Adaptive Management Plan (RECOVER 2015) in accordance with WRDA 2007 and its subsequent implementation guidance. The monitoring is specific to uncertainties raised during CEPP PACR planning which require refined data to address, and which will inform feasible options to adjust CEPP PACR as identified in the Adaptive Management Plan. Per USACE planning guidance ER-1105-2-100 Appendix E, the intent of focusing on the uncertainties is to address questions and reduce the uncertainties. For CEPP PACR, doing so helps to ensure that the TSP and CERP water infrastructure investments continue to be good investments over the long-time span of the project, potentially avoid expending funds if detailed data collection shows reductions in construction needs, and helps to avoid exceeding Section 902 cost increases by incorporating the best new knowledge into design, construction, and operations.

The adjustments and options identified in this adaptive management plan are part of the TSP, except for the few “future opportunities” suggestions noted above that may apply to future restoration projects. These would require separate authorization and they are demarcated in the Adaptive Management Plan. The suggestions are provided to capture the best current understanding of measures that may be needed to achieve Everglades restoration beyond the CEPP PACR, with recognition that the CEPP PACR provides a significant increment but not complete restoration.

Part 2: Water Quality Monitoring Plan – Contains the necessary monitoring to ensure the CEPP PACR implementation complies with all applicable State water quality standards.

Part 3: Hydrometeorological Monitoring – Identifies the necessary hydrologic and meteorologic monitoring needed to operate the CEPP PACR project structures.

Part 4: Ecological Monitoring Plan – The primary purpose of the CEPP PACR Ecological Monitoring Plan is to identify the monitoring necessary to inform decision-makers, and the public on achievement of project objectives, i.e., its achievement of success. This monitoring will be leveraged as much as possible to contribute to CEPP PACR adaptive management. However, given the scope and scale of the CEPP PACR, the ecological monitoring and the monitoring identified in the adaptive management plan are not one-and-the-same because the ecological monitoring plan focuses on success at meeting project objectives (per WRDA 2007 guidance) while the monitoring specified in the adaptive management plan focuses on addressing project uncertainties (per WRDA 2007 and subsequent guidance) that may be more specific in their location and/or scale than the overall project objectives. Also, the adaptive management plan focuses on project adjustments that could be made relatively easily to improve project performance, and the monitoring described in that plan will inform such adjustments.

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Part 1. CEPP PACR Adaptive Management Plan

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D.0 CEPP PACR ADAPTIVE MANAGEMENT PLAN EXECUTIVE SUMMARY

The Central Everglades Planning Project Post Authorization Change Report (CEPP PACR) planning process and tentatively selected plan (TSP) were based on extensive existing scientific knowledge of the Everglades and associated estuaries, understanding of the problems and opportunities, and the evaluation of alternatives and estimation of the potential project restoration performance much of which was established during CEPP and is now being applied to the CEPP PACR with revisions or deletions where needed. While the CEPP PACR is based on this wealth of knowledge, this Adaptive Management Plan is provided to help address uncertainty that exists as in every natural resource management and restoration effort. Several sources of agency guidance exist regarding such uncertainties, including the U.S. Army Corps of Engineers (USACE) ER-1105-2-100 Section 3-5 and Appendix E, WRDA 2007 Section 2039 and its implementation guidance, the 2003 Programmatic Regulations for the Comprehensive Everglades Restoration Plan, and its subsequent guidance including CERP Guidance Memorandum 56 (CGM 56; USACE and SFWMD 2011) the Adaptive Management Integration Guide (RECOVER 2011b), and the CERP Program-level Adaptive Management Plan (RECOVER 2015). Per these sources, the concerns and uncertainties of coordinating agencies and stakeholders were taken into consideration throughout planning. This plan specifies strategies and appropriate timing to address the uncertainties. Additional detail of these plans will be addressed through the Construction Phasing Transfer and Warranty Plans during the development of the Project Partnership Agreements.

The Adaptive Management Plan provides a screened and prioritized summary of specific uncertainties that can be addressed with efficiently structured approaches. The TSP describes the approaches (called strategies) and suggests management options for future consideration if needed. The CEPP Adaptive Management Plan, from which the CEPP PACR Adaptive Management Plan was developed, is a culmination of input from well-developed USACE planning procedures, extensive scientific and local knowledge that has developed over decades of experience, and input from the CEPP Project Delivery Team (PDT) during planning and the CEPP Value Engineering and Cost Risk Analysis workshop.

Every uncertainty in the TSP Adaptive Management Plan was screened as part of the CEPP PACR Adaptive Management Plan. The screening criteria were based on CGM 56 and criteria provided in the CERP Adaptive Management Integration Guide (RECOVER 2011b) and the CERP Program Level Adaptive Management Plan (RECOVER 2015). Each uncertainty needed to: (1) potentially affect the TSP's ability to meet its goals and objectives and remain within its constraints; (2) be at an appropriate TSP scale spatially and temporally; (3) have options for adaptive management actions such as potential project adjustments; and (4) have a combination of high importance to TSP and high uncertainty that could be reduced by practical adaptive management means. Details of this screening process are described in the CEPP PACR Adaptive Management and Monitoring Annex.

Adaptive management activities will be implemented during the CEPP PACR, and the Adaptive Management Plan will be updated accordingly. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given the new knowledge and answers to key questions the adaptive management strategies and options proposed in this Plan may need refinement. Therefore, items included in this plan are not guaranteed to be funded as-is, but will be considered again when TSP is closer to being implemented and as appropriate, and funding decisions will be made commensurate with available funding at that time.

D.1 Adaptive Management Plan Background

CEPP PACR planning and TSP were based extensively on the processes implemented in CEPP, scientific knowledge of the Everglades ecosystem and associated estuaries, from understanding the problems and opportunities to evaluating alternatives and estimating potential project restoration performance (Davis and Ogden 1994, DOD 2003, RECOVER 2004, Ogden 2005, RECOVER 2009, McVoy et al. 2011,, RECOVER 2011a, CEPP PIR Appendix H) and USACE and CERP guidance. However, uncertainty exists in every natural resource management and restoration effort since many processes in the ecosystem are not linear, they work synergistically together, and they will unfold in a future climate that is likely different than the one used to formulate the CEPP and the CEPP PACR Adaptive Management Plans. These Adaptive Management Plans address the key uncertainties identified during the CEPP PACR planning that relate to achieving restoration success and making adjustments in the TSP if determined to be necessary to improve performance.

Congress understood that there were uncertainties in the CERP and therefore required CERP to include adaptive management for its individual projects (WRDA 2000). The 2003 programmatic regulations (Pro Regs) outlined an adaptive management program that would provide the tools needed to gather new information from the RECOVER monitoring and assessment plan (MAP; RECOVER 2009) and incorporate these so that CERP could be adjusted to ensure restoration success. The National Research Council's Committee on the Independent Scientific Review of Everglades Restoration Progress (CISRERP) endorsed the CERP adaptive management program (NRC 2007) and concluded that "uncertainties remain about the degree to which a resilient, self-sustaining ecosystem can be restored under the dramatically changed environment of South Florida" (NRC 2008). The CISRERP noted that adaptive management is essential for "...designing management strategies for dealing with complex ecosystem projects for which probable ecosystem responses are poorly known and hence, difficult to predict" (NRC 2007). The CISRERP further reinforced its view regarding the essentialness of adaptive management in CERP project planning and implementation by stating that, "Given the enormous scope and complexity of the restoration effort, the success of the CERP depends on strategic, high-quality, responsive, and sustained science and an effective adaptive management framework" (NRC 2010).

Per the 2003 Pro Regs, CERP produced guidance for project teams to develop adaptive management plans and integrate adaptive management activities into all phases of a project lifecycle, e.g., planning, design, construction, and operations (USACE and SFWMD 2011, RECOVER 2011b). These are appropriate to the large scale and complexity of CERP and its projects, with its changing context of new non-CERP water infrastructure projects, and the shifting nature of its ecosystems. The intent of the detailed guidance is to improve restoration performance and reduce costs by increasing certainty throughout project implementation. The CERP guidance is consistent with the Everglades adaptive management WRDA 2000 authorization, as well as follows the more general 2009 adaptive management guidance from USACE Headquarters on implementing Section 2039 of WRDA 2007.

In summary, there is extensive knowledge about the Everglades and there are uncertainties that arise during project planning that need to be addressed. Rather than delaying planning for the sake of further data collection or model development, the adaptive management plan provides a mechanism to systematically address uncertainties during the TSP implementation in order to confirm that project performance is on the right trajectory, to detect early if an adjustment is needed, and to provide sound data to inform operations and implementation decisions. The adaptive management plan identifies which areas to monitor to detect performance, and options for adjusting if needed to remain on track with performance expectations, as well as suggesting future CERP options to meet overall CERP restoration goals. The suggestions for future CERP options are not expected to be authorized as part of the CEPP PACR Plan. Rather, these are described to capture the best current understanding of needs that may be considered in the future to further improve restoration beyond the TSP.

Definitions that will help the reader in understanding Adaptive Management include the following. Additional definitions, specific to the adaptive management strategies that make up the bulk of this adaptive management plan, can be found in **Table D.1-1, CEPP PACR Adaptive Management Uncertainties and Strategies Template and Definitions** (at the end of this section)**.** The concepts and definitions are described in more detail in CGM 56 (2011), the CERP Adaptive Management Integration Guide (RECOVER 2011b), and the CERP Program Level Adaptive Management Plan (RECOVER 2015).

- **Adaptive Management** – A scientific process for continually improving management policies and practices by learning from their outcomes; Adaptive Management links science to decision making to improve restoration performance, efficiency, and probability of success. In the context of Everglades restoration, adaptive management is a structured approach for addressing uncertainties by testing for best project designs and operations to achieve restoration goals and objectives, linking science to decision making, and adjusting implementation, as necessary, to improve the probability of restoration success.
- **Uncertainty** – A question faced during planning or implementation regarding the best actions to achieve desired goals and objectives within constraints, which cannot be fully answered with available data or modeling.
- **Management Options** – Potential structural, non-structural, and/or operational alternatives to be undertaken to improve restoration performance. Adaptive management plans contain potential management actions “options” to improve performance in meeting project/program goals and objectives.
- **Strategies** – A plan to address one or more uncertainties identified in the adaptive management plan. The adaptive management strategies fit into the following approaches:
  - *Active Adaptive Management* (See **Figure D.1-1**) – Multiple pilot projects or design tests are implemented to determine the most efficient and effective way to achieve desired goals and objectives. Each design or operational action is monitored, assessed, and results are used to inform implementation of the best design for a project component or operations. Pilot projects or design tests are usually conducted before implementing the full project component that they are intended to inform.

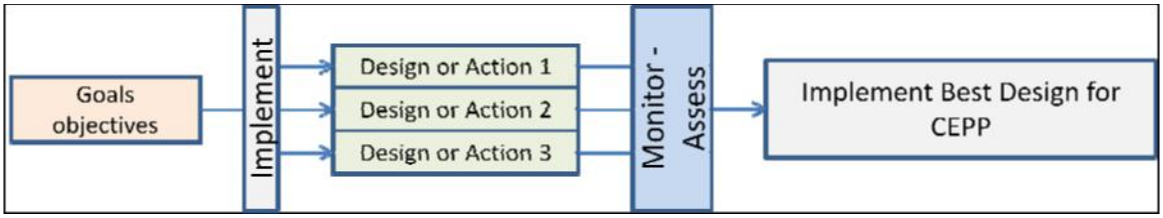

Figure D.1-1. Active Adaptive Management

Project goals and objectives are used to determine multiple, alternate designs or management actions that could achieve the goals and objectives. These are tested by implementing them with associated monitoring. Assessment of the results indicates the best design of a particular component to move forward.

– *Passive Adaptive Management* (see **Figure D.1-2**) – Most of the adaptive management plan strategies are considered passive adaptive management approaches. One project component or set of operational criteria is implemented to test its ability to achieve desired goals and objectives. Results are monitored, assessed, and communicated to the appropriate participating agencies to determine how best to adjust project component designs, operations, CEPP contingency options, or inform future CERP projects.

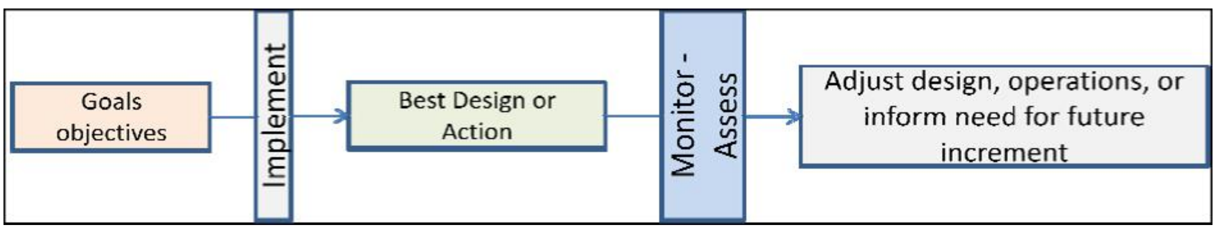

Figure D.1-2. Passive Adaptive Management

The diagram illustrates that, in Passive Adaptive Management, a design or management action is implemented to achieve project goals and objectives. Then, the associated monitoring and assessment produce documentation of successes and (potentially) shortcomings, that can be used as positive or negative lessons-learned to adjust other project component designs, adjust operations, and/or inform a future restoration increment.

Table D.1-1. CEPP PACR Adaptive Management Strategies: Template and Definitions

The CEPP PACR adaptive management uncertainties and the strategies to address them are provided in the format shown here Please see further explanation in Section D.3.

CEPP PACR Adaptive Management Uncertainty and ID#. The uncertainty is a question faced during planning or implementation regarding the best restoration actions to achieve desired goals and objectives within constraints, which cannot be fully answered with available data or modeling. Uncertainties were screened and prioritized to determine which to include in the Adaptive Management Plan.

CEPP PACR Objective or Constraint: Uncertainties related to CEPP PACR objectives or constraints, among other criteria, to be included in the Adaptive Management Plan. This rule helped to focus the scope of the Adaptive Management Plan.

Region(s). Area of CEPP PACR footprint to which the uncertainty and strategy pertain.

Associated CEPP PACR features: Structures or measures to which the uncertainty and strategy pertain.

Driver or uncertainty type: Unlike most Adaptive Management Plans, not all CEPP PACR Adaptive Management uncertainties and strategies are ecological.

Types such as Engineering and Operations are identified.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? Why the uncertainty needs to be addressed in the CEPP PACR.

Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each. A scientific approach begins with a well-informed, pointed, detailed statement that will be tested. For the purposes of the CEPP PACR's Adaptive Management Plan the statement can be referred to as an expectation or hypothesis. Approaching uncertainties scientifically is efficient because it is targeted; a properly identified hypothesis statement is the most important step to lead to effective, efficient methodology to address an uncertainty. It leads to proper identification of what to measure, how, how often, how to analyze, etc.

More Information on attributes to be measured:

What is expected to be learned by measuring this attribute, i.e., how will the CEPP PACR benefit from knowledge gained about this attribute?

What is the time frame in which changes to this attribute are expected to be measurable?

Is this attribute complemented by other monitoring programs within and/or outside of the CEPP PACR? If so, provide reference to other monitoring. Note the monitoring paid for by others in the CEPP PACR Adaptive Management budget spreadsheet.

When during the CEPP PACR life cycle should this monitoring begin and end?

Methodology for testing each expectation or hypothesis (including frequency of monitoring) and for reporting: More information on what to measure, how, how often, how to analyze, and when and how to report results. PLEASE NOTE: the CEPP PACR Adaptive Management Plan varies in the level of methodology detail provided; in several cases the details will be formed during the CEPP PACR's detailed design phase. In ALL cases, methodology will be reviewed, updated and adjusted if needed by agency subject experts, before initiation, to best meet the intent of the Adaptive Management Plan.

Triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action. Triggers or thresholds are a point, range, or limit that signifies when restoration performance is veering away from expectations and is trending toward an unintended outcome. Triggers/thresholds should be described per attribute to be monitored because each should result in an outcome that informs management decisions.

Management options that may be chosen based on test results. Management Options are provided in case a performance trigger or threshold is crossed, which would indicate that the CEPP PACR performance needs to be adjusted. The Management Options are suggested paths forward and adjustments that can be made to keep the CEPP PACR progressing toward objectives and within constraints. The Management Options are summarized in 11x17 pull-out tables after each region's strategies.

D.2 How the CEPP PACR Adaptive Management Plan was Developed: Identification, Screening, and Prioritization of CEPP PACR Uncertainties

The CEPP PACR Adaptive Management plan development consisted of the activities below, consistent with the USACE planning guidance and CERP adaptive management guidance. The CEPP PACR has been adapted from this original CEPP plan as needed to reflect the CEPP PACR areas of influence, which will exclude some of the components that were included in the larger CEPP project:

- Stakeholder involvement;
- USACE planning and adaptive management principles were applied in the screening of project features that were used to create alternative plans and the TSP to increase confidence that the CEPP PACR's components would have sufficient flexibility to continue to be good investments in a shifting environment.
- Identification and prioritization of key CEPP PACR adaptive management uncertainties, also referred to simply as "uncertainties" throughout this Adaptive Management Plan (**Section D.3** of this adaptive management plan) related to achieving the CEPP PACR goals and objectives and avoiding constraints (Section 1 of the PIR);
- Development of adaptive management strategies to address the uncertainties during the CEPP PACR design, construction, and operations that consider existing Everglades conceptual ecological models, hypotheses, performance measures, and monitoring (**Section D.3** of this adaptive management plan);
- Identification of monitoring thresholds and/or triggers and associated management options to adjust, if necessary, based on feedback from assessments (**Section D.3** of this adaptive management plan);
- Development of an adaptive management implementation process to carryout adaptive management activities during design, construction, operations related to baseline and post-project construction monitoring, tests, analyses, and the process for communicating scientific findings to decision-makers, restoration partners, and the public (**Section D.5** of this adaptive management plan).

The identification of the CEPP PACR uncertainties to be considered for inclusion in the CEPP PACR Adaptive Management Plan began with uncertainties already identified in the Decompartmentalization and Sheetflow Enhancement of Water Conservation Area 3 project ("Decomp") documentation report (USACE and SFWMD 2012), and the prioritized list of CERP scientific restoration uncertainties identified by RECOVER in 2011.

The list of uncertainties was screened using the following criteria:

a) Must be directly related to CEPP PACR goals, objectives, or "constraints." The constraints included but were not limited to the legal/USACE definition of constraints; they also included important considerations identified during the CEPP PACR planning process.
b) Must be at project-scale. Although the CEPP PACR is large, it is not at a system-wide scale. System-wide uncertainties were routed to appropriate groups.
c) Must have adaptive management options, i.e., ability to be addressed during implementation, improved by adjusting the TSP. In some cases, additional ability to address the uncertainty with

a future increment of restoration was noted as a "future opportunity", but this feature was not sufficient in itself to pass this CEPP PACR Adaptive Management criteria.

d) Must be an uncertainty. Don't include items that are already known. For example, don't ask "What are the effects of reduced fresh water discharges on oysters in the northern estuaries?" which is known. Instead ask, "Will the TSP reduction of fresh water peak discharges in the northern estuaries improve salinity conditions in x, y, z locations enough to significantly improve conditions for oysters?"

e) The uncertainty needs at least one attribute that is measurable that will provide information to resolve the uncertainty, i.e. the attribute must be a trait able to change in the timeframe of the adaptive management plan, and one that is distinct from the 'background noise' of natural variability. Long-term changes need a faster responding surrogate-measure for the adaptive management plan.

f) Some items remained on the uncertainties list to "Keep them in view". Some examples suggested by the team include: a) remaining watchful for the TSP effects on Lake Okeechobee's (LO) littoral zone, and to balance the ecological needs of the Lake and the northern estuaries; b) observing effects of flow in Shark River Slough on peat dynamics, which is important but hard to link to management options; c) remaining watchful of the potential for the TSP to cause hydrologic changes in the Pennsuco wetlands east of the project area. Due to the need to keep these important topics in view, they passed this criterion.

Once a shortlist of screened uncertainties was identified, the following criteria were used to prioritize them:

Risk: What is the risk (high, medium, low) of not meeting the TSP restoration goals if this uncertainty is not addressed?

- Low risk means that even if the uncertainty isn't addressed, it doesn't pose much risk to achieving the TSP goals and objectives.
- Medium risk means that if the uncertainty isn't addressed, it may or may not affect achievement of a goal/objective.
- High risk means that without addressing this uncertainty, there is a high risk to achieve the TSP goals and objectives.

Knowledge: What is the level of (high, medium, low) understanding of this uncertainty (i.e., how much is known about this uncertainty)?

- Low understanding means little is known about the question/issue or how to address it.
- Medium understanding means some information is known in some geographical areas, but not all.
- High understanding means a lot is known about addressing this question in multiple geographical areas.

Relevance to Adaptive Management for the TSP: What is the level of confidence (high, medium, low) that anything could be done to address the uncertainty? The team's preliminary identification of management options helped to determine this.

- Low confidence means that even if this uncertainty is addressed, the TSP or operations will not be able to be modified given the results of TSP implementation.

- Medium confidence means if this question is addressed, a connection to future CERP project implementation is established/documented but future adjustments to the TSP may or may not be limited, especially if indicator response is longer than 10 years and is more relevant to RECOVER system-wide monitoring.
- High confidence means if this question is addressed, TSP design, implementation, and/or operations can be modified to improve restoration results.

The identification, screening, and prioritization process resulted in a final prioritized list of uncertainties. This list was used to develop strategies, management options, and costs in order to develop the Adaptive Management Plan.

D.3 CEPP PACR Adaptive Management Uncertainties, Strategies, and Management Options

The TSP uncertainties in this section consist of prioritized needs and opportunities to learn in order to make scientifically sound recommendations to refine the TSP design, construction, and operations; the strategies and management options provided to address each uncertainty are intended to guide TSP performance in the face of inevitable uncertainties, with existing knowledge and knowledge that will be gained through monitoring and assessment. The strategies are focused on the TSP, but where possible they are designed to contribute to future increments of CERP restoration as well in order to maximize 'return on investment' for resources invested in pursuing the adaptive management activities. Suggestions of future increments of CERP that may be useful are the best current understanding of needs that may be considered in the future to further improve restoration beyond the TSP, and are not intended to be authorized as part of the CEPP PACR. These suggestions are summarized in the CEPP PACR PIR Section 6.9.1, Incremental Restoration and Future Opportunities. As with the other monitoring plans in Annex D, the monitoring proposed in the adaptive management strategies was guided in part by two objectives: to be complete from a CEPP PACR perspective by providing the monitoring required to address TSP-specific uncertainties; and to integrate with other Everglades monitoring to take advantage of existing monitoring efforts, knowledge, and information and thereby leverage dollars committed and spent elsewhere to avoid redundancies and insure cost-effectiveness. *Where possible, the CEPP PACR adaptive management strategies rely on existing monitoring resources such as physical instrumentation, stations, locations, servicing, and analysis efforts funded by RECOVER, CERP sponsors, and partner agencies. Therefore, the monitoring requirements described here are limited to the additional, marginal increase in monitoring resources and analysis efforts needed to address TSP-specific adaptive management questions.* This point is discussed in the CEPP PACR Adaptive Management Implementation section of this plan, and a table is provided to show leveraged monitoring. In addition, it should be noted that the timing of the strategies is staggered throughout the design and implementation of the project. Please see **Section D.5, Implementation of CEPP PACR Adaptive Management,** and the associated Figures and Tables for more detail on the estimated start- and stop-times for each adaptive management strategy.

The uncertainties, their strategies, and management options are organized in this Plan by geographic region: CEPP PACR-wide, Lake Okeechobee/Northern Estuaries, Greater Everglades, Southern Coastal Systems, and Lower East Coast.

The uncertainties, their identification numbers (ID#), and the CEPP PACR project objective and/or constraint are listed here for reference. The project objectives and constraints are described in detail in CEPP PACR PIR Section 1 (Introduction). A list of uncertainties that were screened out is provided in the final section of this adaptive management plan to show the array of ideas that were considered and brief notes from the screening process. As the Project Team learns from implementation, the list of adaptive management uncertainties will be updated to identify which have been addressed and where the risks to achieving restoration success have been lowered.

The remainder of this section of the adaptive management plan (**Section D.3**) provides strategies for addressing the following screened uncertainties developed during the CEPP process.

Note: the uncertainty ID numbers below refer to the ID numbers assigned to each uncertainty during Adaptive Management screening, and therefore may not appear sequential since those that did not pass screening are no longer included. The ID numbers were maintained for organizational purposes; future refinements of the CEPP PACR Adaptive Management Plan may include re-numbering of the uncertainties.

CEPP PACR-wide

- How will the TSP influence the introduction and growth of non-native invasive and native nuisance species populations within the project area, and will the species influence the predicted landscape and performance of the plan? (ID#59/66; CEPP Objective 1)

Lake Okeechobee

- Do CEPP's operational refinements for Lake Okeechobee, which include class limit adjustments beyond the operational flexibility available under the LORS 2008 Regulation Schedule and which reduce the duration and number of high volume fresh water discharge events to the northern estuaries, affect the Lake Okeechobee littoral and nearshore vegetation coverage? (ID#3, CEPP Objective 3)

Northern Estuaries

- St. Lucie Estuary
  - Do the further reductions of high volume fresh water discharges (high flows) in the TSP result in measurable increases in submerged aquatic vegetation (SAV) coverage in St. Lucie Estuary (SLE)? (ID#1; CEPP Objective 3)
  - To what extent will the reduction in the frequency and magnitude of high flows to the SLE stabilize conditions enough to improve benthic habitat in the SLE in the south fork? (ID#46; CEPP Objectives 4, 5)
  - To what extent will the reduction in the frequency and magnitude of high flows to the SLE help reestablish historic oyster beds on the South Fork SLE? (ID#45; CEPP Objectives 3, 5)
- Caloosahatchee Estuary
  - Do the small further reductions of high volume fresh water discharges in the TSP result in measurable increases in SAV coverage and oyster acreage and health in the Caloosahatchee Estuary? (ID#2; CEPP Objective 3)

   – Will the increase in low flow violations in the Caloosahatchee Estuary hinder re-establishment of persistent *Vallisneria* beds in the upper Caloosahatchee Estuary? (ID#49; CEPP Objectives 4, 5)

Greater Everglades

- Are the flow velocities, flow direction, volumes of fresh water, and water depth improvements sufficient to reestablish historic ridge and slough landscapes? (ID#73; CEPP Objectives 1, 2, 5)
- Can the TSP contribute to the creation of hydrology favorable for tree island elevation requirements? (ID#76; CEPP Objectives 1, 2, 5)
- Are inundation and hydroperiod sufficient to reduce current high rates of soil oxidation and peat fires? (ID#5; CEPP Objective 2)
- How much will the project improve alligator relative density and body condition in northern WCA 3A? (ID#10; CEPP Objectives 4, 5)
- How much will hydrologic restoration and vegetation management result in increases in prey densities (aquatic fauna)? (ID#9; CEPP Objective 1)
- How much will hydrologic restoration and vegetation management result in increases in wading bird foraging conditions and increased nest number? (ID#75; CEPP Objective 1)

Everglades National Park (ENP)/ Southern Coastal Systems

- Will there be downstream biogeochemical effects associated with modifying inflows and hydrologic conditions in ENP, including effects on nutrient movement, availability, and ecological responses? This includes consideration of hydrologic effects on nutrient loading, nutrient release from soils, transport, and water-quality related ecological indicators, such as periphyton tissue nutrients, cattail expansion, and algal bloom events, especially in eastern Florida Bay where nitrogen levels are relatively high? (ID#63; CEPP Objective 1)
- Will the TSP further improve flows to Florida Bay and the Lower Southwest coast resulting in more natural salinity patterns (magnitude, spatial distribution and timing)? (ID#67; CEPP Objective 2)

Adaptive management strategies are provided in this section to describe and address each CEPP PACR adaptive management uncertainty and inform implementation based on the body of existing scientific knowledge in Everglades restoration. This section comprises the bulk of the CEPP PACR Adaptive Management Plan. It provides 1-2 page strategy descriptions for each uncertainty (sometimes combined, where appropriate) and summary tables of suggested management actions to improve restoration performance, as illustrated in **Table D.1-1.** The 1-2 page strategy write-ups include information on drivers of the uncertainty, restoration targets and TSP targets for particular attributes of the ecosystem associated with the uncertainty (such as a key species or ecological features), how these attributes will be monitored to track progress toward the targets, the timeframe in which changes in these attributes will be measurable, and identification of a trigger or threshold that would give early warning that performance is veering from restoration expectations. *The "timeframe in which changes will be measurable" does not imply that changes will be complete in that timeframe; rather, the timeframes provide an estimate of time needed to begin to be able to distinguish project effects. For practicality, the CEPP PACR Adaptive Management Plan screening criteria included the need to have attributes measurable within the time of the Adaptive Management Plan, which in some cases necessitated a 'proxy' attribute to be measured that* *would represent expected changes on a longer time scale. In addition, the triggers and thresholds were identified with the best available information, but the AM team recognizes that they should be updated to keep current with best available science.* Second, following the strategies, tables of suggested management options are provided, called management option matrices (MOMs). These provide suggestions of paths forward and adjustments that can be made in order to keep the CEPP PACR progressing toward the targets, based on specific decision-criteria, e.g., a trigger or threshold is crossed (reflecting unintended effects related to a constraint) or is not crossed (reflecting lack of restoration progress towards restoration goals and objectives). The purpose of the two formats is to provide A) background and detail of each strategy in the 1-2 page write-ups and B) a table reference summary and crosswalk that relates monitoring to specific decision-criteria and potential actions for multiple strategies in a specific area. The detailed write-up descriptions are referred to as the "strategies" and the summary tables are referred to as "management options matrices" (MOMs) (**Table D.1-1**).

D.3.1 System-Wide Restoration Uncertainty and Strategy: Invasive and Nuisance Species

D.3.1.1 Invasive and Nuisance Species in the CEPP PACR Footprint

The introduction and expansion of invasive and nuisance plant and animal species has the potential to alter the predicted restoration landscape pattern and species composition. Such species can alter plant community structure, species composition, fire frequency and intensity, habitat quality, compete with and displace native species, threaten endangered species, and alter trophic dynamics and food webs. The high profile floral and faunal invasives (e.g., *Melaleuca*, Brazilian Pepper, Burmese python) and their impacts to the landscape are well documented. However, these species are but a fraction of the invasive and nuisance species in the Everglades ecosystem. Many of the other species' life histories and responses to disturbance and treatments are insufficiently understood.

The CEPP PACR adaptive management invasive species strategy described here focuses on consolidating species data that is existing and proposed to be collected, in order to improve the project's ability to target species management resources most effectively in the specific conditions that will be created by the TSP and thereby prevent invasive and nuisance species impacts on the performance of the TSP. This adaptive management strategy has been coordinated with the CEPP PACR Invasive and Nuisance Species Management Plan (INSMP).

This topic is included in the Adaptive Management Plan because of its level of uncertainty and risk to project outcomes, its ability to be addressed through management options, and to ensure that it remains part of CEPP PACR discussions as lessons are learned throughout the implementation of the project.

CEPP PACR adaptive management Uncertainty #59/66: How will the project influence the introduction and growth of non-native invasive and native nuisance species populations within the project area, and will the species influence the predicted landscape and performance of CEPP PACR? (Driver or type: Ecological)

This uncertainty is related to CEPP PACR objective of restoring a natural mosaic of wetland and upland habitat in the Everglades system, and relates to all regions and features of the TSP.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? It is anticipated that addressing this uncertainty will improve the understanding and ability to predict how invasive and nuisance species influence the ecosystem function and structure within the footprint of the project, and potentially influence the outcome of the TSP restoration activities. Improved species profiles and prediction/risk assessment abilities can help target resources to the most effective species management activities, and can inform future design and operations of other restoration projects to avoid expensive trial-and-error attempts to reduce the impacts of invasive and nuisance species. The proposed activities will reduce the possibility of invasive and nuisance species hindering CEPP PACR from achieving its restoration objectives.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured to test each. No new monitoring is proposed in this adaptive management strategy to improve predictions and risk assessment, rather, data from the CEPP PACR INSMP and Ecological Monitoring Plan, RECOVER MAP, other CERP INSMPs and ecological monitoring plans, historical and current databases, and aerial photos may be used to develop and/or refine risk assessment tools to direct species management decisions. Before implementation this data should be consolidated in CERPZone to develop the needed species profiles and tools.

It is recommended that the causal relationship between invasive or nuisance species to restoration activities and outcomes should be investigated as the data is consolidated. As CEPP PACR Adaptive Management Plan implementation approaches, the invasive and nuisance species experts among the agencies and interested stakeholders should be consulted to identify the most relevant species and questions to investigate and methods to follow. Species should be chosen based in part on their ability to represent a broader group of species to maximize the knowledge gained from monitoring their responses.

Methodology for testing each expectation or hypothesis. No new monitoring is proposed as part of the Adaptive Management Plan to address this uncertainty; please see the CEPP PACR INSMP for details about species and surveillance methodology. In addition, the CEPP PACR Ecological Monitoring Plan to monitor project success includes vegetation change monitoring. During this monitoring plant species will be documented in locations that will be deemed sentinel sites by invasive and nuisance species agency experts for measuring restoration success. If invasive or nuisance plant species are found at these sites the vegetation management teams at the implementing agencies will be notified and will address the presence of the species as specified in the INSMP. Regarding fauna, USACE contracts include a requirement to report invasive or nuisance animal species to the project's environmental lead and the Invasive Species Management Branch. A similar requirement will be pursued for CERP project and program level monitoring.

Consolidation of existing information and refinement or development of Invasive Risk Assessment Tools are suggested prior to CEPP PACR implementation to better define triggers for when management actions should be taken and avoid expensive negative impacts through a reactive management approach.

How results will be reported, and the triggers/thresholds that indicate good performance or need for adaptive management action: Lessons learned will be provided as feedback to the next stages of CEPP PACR design, construction, and implementation by the invasive and nuisance species agency experts during interactions with CEPP PACR Design Team, Operations, and others as appropriate. There are currently several forums for sharing this information and we anticipate similar forums in the future. The INSMP is a living document that will also be updated with lessons learned.

Management options that may be chosen to reduce the impacts of invasive species. Feedback to management could include informing project decisions such as timing of delivering water, or routing water through an area slightly differently than originally specified, in addition to informing the invasive and nuisance species management team actions. Suggested adaptive management options listed below are not in any particular order and can be implemented simultaneously, as appropriate.

- Refinement or development of Invasive Risk Assessment Tools.
- Implementation of Invasive and Nuisance Species Management Plan to immediately identify and eradicate new opportunistic/highly mobile invasive exotic species in areas of concern (e.g. active construction sites).
- Implementation of Invasive and Nuisance Species Management Plan for a regional approach to suppress, control, and/or eradicate slow-growing/less mobile species.
- Suppression of established invasive species to the lowest feasible level such that ecosystem impacts are minimized.

Redesign of existing or planned features, as appropriate and based on lessons learned, to make them less supportive of invasive exotic species proliferation/movement.

D.4 Lake Okeechobee and the Northern Estuaries

A clear relationship between the health of the northern estuaries habitats and the volume and timing of fresh water discharges from Lake Okeechobee and the estuarine watersheds has been established (Doering and Chamberlain 1999, Barnes 2005, Sime 2005). Discharges change salinity in the estuaries, which affects the health, reproduction, and survival of key species. These species have an ideal range of salinity, and can tolerate some variations; their range of salinity is referred to as the “salinity envelop”. Likewise, key species in LO represent LO’s ecological health (Havens and Gawlik 2005). These species have an ideal range of water depth in LO and can also tolerate some variations; their ideal water depth range can be referred to as a “stage envelop”. In CEPP PACR’s planning, great care was taken to determine operations that balance the stage needs of LO and the salinity needs of the northern estuaries while routing as much water as possible south, through the reservoir and stormwater treatment area (STA) and beyond to the Everglades. The adaptive management questions in this northern region of CEPP PACR focus on achieving the balance among these closely related systems using the deep level of knowledge about the needs of the estuarine and lake habitats, as well as water quantity and quality needs of the Greater Everglades.

D.4.1 Lake Okeechobee’s Balance with Northern Estuaries and the CEPP PACR Reservoir and STA

This CEPP PACR adaptive management uncertainty highlights the balance needed between maintaining Lake Okeechobee (LO) at ecologically beneficial, water supply and flood risk management appropriate lake stages, the ecological performance in the northern estuaries, and the need to send water from LO south into the project features. The strategy proposes analyzing data, from existing monitoring programs that would be continued during project implementation, to determine if operations that attempt to improve conditions in the estuaries and deliver water south to the Everglades during the dry season also affect LO's littoral and nearshore vegetation. The hypothesis, monitoring, and data analysis in this strategy focus on LO. Estuarine monitoring is described separately.

Modeling of the hydrology of LO and the estuaries shows that the estuaries will receive fewer high-flow events that violate the salinity envelopes of the northern estuaries, and LO will at times have higher stages (while remaining within the current operation schedule), which has the potential to affect LO's vegetation. The critical issue will be what time of year and for what duration Lake stages are higher. High lake stage allows wind-driven waves to uproot emergent and submerged aquatic vegetation (EAV and SAV, respectively) in the nearshore region. It may also result in re-suspension or transport of suspended solids in or to the nearshore and littoral regions, reducing water clarity and light penetration, resulting in less SAV growth. Another issue is if stage reversals occur during the spring recession, bird species such as wading birds, snail kites, and ground nesters could be adversely affected by flooding of nests and/or loss of foraging habitat. Small stage reversals (e.g., < 6 inches) may also flood apple snail egg masses, even though it may take larger stage reversals to cause detectable changes to vegetation in the lake. Vegetation impacts would also probably not be detectable if a stage increase is of short duration; i.e., 1-3 months. In conclusion, we expect that higher water levels (e.g., >15 ft NGVD) resulting from the TSP operations should be infrequent and of short enough duration to prevent significant reductions in the littoral and near shore EAV and SAV. This adaptive management plan was designed to verify that expectation and to inform potential future decisions if Lake Managers need to address unintended TSP influences on LO.

CEPP PACR adaptive management Uncertainty #3: Do CEPP PACR's operational refinements for LO, which include class limit adjustments beyond the operational flexibility available under the LORS 2008 Regulation Schedule and which reduce the duration and number of high volume fresh water discharge events for the northern estuaries, affect LO littoral and nearshore vegetation coverage?

Driver or uncertainty type: Ecological and operational; balancing multiple objectives (water supply, flood control, and ecological health of the lake and estuaries).

This uncertainty is related to the CEPP PACR constraint of remaining within the approved operating schedule of Lake Okeechobee and doing no ecological harm to LO. It focuses on the ecological effects of operations in Lake Okeechobee operations in the region that will balance the needs of LO, the northern estuaries, and will optimize the volume and timing of water to send south to the Everglades. The associated CEPP PACR and non-CEPP PACR features are LO operations, A-1 FEB, A-2 Reservoir and A-2 STA, STAs 3/4, C-44 Reservoir, C-43 Reservoir, and Indian River Lagoon-South Project.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? CEPP PACR was designed to not negatively impact LO ecosystem, which is represented here by the relationship between vegetation and lake stage. The purpose of this adaptive management item is to detect unintended negative effects early and provide reliable data analysis for subsequent discussions of Lake Okeechobee regulation schedule modifications that could be needed.

Expectations and hypotheses to be tested to address uncertainty #3, and attribute(s) that will be measured to test each. During CEPP PACR planning, the conclusion of model evaluation of all alternatives indicated that they had a low potential to impact vegetation because stage differentials between the TSP and the FWO were typically small, intermittent and had sufficient recovery time between them. Therefore, the expectations to be checked are that there usually will be no discernible negative littoral or near shore vegetation impacts in the lake resulting from CEPP PACR's operational changes, which will hold additional water in the lake compared to FWO. (Note: the additional water held in the lake remains within the current LORS 2008 requirements.)

Attributes to be measured to examine the potential impacts of additional lake stages resulting from CEPP PACR include quantifying the additional water held in LO and associated change in lake stages, and associated changes in littoral and nearshore vegetation areal coverage. Lake stages and vegetation coverage are currently monitored by the SFWMD. SFWMD tracks lake stages and provides weekly updates and a weekly stage hydrograph. If this tracking continues then pre-CEPP PACR and post-CEPP PACR lake stage data would be available. These data would show, for example, if CEPP PACR operations are holding the lake >6 inches above the ecological performance measure stage envelope, and for what duration. If such incidents occur, they will be tracked and compared with the vegetation data (described next). Existing meteorological data in conjunction with water control structure data will be analyzed to verify whether changes are due to CEPP PACR operations or due to climatic changes (e.g., period of increased rainfall), as LO monthly stages are significantly correlated to prior 2 years of watershed rainfall (RECOVER 2009).

Currently the SFWMD Lake and River Ecosystem Section conducts monitoring of LO's nearshore and littoral EAV and SAV via aerial photography and quadrat sampling, respectively, to estimate vegetation coverage. The EAV and SAV monitoring is anticipated to continue so that changes in vegetation coverage over time can be detected. If lake stages are held significantly higher with CEPP PACR, then the vegetation data can be analyzed for changes associated with the additional lake stages. No additional monitoring is currently suggested for this uncertainty. Instead, CEPP PACR-specific data analysis and reporting is proposed to address: if and when the lake stages are held slightly higher, due to CEPP PACR operations, and if so, are they affecting the littoral and near shore vegetation?

More Information on Attributes to be measured:
For each attribute, specify the following.

- **What is expected to be learned by measuring this attribute, i.e., how will CEPP PACR benefit from knowledge gained about this attribute?** Data on the lake's stages and the vegetation coverage are needed to test whether CEPP PACR affects the lake vegetation, though significant datasets exist to support stage and vegetation coverage relationships.
- **What is the time frame in which changes to this attribute are expected to be measurable?** Within 1 year of operating CEPP PACR, when additional water is stored in the lake, resulting from CEPP PACR operations.
- **When during the CEPP PACR's life cycle should this monitoring begin?** Since monitoring programs currently exist, they will not need to be initiated but should instead be continued in order to collect legitimate pre- and post-CEPP PACR data. Conversely, if the current level of monitoring is decreased, then baseline monitoring will need to begin 3 to 5 years prior to the A-2 reservoir becoming operational.

Methodology for testing each expectation or hypothesis (include frequency of monitoring). No new monitoring is proposed to address this uncertainty; instead, existing monitoring programs should be maintained to gather the needed data. TSP specific analysis would be needed to determine if TSP operations affect vegetation coverage. A total of four weeks per year of additional data analysis and reporting has been proposed in the CEPP PACR adaptive management budget for addressing this uncertainty, when significant increases in lake stage occur due to additional water storage resulting from the TSP.

Triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action. Significant decrease in littoral or near shore vegetation coverage, i.e., a reduction in vegetation coverage of >10 percent which persists for one growing season (Spring to Fall) that is causally linked to instances of withholding more water in the lake resulting from the TSP. A more refined threshold that identifies optimal species distribution and composition may be developed, and could be informed by the following existing sources of information:

- Spatial extents in acres of marginal and optimal habitat are provided in the 2008 LORS Biological Opinion. However, the distribution of habitat types has significantly changed with dry years since 2008; updated information should be used to make accurate assessments of the TSP effects.
- Lake Okeechobee Regulation Schedule thresholds for littoral vegetation from Endangered Species Act (ESA) consultation (Snail Kite critical habitat).
- A newly developed RECOVER performance measure (still under review) for LO littoral zone emergent vegetation, could be used for comparison of whether changes are positive or negative in terms of vegetation coverage. Additional modeling efforts may be able to further quantify lake stage – vegetation relationships and the potential ecological benefits of building additional water storage in the watershed.
- The Florida Fish and Wildlife Commission also conducts lake monitoring, focused on fish species. It is to be determined if or how the fish monitoring could contribute to addressing the adaptive management Uncertainty described here about the ecological effect of refinements to Lake Okeechobee operations.
- The USACE is funding snail kite monitoring on the lake as required by the Biological Opinion (BO) for the 2017 LORS and the 2016 BO for the Everglades Restoration Transition Plan. It is to be determined if or how this monitoring could contribute to addressing this CEPP PACR uncertainty particularly because of the confounding effects of the invasive apple snail on snail kite use of LO habitats.
- Other, as yet untested methods that may be developed in the intervening years until the A-2 reservoir comes on-line.
- The revised nearshore SAV PM, which assesses yearly SAV coverage compared to the total areal coverage potentially colonizable (based on bathymetry and previous mapping efforts), may be used to determine nearshore SAV health.
- **Management options that may be chosen based on test results are included in the Management Options Matrices (MOM) for LO, the A-2 reservoir, the A-2 STA, and the Northern Estuaries, which are all linked to each other.**

Table D.1-2. Lake Okeechobee (LO) Balance with Northern Estuaries Management Options Matrix

The Management Option Matrix (MOM) shown here, and those throughout the adaptive management plan, help link monitoring identified in specific adaptive management strategies to decision criteria and suggested management options to consider for adjusting CEPP PACR if monitoring reveals performance issues related to CEPP PACR operations. For the CEPP PACR adaptive management plan, nearshore and littoral zone vegetation represents the lake's ecology. Currently no alternate explanations for changes in vegetation are included, such as increased fish populations. After authorization of CEPP PACR and before implementation of the CEPP PACR Adaptive Management Plan, it is recommended that such possibilities be considered and accounted for in this and other CEPP PACR adaptive management strategies to the extent possible.

Uncertainty Tracking ID#	Timeframe to Detect Change of Attributes*	Attribute or Indicator	Specific Property to be Measured and Frequency	Decision Criteria: Trigger(s) for Management Action	Management Action Options Suggestions
#3	<1 year	Native vegetation in LO littoral and nearshore zones	Acres of native vegetation Vegetation species composition	Significant decrease (>10%) in littoral or near shore vegetation coverage, which persists for one growing season (Spring to Fall) and causally linked to instances of withholding more water in LO resulting from the TSP	• Adjust operations to hold more water in LO at times when less likely to impact vegetation, • Adjust operations to send more base-flow water to the estuaries, if flow won't impact salinity envelopes, • Adjust operations to move more water to the FEB during periods of ecologically harmful high LO stages to prevent additional ecological damage in LO and estuaries. • Adjust operations to share the balance of extra water between LO and the estuaries until increased capacity and storage are available, i.e., this could include alternating between sending water to the estuaries or keeping it in LO during times of excess water. (This information will better inform the weekly operations call discussions and increase the options that are discussed) **Potential considerations for future CERP and non-CERP restoration projects:** More storage reservoirs, particularly north of LO; If a discussion ensues about LO schedule it is suggested that streamlined modeling can show effects of lake changes on LO vegetation.

*The "timeframe to detect changes..." does not imply that changes will be complete in that timeframe; rather, they provide an estimate of time needed to begin to be able to distinguish effects of CEPP PACR. These time frames are indications of response speeds, not limits on how long the monitoring will be conducted.

D.4.2 St. Lucie Estuary

The CEPP PACR and LO operational adjustments combined with Indian River Lagoon South operations are intended to help reduce high flows from the LO and basin runoff to the Northern Estuaries. Uncertainty exists in whether the project features will improve LO high flow releases during the wet season to the degree necessary to reduce low salinity events in the south fork portion of the SLE that stress both benthic SAV and oysters. In addition, uncertainty exists regarding the recovery of SAV in the estuary if additional measures are not taken to improve water clarity and sediment problems, such as removal of mucky sediments and further Best Management Practices (BMPs) in the watershed that will be needed to improve water quality.

CEPP PACR Adaptive Management Uncertainties: There is a group of closely-related ecological uncertainties in the SLE.

- Do reductions of high volume fresh water discharges (high flows) result in measurable increases in submerged aquatic vegetation (SAV) coverage in SLE? (ID#1)
- To what extent will the reduction in the frequency and magnitude of high flows to the SLE help reestablish historic oyster beds on the South Fork SLE? (ID#45)
- To what extent will the reduction in the frequency and magnitude of high flows to the SLE stabilize conditions enough to improve benthic habitat in the SLE in the south fork? (ID#46)

This group of uncertainties is related to the CEPP PACR objective of reducing high volume discharges from Lake Okeechobee to the Northern Estuaries. The region is Lake O – Northern Estuaries. The associated CEPP PACR and non-CEPP features are Lake O operations, the A-2 reservoir and A-2 STA, the Indian River Lagoon-South project and C-44 reservoir, and S-80.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? The TSP benefits to the SLE can be optimized if sufficient information about the on-the-ground effects on the estuaries is gathered and reported.

Expectations and hypotheses to be tested to address the SLE uncertainties, and attributes that will be measured to test each. The proposed monitoring may be complemented by RECOVER Northern Estuaries monitoring programs and by project-level monitoring. The locations of specific monitoring proposed here will be conducted in the specific locations where CEPP PACR Planning Modeling showed effects from the TSP.

A. High Flow Salinity (pertains to uncertainties #1, 45, and 46)

- The TSP will result in fewer high flows to SLE, based on planning model results that showed a reduction of 33-42% of high flow discharge >2000 cubic feet per second (cfs) at the S-80 Structure over 41-year period of record).

B. Benthic habitat (pertains to uncertainty #46)

- The TSP will result in an improvement in benthic habitat that will result in Marine Biotic Index (MAMBI) score improvement in the south fork and potentially the middle estuary due to improve salinities. Expected improvement by one benthic MAMBI score in the south fork monitoring sites M4 and M5; expected to move from Moderate (orange) to Good (green) at site M4 and Good (green) to High (blue) at site M5.

- Alternatively, the TSP may not result in an increase in benthic habitat due to poor sediment and water quality in the SLE.

C. Submerged Aquatic Vegetation (SAV) (pertains to uncertainty #1)

- The TSP will increase SAV bed density (# shoots/acre) of manatee grass by 20%, measured at Boy Scout Island. This is based on the CEPP PACR Planning Modeling that showed a decrease in die-off events and increase in *Halodule* acreage, shoot density, and blade length in the area directly outside of the mouth of the SLE at Boy Scout Island from 1,873,297 shoots per acre to 2,249,388 shoots per acre.
- The TSP should improve seagrass shoot density in other areas where seagrass already exists, where salinity range is met.
- This measure is assuming that the numbers generated during CEPP planning will improve slightly under the TSP due to the additional small number of reduced high level discharges. The same ecological modeling was not done for CEPP PACR due to time constraints.

D. Oysters (pertains to uncertainty #45).

- TSP will increase the acres of oysters by 81 in the CRE and by 41 in the SLE over the FWO conditions.

More Information on Attributes to be measured:

- **What is expected to be learned by measuring this attribute, i.e., how will CEPP PACR benefit from knowledge gained about this attribute?** The attributes have been identified as indicators of ecological health in the St. Lucie estuary and indicators of restoration performance. They are the minimal efficient attributes to monitor performance in the St. Lucie.
- **What is the time frame in which changes to this attribute are expected to be measurable?** See triggers and thresholds below.
- **Is this attribute complimented by other monitoring programs (within and/or outside of CEPP PACR)?** The monitoring is complemented by RECOVER MAP and restoration project monitoring. The locations for monitoring are focused in areas where CEPP PACR modeling showed the most likelihood to achieve restoration benefits in the SLE.
- **When during CEPP PACR's life cycle should this monitoring begin?** Since RECOVER, estuarine monitoring can be used for baseline comparison, this monitoring should begin when CEPP PACR changes flows to the estuaries by routing water south rather than discharging it to the estuaries.

Methodology for testing each expectation or hypothesis (include frequency of monitoring). The above hypotheses will be tested by monitoring restoration performance related to improved salinities in the SLE due to reduction of high flows at S-80, after implementing the project. Three primary indicators (benthic invertebrate community health, SAV, oysters) will be used as multiple lines of evidence to verify ecological restoration response to improve salinities. Information will feed back into improved operations of the reservoir and STA in coordination with Lake Okeechobee and IRL-S, as well as future CERP increments related to storage, to further reduce high flow discharges to the estuaries. In addition, the monitoring will confirm whether water quality (nutrients) and/or sedimentation (total suspended solids) may be affecting restoration performance, which would need to be addressed by IRL-S implementation and/or future CERP increments and State water quality best management practices.

IRL-S is an important CERP project that works synergistically with the TSP to improve high freshwater flows from the basin and also addresses associated sediment and nutrient inputs from the basin, thus reducing stress on the both benthic invertebrates, SAV, and oysters. If that project is not implemented, the benefits to SAV (acreage and shoot density), benthic invertebrates (improved community health index scores), and oysters (increased density per acre) associated with the TSP may not be realized. If the IRL-S C-44 reservoir is operational before the project, then CEPP PACR baseline monitoring in the northern estuaries will document the changes due to that project to differentiate from changes resulting from the TSP.

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action. The associated thresholds identified in the statement of hypotheses on page D.1-20 combined with the following monitoring parameters and timing are identified to help determine in the future whether adjustments to the TSP operations are needed, and they may additionally inform future restoration projects by providing lessons learned.

- *Flows and Salinity*: High flows and low flows are compared to rainfall, and expected to show changes compare to baseline in a minimum of 2 years, as well as comparable water years in the modeling period of record. If no changes are observed, then operational adjustments would be the next action. Rainfall will be measured from National Weather Service data in the basin. Existing monitoring of flow and salinity will be used with the exception of adding a salinity recorder at the Palm City Bridge. Flows are measured by continuous recorders at the salinity control structures in the SLE (S-80, S-49, S-48, and Gordy Road). Salinity can be measured at Roosevelt (US1) Bridge (existing monitoring by SFWMD) and Palm City Bridge (needs to be added).
- *Water Quality*: Existing water quality monitoring at 10 stations in the SLE will be used to detect water quality conditions to determine if they have changed from the baseline. Nutrients may be a confounding factor to investigate if salinity goals are met, but ecological indicators did not respond.
- *Benthic*: A minimum of 2 years is needed to detect progress in the MAMBI benthic community index score, after achieving the right flows and salinity. The RECOVER monitoring should be used to inform TSP restoration progress. Particularly in the South Fork estuary, sites M4 and M5 can be compared to the middle estuary and IRL-S sites to determine if the change is due to improvements in reducing high flows from the S-80.
- *SAV*: A minimum of a 4-year period is needed to compare to baseline and look for incremental progress towards TSP performance expectation for both indicators. RECOVER monitoring and sampling protocol will be used. Additional resolution is needed in South Fork, North Fork, and 2-3 years in the middle to outer estuary. RECOVER does not monitor SLE only IRL and outer point at St. Lucie (Willoughby Cove). In addition, mapping of SAV in SLE every 2-3 years is needed to detect additional areas that may have improved seagrass coverage (*Halophila* and *Halodule* seagrass species). The quadzilla mapping technique or cheaper option should be used to quantify change in SAV acreage in areas where salinity is expected to have improved resulting in increased chance of SAV expansion.
- *Oysters*: A minimum 4-year period is needed to compare to baseline and look for incremental progress towards TSP performance expectation for oyster density and oyster health. RECOVER monitoring can be used to monitoring oysters in the north and south forks of the SLE and in 2

areas in the middle estuary. Current RECOVER sampling protocol samples live-dead counts four times a year (April, June, October, January) and should be able to analyze potential increase in oyster density related to TSP by teasing out inter-annual variation due to climatic changes. In addition, high-flow or low-flow event driven monitoring should be conducted. RECOVER monitoring that measures recruitment, growth, predation, disease in existing locations can be used to understand how flow performance measure violations may be impacting salinity issues that affect these oyster parameters.

Management options that may be chosen based on monitoring results. One key assumption to be considered before determining whether management options should be implemented for SLE is whether the TSP is meeting its expected 370,000 average acre-ft per year delivery of water south to the Greater Everglades, which means it is accepting water from Lake Okeechobee. Operations of the lake reservoir and STA will be optimized to meet the average volume delivery goal, and where possible, to get additional reduction of high-flow discharge events beyond what was estimated in the modeling, as well as minimize low flow exceedence events.

The following options are consistent with CERP SAV, benthic invertebrates, and oyster indicators:

- **If there is an issue with flows:** Optimize flows between IRL-South, Lake Okeechobee, and CEPP PACR; consider increasing water storage capabilities in the next increment of CERP (see CEPP PACR PIR section, "Future Opportunities").
- **If there is an issue with sediment**: Evaluate benthic monitoring results as first indicator of issues with sediment. If results suggest that despite salinity improvements the ecological restoration is hindered by undesired sediment (potentially high organic, anoxic, high sulfide muck) then muck removal may be needed. Muck removal is not part of the TSP nor has it been evaluated during planning; it is provided here as a suggestion for parties to consider for a future effort if needed. The suggested methods include identifying suitable salinity areas given the TSP and other project results, then removing muck in those areas as described in Indian River Lagoon South project document.
- **The following options are specific to SAV and oysters**:
  - SAV – If there is an issue with water quality: provide the results as feedback to the implementing agencies to further optimize water quality using IRL-South Stormwater Treatment Areas, water quality features and State water quality projects/BMPs. If there is an issue with lack of seed source: Implement seagrass plantings, which may be a non-implementing agency restoration effort.
  - Oysters – If there is an issue with lack of oyster substrate: Add suitable substrate such as oyster cultch (material such as oyster shells or concrete laid down on oyster areas to provide mobile oyster spat with places to attach), or add mature oysters to increase spat production as described in the Indian River Lagoon South project.

D.4.3 Caloosahatchee Estuary

After implementing the TSP, restoration performance will be monitored related to improved salinities in the Caloosahatchee Estuary due to reduction of high flows at S-77 (from LO) and S-79, which is the main structure that discharges into the Caloosahatchee River and Estuary (CRE). It is uncertain whether the project will improve LO high flow releases during the wet season to the degree necessary to reduce low salinity events in the middle and lower estuaries that stress both SAV and oysters in the Caloosahatchee. In addition, we are uncertain about whether water quality and sedimentation in the Caloosahatchee will improve from existing LO flows that stress SAV photosynthesis.

Two primary indicators (SAV, oysters) will be used as multiple lines of evidence to verify ecological restoration response to improve salinities. Information will feedback into improved operations of the A-2 project in coordination LO and C-43 project, as well as future CERP increments related to storage to further reduce high flows. In addition, the monitoring will confirm whether water quality (nutrients) and/or sedimentation (total suspended solids) may be affecting restoration performance, which would need to be addressed by future CERP increments and State water quality BMPs. While it is possible that other factors could affect the estuaries and would not be identified by monitoring SAV and oysters there is a need to focus on a relatively small number of ecological indicators in order to be able to set targets and track change efficiently; therefore the valued ecosystem component (VEC) concept is used. For the uncertainties addressed in this adaptive management plan the VECs are SAV and oysters, which have long been recognized as supporting estuarine habitat in these estuaries and have extensive historical data sets. Salinity is a primary indicator of the effects of fresh water flow changes, which help mediate extreme salinity fluctuations for oysters and SAV.

C-43 is an important CERP project that works synergistically with the TSP to improve high and low freshwater flows from the basin and Lake Okeechobee, and also addresses associated sediment and nutrient inputs from the basin, thus reducing stress on both SAV, and oysters. If that project is not implemented, the benefits to SAV (acreage and shoot density) and oysters (increased density per acre) associated with the TSP may not be realized. If the C-43 reservoir is operational before the project, then RECOVER and CEPP PACR baseline monitoring would document the changes due to that project to differentiate from changes resulting from the TSP.

CEPP Adaptive Management Uncertainties in the Caloosahatchee Estuary: There is a group of closely-related ecological uncertainties in the Caloosahatchee Estuary.

- Do reductions of high volume fresh water discharges result in measurable increases in SAV coverage and oyster acreage and health in the Caloosahatchee estuary? (ID#2)
- Will the increase in low flow violations in the Caloosahatchee estuary be detrimental to re-establish persistent *Vallisneria* beds in the upper Caloosahatchee estuary? (ID#49)

This group of uncertainties is related to the CEPP objective of reducing high volume discharges from Lake Okeechobee to the Northern Estuaries. The region is LO – northern estuaries. The associated CEPP PACR and non-CEPP features are LO operations, the reservoir and STA, S-77, and S-79.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP benefit from addressing this uncertainty? TSP benefits to the Caloosahatchee Estuary can be optimized if sufficient information about the on-the-ground effects of the TSP on the estuaries is gathered and reported.

Expectations and hypotheses to be tested to address the Caloosahatchee Estuary uncertainties, and attributes that will be measured to test each. The proposed monitoring will leverage and compliment RECOVER northern estuaries monitoring and other project-level monitoring. The locations of project specific monitoring proposed here will be conducted in the specific locations where CEPP PACR planning modeling showed effects.

A. Flows (pertains to uncertainty #49)

- High flow reduction (>2800 cfs): of45% over FWO project.
- Low flow exceedence (<450cfs): A slight increase (of 3 over the POR) between FWO and the TSP.

B. Submerged Aquatic Vegetation (SAV) (pertains to uncertainties #2, 49)

- For CEPP it was estimated that there would be an Increase in the number of shoots per acre density in the middle to lower estuary measured by Shell Point from 1,165,536 shoots per acre to 1,250,523 shoots per acre or >15.3% increase. The TSP should further improve the conditions in the middle estuary and is expected to result in additional improvements in acreage and health of seagrass beds.

E. Oysters (pertains to uncertainty #2, 49).

The TSP would result in 81 more acres of oysters in the CRE and 41 more in the SLE as compared to the FWO. **More Information on Attributes to be measured:**

- **What is expected to be learned by measuring this attribute, i.e., how will CEPP PACR benefit from knowledge gained about this attribute?** The attributes have been identified as indicators of ecological health in the northern estuaries and indicators of restoration performance. They are the minimal efficient attributes to monitor project performance in the estuaries.
- **What is the time frame in which changes to this attribute are expected to be measurable?** See triggers and thresholds below.
- **Is this attribute complemented by other monitoring programs (within and/or outside of CEPP PACR)?** The monitoring is complimented by RECOVER MAP and restoration project monitoring. The locations for project monitoring are focused in areas where CEPP PACR modeling showed the most likelihood to achieve restoration benefits in the Caloosahatchee Estuary.
- **When during CEPP PACR's life cycle should this monitoring begin?** If pre-project estuarine monitoring can be used for baseline comparison, this monitoring should begin when CEPP PACR changes flows to the estuaries by routing water to the reservoir and STA complex and south rather than discharging it to the estuaries.

Methodology for testing each expectation or hypothesis (include frequency of monitoring). Hypotheses will be tested by measuring a reduction in high flows at S-79, after implementing the project features and LO operations changes; some reviewers have noted that this may be the primary adaptive management indicator to monitor in the Caloosahatchee Estuary. Restoration performance related to two species of SAV and oysters will be measured to provide multiple lines of evidence of ecological response due reduction of high flows (oysters, manatee grass, and *Halodule* in middle to lower estuary) and low flow exceedences (*Vallisneria*). Baseline monitoring will be compared to monitoring when the A-2 Reservoir and A-2 STA and LO operations are fully implemented. Information will feed back into improved operations of the project in coordination with Lake O and C-43, as well as future CERP increments related to storage to further reduce high flows. In addition, the monitoring will confirm whether water quality (nutrients) by future CERP increments and state water quality best management practices.

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management. Flows and Hydrology: Basin, Lake Okeechobee and S-79 flows will be measured to confirm progress towards expected TSP performance. Rainfall in Kissimmee, LO, and C-43 basin will need to be considered to determine whether two consecutive water years are similar to baseline water years to compare performance improvements against. In addition, baseline monitoring (before project implementation) will be compared to flows achieved 2 years after TSP and Lake O operations are implemented. Flows will be measured at S-79 and S-77. Salinity at Ft Myers, Shell Point, and Cape Coral will be monitored using existing networks.

SAV and Oysters: SAV and oysters will be measured after a minimum 4 year period of flows and salinity expected performance being achieved. Results will be compared to baseline and analyzed for incremental progress towards expected performance for both indicators (SAV and oysters). RECOVER SAV monitoring will be used (same protocol for quadzilla mapping at stations 1 and 2 for *Vallisneria*). The target indicates the first area downstream of S-79 where *Vallisneria* is most likely to reestablish is from 15 to 19 miles upstream from Shell Point. RECOVER oyster monitoring at Iona Cove, Cattle Dock, Bird Island, and Kitchel Key will be used. RECOVER should continue predation and disease monitoring to better understand when oyster die-off events may be occurring to inform operations (to reduce disease and predation). Nutrients and total suspended solids will be compared in the same 4 year period to ensure these factors did not get worse from baseline. If salinity expectations are met with the TSP but SAV and oyster performance is not, there could be an issue with nutrients or total suspended solids preventing proliferation of these species, which would clarify needs and opportunities for future projects and thus prevent misdirection of future efforts.

Management options that may be chosen based on results. The following management options may be considered if expected flow and salinity performance and the subsequent ecological benefits are not realized:

- **If there is an issue with flows:** Optimize flows between C-43, Lake Okeechobee, the reservoir and STA, other projects as appropriate, and the TSP.
- **If there is an issue with sediment**: The CEPP Plan may reduce sediment loads to the estuaries by reducing water discharge volumes. However, the TSP does not otherwise include provisions to improve estuarine substrate that is an important aspect of estuarine habitat. Evaluate benthic monitoring results as first indicator of issues with sediment. If results suggest that despite salinity improvements the ecological restoration is hindered by undesired sediment (potentially high organic, anoxic, high sulfide muck) then muck removal may be needed. Muck removal is not part of the C-43, CEPP, or the TSP nor has it been evaluated during CEPP PACR planning; it is provided here as a suggestion for parties to consider for a future effort if needed. The suggested methods include identifying suitable salinity areas given CEPP PACR and other project results and then removing muck in those areas, as described in Indian River Lagoon South project document.
- **The following options are specific to SAV and oysters:**
  - SAV – If there is an issue with water quality: provide the results as feedback to the implementing agencies to further optimize water quality using water quality features and State water quality projects/BMPs.
  - Oysters – If there is an issue with lack of oyster substrate, see suggestions for future restoration projects included in the management options matrix (**Table D.1-3**).

Table D.1-3. St. Lucie Estuary Management Option Matrix. See Table D.1-3 caption for further explanation.

Uncertainty ID	Time until Changes are Measurable*	Indicator or Attribute	Specific Property to be Monitored, and Frequency	Decision Criteria: Confirmation of CEPP Performance or Trigger(s) for Management Action	Management Action Options
1, 45, 46	5 year	Flows	Total flows into the SLE at S-80, 49, 48, and Gordy Road	After 5 years of operation, evaluate the 5 years of flow data to determine if monthly average flows exceedences that were >2,000 cfs were fewer (17% of time vs. 30%) (5 year snapshot until target is recognized)	Within approved Lake O schedule, and utilizing IRL-S, the FEB capacities, and other projects as appropriate, examine whether adjustments can be made to further optimize flows and meet low flow needs and reduce high flows. **Potential considerations for future CERP and non-CERP restoration projects:** Increase water storage capability to continue to restore lower volumes of fresh water discharges to the estuaries; muck removal to improve substrate; if there is an issue with lack of SAV seed source implement seagrass plantings (may be non-implementing agency effort); if there is inadequate amounts of oyster substrate add suitable substrate such as oyster cultch (material such as oyster shells or concrete laid down on oyster areas to provide mobile oyster spat with places to attach); add mature oysters to increase spat production as described in the Indian River Lagoon South project.
1, 45, 46	5 year	Salinity	Salinity at US 1 bridge	After 5 years of operation, evaluate the 5 years of flow data and see if % of time within 12 – 20 psu increased from 32-36%, and % of time below 12 psu decreased from 50 to 40 %.	
46	5 years	Benthic	Benthic fauna at total 14 stations compared to 2 south fork stations (M-4 and M-5)	After 5 years of operation and evidence of ideal flows and salinities met, Marine Benthic Index should move from Moderate (orange) to Good (green) at site M4; and Good (green) to High (blue) at site M5	
45	5 years	Oysters	Oyster live-dead counts to four times a year (April, June, October, January); monthly monitoring samples for recruitment, growth, predation, and disease at existing locations.	After 5 years of operation and evidence of ideal flows and salinities met, oyster density per acre should increase by 14% (574,674 to 655,614). If not, Check for decreasing oyster recruitment, growth, predation, and disease trends	
1	5 years	SAV	4 or 5 stations same as RECOVER technique, SAV shoot density and species. Compare North to South Fork and Mid estuary. Mapping of SAV acreage in St. Lucie every 2-3 years. Continue monitoring and assessment of water quality data	After 5 years of operation and evidence of ideal flows and salinities met, SAV shoot density per acre should increase by 20.1% (1,873,761 to 2,250,132). If flows and salinity expectations are met but SAV does not improve, then check water quality results that may impact SAV growth and recruitment.	

*The "timeframe to detect changes..." does not imply that changes will be complete in that timeframe; rather, they provide an estimate of time needed to begin to be able to distinguish effects of the TSP. These time frames are indications of response speeds, not limits on how long the monitoring will be conducted.

Table D.1-4. Northern Estuaries – Caloosahatchee Management Options Matrix. See Table D.1.3 caption for further explanation.

Uncertainty ID	Time until Changes are Measurable*	Indicator or Attribute	Specific Property to be Monitored, Location, Frequency	Decision Criteria: Confirmation of CEPP Performance or Trigger(s) for Management Action	Management Action Option
#2, 49	5 years	Flows	• Structure flows into the CRE at S-79	• After 5 years of operation, evaluate the 5 years of flow data to determine if average monthly low flows (<450cfs) decreased from 23% to 5% of time (5 year snapshot until target is recognized).	Within approved LO schedule and utilizing C-43 and the FEB capacities, and other projects as appropriate, examine whether adjustments can be made to improve flows. **Potential considerations for future CERP and non-CERP restoration projects:** Same as those for the SLE.
#2 and 49	5 years	Salinity	• Salinity (PSU) at Shell Point (*Halodule* and oysters), Ft. Myers (*Vallisneria*, and Cape Coral (15 minute sampling)	• After 5 years of operation, the desired range of salinity (16-28 psu) should be met 66% of the time (9% improvement over existing conditions) at Shell Point, and 45% of the time (8% improvement over existing conditions) at Cape Coral.	
#2 and 49	5 years	Oysters	• RECOVER oyster monitoring sites at Iona Cove, Cattle Dock, Bird Island, and Kitchel Key. Oyster density per square meter, oyster growth, disease and predation. Quarterly sampling.	• After 5 years of operation, oyster shoot density per meter squared should increase by 4.4% at Shell Point and 7.1% at Cape Coral. If not, examine oyster disease, predation monitoring.	
#2 and 49	5 years	SAV	• RECOVER SAV monitoring for seagrass shoot density and species coverage. • SAV acreage mapping every 5 years	• After 5 years of operation, increase seagrass shoot density (*Halodule*) per acre by 15.3% at Shell Point. • After 5 years of operation, reestablish *Vallisneria* beds 15 to 19 miles upstream of Shell Point. • If flows and salinity expectations are met but SAV does not improve, then check water quality results that may impact SAV growth and recruitment.	

*The "timeframe to detect changes..." does not imply that changes will be complete in that timeframe; rather, they provide an estimate of time needed to begin to be able to distinguish effects of the TSP. These time frames are indications of response speeds, not limits on how long the monitoring will be conducted.

D.4.4 Greater Everglades Strategies and Management Options

A large portion of CEPP PACR's area consists of the central Greater Everglades, including Water Conservation Area 3A (WCA 3A) and the inland portion of Everglades National Park (ENP). The hypotheses, questions, uncertainties, and management options below focus on the TSP expected improvement of the ecological condition of the Everglades in terms of geo-morphological features, water flow, peat depths, vegetation, fire reduction, and fundamental prey and predator interactions. Over 15 years of scientific work, interagency collaboration, and public involvement have elevated these Everglades features to the forefront based on ecological and social values. The CEPP PACR-specific questions were identified based on expected improvements from project features and operations. It should be noted that several of the questions below begin with "How much..." and these topics were honed to focus on indicators or species for which there is enough scientific understanding to estimate a target with upper and lower bounds. The estimations are described in each "Adaptive Management Strategy". It is recognized that some estimations need refinement as data is collected and understanding of the Everglades ecosystems continually improves.

As noted above, adaptive management will be reiterated in the CEPP PACR, and the Adaptive Management Plan will be revisited. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given the new knowledge, key questions and adaptive management options proposed in this Plan may need refinement. Therefore, items included in this plan are not guaranteed to be included or funded as-is, but will be considered again when CEPP PACR is closer to being implemented.

D.4.4.1 Flow Velocity for Ridge and Slough

CEPP PACR Adaptive Management Uncertainty #73: Are the flow velocities, flow direction, volumes of fresh water, and water depth improvements from CEPP PACR sufficient to reestablish historic ridge and slough landscapes? (Driver or uncertainty type: Hydro-ecological)

This uncertainty is related to the CEPP PACR objective of restoring a natural mosaic of wetland habitats in the Everglades system, and relates to all regions and features of CEPP PACR, but is most specific to regions immediately downstream of major restoration features, especially the HRF Spreader Canal in NW WCA 3A.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty?

This critical uncertainty directly impacts the sustainability of the ridge/slough landscape and the ability of CEPP PACR to redistribute sediments, alter peat oxidation rates, prevent peat fires, produce microtopography, and create the diversity of habitats needed by the plant and animal communities of the Everglades. The flow velocities in the direction of historic sloughs and ridges, water volumes, and water depths downstream of new inflow structures are expected to enhance the transport of slough bed particles, periphyton-derived particles, and water column-derived particles. According to the ecological theory of Dynamic Equilibrium, the creation of historic transport conditions will restore historic depths of sloughs and elevation of ridges.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Central to this uncertainty is the hypothesis that historical flow velocities, directionality, and volumes will restore historical depths of sloughs and elevation of ridges. This uncertainty will be evaluated in the NW and NE sections of WCA 3A. Specific attributes and expectations include:

Hydrology:

- Velocity – Pulsed velocities reaching 2.5 cm/second or greater in downstream marsh of HRF.
- Direction – Mimic historical slough and tree island directionality.

Sediment:

- Organic – sediments will accumulate quicker in regions with long hydroperiods and will be redistribution in regions with periodic high flow velocities to create preferential flow paths and historic slough landscapes.

Vegetation:

- Northwestern WCA 3A – woody herbaceous vegetation will restore to ridges of sawgrass and sloughs with water lily south of HRF feature.

Quantification of the distribution, subsidence, accretion and movement of sediments, floc and peat is required to understand the role of flow velocities, direction, volumes, and water depth on the restoration and maintenance of healthy sloughs and ridges. The flow velocities, direction, volume, and water depth will be measurable immediately upon implementation of the TSP structures; entrainment and transport of particles should also be measurable quickly. Re-creation of slough-ridge patterns that can be validated by surveys of peat elevations and vegetation structure will take at least 5-10 years to measure but will have some early indicators via measurements of water and sediment movements.

Methodology for testing each expectation or hypothesis: A BACI (Before-After-Control-Impact) methodology will be used for testing hypotheses. In this approach, the before period is defined by measurements made 2-3 years prior to the impact and the after as the period during and following pulsed flow events. Control and impact reflect the regions not influenced and influenced by the structures and features, respectively. The monitoring will use a multidisciplinary approach that directly couples the monitoring of hydrology, sediment transport, vegetation, and wildlife (and, thus multiple hypotheses). The central focal points of the monitoring will be the detailed description of the hydrologic flow fields in the region of the structures and features, and the environmental conditions of the downstream communities. Monitoring shall use well-established vegetation and biogeochemical methods and state-of-the art tracer technologies when appropriate. The detailed plans for these measurements and QA/QC protocols will be described in more detail after CEPP PACR authorization.

How results will be reported and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: The BACI statistical design will be used to formulate conclusions, address the uncertainties and make recommendations. Results will be provided on an annual basis to Project Managers, agency leads and the general public as part of the SFER. Conclusions and recommendations for adaptive management actions will be provided every 2-3 years after integration with monitoring results from RECOVER, CEPP and CEPP PACR (non-adaptive management), and other agencies (non-CEPP) such as USGS, USEPA, USFWS, etc. This integration, reported by RECOVER, will evaluate the triggers/thresholds that indicate good CEPP performance based upon established and approved RECOVER Performance Measures. Examples include: 1) timing and amplitude of water depth fluctuations, 2) water flow direction and magnitude, 3) sediment transport patterns, and 4) ridge and slough functionality, connectivity and aligned with ridges.

The process to establish and recommend an adaptive management action will be more complicated than simply reporting because it will be constrained by: 1) requirements of the BACI approach, 2) the size of the downstream testing environment, 3) the size of the new hydrologic structure, 4) the resilience of the downstream habitats (i.e., their ability or inability to change), 5) weather patterns, and 6) TSP sequencing. RECOVER is designed to have the scientific and organization framework to manage this degree of complexity. With appropriate staffing, RECOVER will review the detailed adaptive management strategies, including but not limited to refined methods, frequencies, and logistics. Once an adaptive management study is implemented, and at least two years of post-construction data have been reviewed, RECOVER will evaluate results and may recommend staying with the methods or modifying them, or may suggest a new management action.

Management options that may be chosen to improve performance and assess the role of flow for ridge and slough restoration: Feedback to management could inform project decisions on timing, pulsing, or routing of water deliveries through an area differently than originally specified but within the approved CEPP PACR Plan. Suggested adaptive management options listed below are not in any particular order and can be implemented simultaneously, as appropriate.

- Implement vegetation management downstream of flow structures to restore landscape patterns and create preferential flow paths. This may include concurrent or series testing of vegetation management options (e.g., fire, harvesting, herbicide, physical stress) downstream of the NW-WCA 3A HRF and the 67A conveyance features to create preferential flow paths along historic flow paths. This could be implemented to minimize easterly flow patterns, if such flow patterns occur.
- Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8 or into a new HRF east of the Miami Canal.

D.4.4.2 Restoring Tree Island Hydrology

CEPP PACR Adaptive Management Uncertainty #76: Can CEPP PACR create hydrology favorable for tree island elevation requirements? (Driver or Uncertainty type: hydro-ecological)

This uncertainty is related to the CEPP PACR objective of restoring a natural mosaic of wetland habitats in the Everglades system, and relates to the potential for longer hydroperiods throughout the Greater Everglades, but especially downstream of new control structures. Addressing this uncertainty should reverse processes of peat subsidence and habitat (vegetation) diversity loss on tree islands.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? The CEPP PACR adaptive management monitoring plan expects to unravel the mechanisms of tree island restoration and sustainability in order to a) manage hydrological parameters (i.e., depth, hydroperiod, flow) downstream of major operational structures and b) promote ecological processes such as, peat accumulation and decomposition rates, vegetation diversity, seedling recruitment and tree growth rates. Expectations are very similar to those associated with the flow uncertainty above. That is, this uncertainty will evaluate the sustainability of the ridge/slough landscape and the ability of the TSP to redistribute sediments, decrease peat oxidation rates, prevent peat fires, produce microtopography and create the diversity of habitats needed by all plant and animal communities. According to the ecological theory of Dynamic Equilibrium, the creation of historic water depths and hydroperiods will restore historic tree island peat depths and plant diversities.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Central to this uncertainty is the hypothesis that historic hydroperiods and water depths on pre-drainage tree islands created a dynamic steady state where islands were able to maintain elevations of 2-3 feet above the surrounding sloughs, had a diverse population of wetland hardwoods and were refugia for nesting and foraging wildlife during high water conditions. This uncertainty will be evaluated in NW and WCA-3A. Specific attributes and expectations include:

- Hydrology:
  - Water Depth: Maximum annual water depths for tree islands with high soil oxidation rates, and as a result, low elevations, might increase by 100%. However, stress associated with high waters will be minimized if hydroperiods do not exceed 11 months.
- Sediments:
  - Peat: Accretion rates are expected to exceed soil decomposition and subsidence rates, causing entire islands to increase in elevation.
  - Biogeochemistry: Restoration will enhance the accumulation of phosphorus in tree island sediments.
- Vegetation:
  - Marsh vegetation: Increased density of herbaceous species, especially in the lower elevation tails.
  - Trees: Increased recruitment of woody vegetation everywhere, but especially on the higher elevation heads.

Methodology for testing each expectation or hypothesis: A BACI methodology will be used for testing expectation everywhere in the Greater Everglades and for all hypotheses. In this approach, the before period is defined by measurements made 2-3years prior to the impact and the after as the period during and following pulsed flow events. The central focal points of the monitoring will be the detailed description of the peat accretion rates and tree root development on tree islands downstream of new water control structures. Monitoring shall use well-established vegetation and biogeochemical methods. The detailed plans for these measurements and QA/QC protocols will be described in more detail after CEPP PACR authorization. Attribute-specific methodologies will include:

- Geomorphology and Hydrology: Tree island soil characteristics, pore water chemistry, and elevation changes will be monitored in such a way as to relate tree island hydrology, soil moisture and surficial flow patterns to peat accretion, community structure, root production and pore-water nutrients. Islands downstream of control structures will be outfitted across transects with Surface Elevation Tables (SETs), feldspar marker horizons, and shallow groundwater wells to monitor peat accretion rates, soil elevations, groundwater movement, and pore-water nutrients. Changes over time will include comparisons with historical aerial photographs.
- Vegetation: Relationships between the hydrological attributes and the slough-ridge sediment and vegetation will be determined by measuring peat depths, elevations, soil nutrients and

vegetation productivity along north-south transects in WCA-3 and west-east gradients in SRS within GRTS sampling units. The Generalized Random-Tessellation Stratified approach (GRTS) of Stevens and Olsen (2004), drawn from a tiling of the Ridge and Slough and sawgrass prairie areas into 2-kilometer (km) x 5 km cells oriented along the directions of ridges, is a probability design, allowing design-based estimates of regional means. It provides spatial balance for inferences about gradients of change, and for model-based inferences (spatial interpolation) of regional means. It supports varying spatial and temporal measurement intensity for different attributes while maintaining co-location for inferences about causal pathways. Thus, it maximizes the flexibility of subsequent analyses of the resultant monitoring data.

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: As described above for the flow uncertainty, the BACI statistical design will be used to formulate conclusions, address the uncertainties, and make recommendations.

Management options that may be chosen to improve performance and assess the role of hydrology for tree island restoration: Feedback to management could include informing project decisions such as timing of delivering water, pulsing of delivery water, managing reservoir/STA water to either enhance or reduce tree island hydroperiods, or routing water through an area slightly differently than originally specified. Suggested adaptive management options for tree islands downstream of project water control structures listed below are not in any particular order and can be implemented simultaneously, as appropriate. Some options that would need additional authorization to improve restoration beyond the TSP are presented in the management options matrix.

- Create moat-like sloughs around tree islands using vegetation management options (e.g., fire, harvesting, herbicide, physical stress) as tested in the Loxahatchee Impounded Landscape Assessment (LILA) Everglades ecological experiments.
- Increase operational flexibility to maximize flow velocities including; 1) hydrological pulsing, 2) adjust conveyance features for additional flow as described in the Plan, 3) vegetation clearing or management.
- Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8.

D.4.4.3 Reducing Soil Oxidation and Fire

CEPP PACR Adaptive Management Uncertainty #5: Are inundation and hydroperiod sufficient to reduce current high rates of soil oxidation and peat fires? (Driver or Uncertainty type: hydro-ecological)

This uncertainty is related to the CEPP PACR objective to improve sheet flow patterns and surface water depths and duration in order to increase soil moisture to minimize muck fire events and loss of peat soils in the Everglades system. Furthermore, the hydrological restoration will prevent peat fires in all regions and all habitats, and will reverse processes of subsidence, especially in Northeast and Northwest WCA 3A.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? Deep-burning peat fires generally occur during periods of extended drought when extreme burning conditions are generally occurring at a landscape level. Therefore, greater understanding of the effect surface water depth and duration on the combustion potential in organic soils will provide a useful tool for informing managers how to allocate more efficiently and effectively limited resources during periods of greatest demand. Thus, by addressing this uncertainty CEPP PACR will help to reduce the frequency and intensity of muck fire events that will help to decrease soil oxidation and reduce potential damage to the plant community, in general, and woody trees in particular.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Central to this uncertainty is the hypothesis that organic soil loss and accumulation is maintained in a state of dynamic equilibrium as a function of surface water depth and duration, water table and fire events. Specific attributes and expectations include:

Attributes:

a) Hydroperiod, flow velocity and direction, and water table depth;
b) Soil accretion rates by using sediment elevation tables (SETs) to document peat accretion rates on natural and created tree islands-link to tree islands (Note that SETs are only on tree islands, which is why SETs are associated with this uncertainty. Ridge and slough elevation changes will be measured in association with GRTS panels for other adaptive management uncertainties);
c) Belowground production and decomposition rates (standardized peat from different areas in the Everglades Protection Area will be used to decompose naturally at different rates due to the different organic matter matrices).
d) Soil moisture and soil bulk density;
e) Organic matter content of peat and percent organic carbon;
f) Microtopography peat depths and pore-water nutrients across landscape units. Porewater nutrients will be monitored to evaluate the stability of the total phosphorus concentrations and the potential for invasive/nuisance species to decline or increase with restoration.

Expectations:

a) Decrease frequencies and durations of dry outs leading to decrease rates of organic soil loss through oxidation and/or peat fires.
b) Increasing peat accumulation due to improving sheet flow.
c) Timing and distribution of water will reduce soil oxidation and fire events.
d) NW WCA 3A: fire frequencies should be reduced.
e) NE WCA 3A: HRF may not be sufficient to eliminate soil oxidation and threat of peat fires within NE 3A.

Methodology for testing each expectation or hypothesis: A BACI methodology will be used for testing expectation everywhere in the Greater Everglades and for all hypotheses. In this approach, the before period is defined by measurements made 2-3 years prior to the impact and the after as the period during and following pulsed flow events. Control and impact reflect the regions not influenced and influenced by the structures and features, respectively. The monitoring will use a multidisciplinary approach that directly couples the monitoring of hydrology, sediment characteristics, and vegetation. The central focal points of the monitoring will be the detailed description of spatial and temporal patterns of soil moisture, soil bulk density and organic matter content that are directly associated with water table depths. Monitoring shall use well-established soil moisture and soil accretion methods. Attribute-specific methodologies will include:

- Hydrology: Soil characteristics, including soil moisture, organic matter content, and bulk density along with water table depths will be monitored in such a way as to relate hydrology and surficial flow patterns to frequency of dry downs

- Soil: Relationships between the hydrological attributes and soil and vegetation processes will be determined by measuring peat depths, elevations, soil nutrients and vegetation productivity along north-south transects in WCA-3 within GRTS sampling units. The GRTS approach of Stevens and Olsen (2004), drawn from a tiling of the Ridge and Slough and sawgrass prairie areas into 2 km x 5 km cells oriented along the directions of ridges, is a probability design, allowing design-based estimates of regional means. It provides spatial balance for inferences about gradients of change, and for model-based inferences (spatial interpolation) of regional means. It supports differing spatial and temporal intensity of measurement for different attributes while maintaining co-location for inferences about causal pathways. Thus, it maximizes the flexibility of subsequent analyses of the resultant monitoring data.

How results will be reported and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: The BACI statistical design will be used to formulate conclusions, address the uncertainties and make recommendations. Results will be provided on an annual basis to Project Managers, agency leads and the general public as part of the SFER). Conclusions and recommendations for adaptive management actions will be provided every 2-3 years after integration with monitoring results from RECOVER, CEPP PACR (non-adaptive management), and other agencies such as USGS, USEPA, USFWS, etc. This integration, reported by RECOVER, will evaluate the triggers/thresholds that indicate good TSP performance. For tree islands, this will require the creation of a new suite of RECOVER Tree Island Performance Measures. Examples include; 1) timing and amplitude of water depth fluctuations, 2) soil moisture, and 3) sediment accumulation rates.

The process to establish and recommend an adaptive management action will be more complicated than simply reporting because it will be constrained by: 1) limitations of the BACI approach, 2) the soil properties in the downstream testing environment, 3) the resilience of the downstream soil and vegetation (i.e., their inability to change), and 4) TSP sequencing. RECOVER was designed to have the scientific and organization framework to manage this degree of complexity. With appropriate staffing, RECOVER will review the detailed strategies of the adaptive management downstream study areas to include but not be limited to detailed methods, scientific focus, engineering practicality, field logistics and restoration relevance. Once an adaptive management study is implemented, and at least two years of post-construction data has been reviewed, RECOVER will evaluate results and may recommend staying with the methods or modifying them, or may suggest a new management action.

Management options that may be chosen to improve performance and assess the role of surface water depth and duration on soil organic content, moisture and bulk density for reducing soil oxidation and frequency of fire events: While effects of muck fire events are broadly accepted as negative, an improved understanding of these events in their local ecological context will increase the ability of managers to adopt appropriate strategies to efficiently and ecologically control them. Thus, feedback to management could include informing project decisions such as timing of delivering water, pulsing of delivery water, managing reservoir/STA water to rise water tables to enhance or increase soil moisture in areas where surface water depth and duration has been lowered than originally specified. Suggested adaptive management options for regions of the TSP water control structures listed below are not in any particular order. Options that may be considered for a future increment of CERP are suggested in the management options matrix.

- Increase operational flexibility to minimize frequency of muck fires in areas where organic soils experience extreme dry conditions.
- Adjust operations along the northern boundary of WCA-3A by redistributing water into the S8.

D.4.4.4 Everglades Predators: Alligators

CEPP PACR Adaptive Management Uncertainty #10: How much will CEPP PACR improve alligator relative density and body condition in northern WCA 3A? (Driver or Uncertainty type: hydro-ecological)

This uncertainty is related to the CEPP PACR objectives of: 1) restoring more natural water level responses to rainfall to promote plant and animal diversity and habitat function and 2) reducing water loss out of the natural system to promote appropriate dry season recession rates for wildlife utilization. It relates to all regions and features of CEPP PACR, but the greatest opportunities for learning are immediately downstream of the Spreader Canal in NW WCA-3A.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? Addressing this uncertainty provides information that will enhance the ability of CEPP PACR to improve and restore a key ecological attribute of the Everglades. Alligators play a key ecological role in the Everglades by improving ecological diversity and function through creation of alligator holes, trails, and nests. However, in many areas such as northwestern WCA 3, conditions are too dry to support alligator populations at targeted levels; thus, these other ecological benefits and functions are not occurring. The CEPP PACR adaptive management monitoring plan will provide a way to determine more specifically the values of hydrological parameters (hydroperiod, depth, frequency of dry downs) that are necessary to maintain healthy alligators and alligator populations at targeted levels. Resolving this uncertainty will contribute to our understanding of how much water is needed for a restored Everglades.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Our hypothesis is that more natural hydrologic patterns with dry downs no more frequent than once every 3-5 years (creating multi-year hydroperiods) will improve both alligator body condition and relative density of alligators. This uncertainty will be evaluated in NE and NW WCA-3A. The Alligator Production Suitability Index Model (Shinde et al. 2013) will be used to provide input for guiding strategies and determining expectations based on expected hydrologic improvements. Specific attributes and expectations include:

- Alligator Body Condition: Longer hydroperiods and less frequent dry downs will result in alligator body condition that is less variable from spring to fall and higher than pre-project.
- Alligator Relative Density: Longer hydroperiods and less frequent dry downs will result in an increase in relative density of alligators. Maximum relative densities will be achieved if dry downs are on average once every 3-5 years.

Methodology for testing each expectation or hypothesis: The testing of this hypothesis will be done in conjunction with the BACI methodology used for uncertainties related to restoring hydrology for ridge and slough and tree island elevation everywhere in the Greater Everglades. In this approach, the before period is defined by measurements made 2-3 years prior to the impact and the after as the period during and following feature completion. Control and impact reflect the regions not influenced and influenced by the structures and features, respectively. The monitoring will use a multidisciplinary approach that directly couples the monitoring of hydrology, and wildlife. For this hypothesis attribute-specific methodologies will include:

Alligator Body Condition: Fifteen alligators will be captured in spring and fall in areas downstream of features and in control areas following protocols developed for RECOVER MAP (Mazzotti et al. 2010). Alligators will be measured, weighed, marked, gender determined and released at their site of capture. Body condition will be calculated using the Fulton's K body condition index. EDEN data will be used to describe prior and current hydrologic variables including hydroperiod, average water depths at various time steps prior to capture and yearly water depth amplitude prior to capture.

Alligator Relative Density: Night-time spotlight counts will be conducted in spring and fall in areas downstream of features and in control areas along designated survey routes following protocols developed for RECOVER MAP (Mazzotti et al. 2010). Environmental data will be taken at the beginning and end of each survey and location and size estimate of all alligators observed will be recorded. A minimum of two transects conducted twice each season will be used. Hydrology data from key USGS gauges as well as data from EDEN will be used to describe both hydrologic conditions at the time of the surveys and hydrologic conditions (hydroperiod, depths, and amplitude) in the 1-5 years prior to the surveys.

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: Results will be reported in the context of what is expected given the improvements to hydrology (estimated using The Alligator Production Suitability Index Model [Shinde et al. 2013]) and in comparison to established targets (Mazzotti et al. 2010). Results will be provided on an annual basis to CEPP PACR Project Managers, agency leads, and the general public as part of the SFER. Conclusions and recommendations for adaptive management actions will be provided every 2-3 years after integration with monitoring results from RECOVER, CEPP PACR monitoring, and other agencies such as USGS, USEPA, USFWS, etc. This integration, reported by RECOVER, will evaluate the triggers/thresholds that indicate good performance (see Mazzotti et al. 2010).

Management options that may be chosen to improve performance and assess the role of hydroperiods and depths for improving alligator body condition and relative density: Feedback to management will include providing information that can inform project decisions such as timing of delivering water, or routing water through an area slightly differently than originally specified. Suggested adaptive management options listed below are not in any particular order.

- Incremental increases in flows to the NE region of WCA-3A to recreate historical slough paths.
- Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8.

D.4.4.5 Prey Densities

CEPP PACR Adaptive Management Uncertainty #9: How much will hydrologic restoration and vegetation management result in increases in prey densities (aquatic fauna)? (Driver or Uncertainty type: hydro-ecological)

This uncertainty is related to the CEPP PACR objectives of: 1) restoring more natural water level responses to rainfall to promote plant and animal diversity and habitat function and 2) reducing water loss out of the natural system to promote appropriate dry season recession rates for wildlife utilization. It relates to all regions and features of the TSP, but the greatest opportunities for learning are immediately downstream of the Spreader Canal in NW WCA-3A.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? Addressing this uncertainty provides information that will enhance the ability of the project to improve and restore the availability of critical, food-web fish and invertebrates. Changes in the densities, availability and spatial distributions of aquatic prey are needed to restore historic food-web interactions, especially for wading birds. However, in many areas such as northwestern WCA 3, conditions are too dry or recession rates are too fast, to support prey populations at significant levels. The CEPP PACR adaptive management plan will provide a way to determine more specifically the values of hydrological parameters (hydroperiod, depth, frequency of dry downs) that are necessary to restore and sustain a healthy prey-base in northern WCA-3A.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Central to this uncertainty is the hypothesis that restoration of multi-year hydroperiods to northern WCA 3A will result in increased density of aquatic fauna and large fish. More specifically, will infrequent dry downs (i.e., no more frequent than once every 5 years) significantly improve density of small and large fish, and will this translate into a more resilient and available food base for wading birds and other large predators? The Fish Habitat Suitability Index Model (Trexler et al. 2003) will be used to provide input for guiding strategies and determining expectations based on expected hydrologic improvements. Specific attributes and expectations include:

- Aquatic Prey: The density of small fish (8 cm or less standard length) and prey invertebrates such as, grass shrimp and crayfish will significantly increase downstream of the new water control structures, in NE WCA-3A where hydroperiods are expected to increase by 35 percent.
- Large Fish: The distribution, movement and density of large fish (>8 cm standard length) will expand and increase into areas with annual average hydroperiods in excess of 11 months.

Methodology for testing each expectation or hypothesis: The testing of this hypothesis will be done in conjunction with the BACI methodology used for uncertainties related to restoring hydrology for ridge and slough and tree island elevation everywhere in the Greater Everglades. In this approach, the "before" period is defined by measurements made 2-3 years prior to the initiation of TSP operations that will affect the area and the after as the period during and following feature completion. Control and impact reflect the regions not influenced and influenced by the structures and features, respectively. The monitoring will use a multidisciplinary approach that directly couples the monitoring of hydrology and aquatic fauna. Detailed methodology for assessment of fish performance is available in the DECOMP Performance Measure Documentation Sheet for Prey-Based Freshwater Fish Density. This monitoring will include presence/absence monitoring for invasive and nuisance fish species and will be coordinated with the INSMP team to consolidate monitoring trips and reduce costs**.** Attribute-specific methodologies will include:

- Aquatic Prey: Aquatic prey populations are monitored using one square meter throw traps. Throw trap samples will be collected in primary sampling units in areas that were identified as feasible for throw-trap sampling. Selection of primary sampling units will be based on a spatially balanced recursive tessellation design. Throw trap locations within a primary sampling unit are three fixed coordinates within a 10-meter by 10-meter cell drawn randomly from the habitat that can be sampled. Landscape estimates for standing crops of prey populations are interpolated via standard kriging across the sampling domain.
- Large Fish: Same as above for small fish plus wet season satellite tracking.

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: The BACI statistical design will be used to formulate conclusions, address the uncertainties and make recommendations. Results will be provided on an annual basis to CEPP PACR Project Managers, agency leads and the general public as part of the SFER. Conclusions and recommendations for adaptive management actions will be provided every 2-3 years after integration with monitoring results from RECOVER, non-adaptive management, and other agencies such as USGS, USEPA, USFWS, etc. This integration, reported by RECOVER, will evaluate the triggers/thresholds that indicate good CEPP PACR performance based upon established and approved RECOVER Performance Measures. Specifically, the distribution and density of small fish will trigger an adaptive management action if any of the following are true: if one year is at least three standard errors above or below the limits of an objective interval; if two out of three years are at least two standard errors above or below the limits of an objective interval; or if four out of five consecutive years are at least 1.5 standard errors above or below the limits of an objective interval.

Management options that may be chosen to improve performance and assess the role of extended hydroperiods and flow for the restoration of aquatic prey densities. Feedback to management will include providing information that can inform project decisions such as timing of delivering water, or routing water through an area slightly differently than originally specified. Suggested adaptive management options listed below are not in any particular order and can be implemented simultaneously, as appropriate.

- Concurrent or series testing of vegetation management options (e.g., fire, harvesting, herbicide, physical stress) downstream of the WCA-3A conveyance features to create preferential flow paths in historic flow path locations.
- Increase operational flexibility to maximize flow velocities downstream of the WCA-3A conveyance features.
- Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8.

D.4.4.6 Wading Bird Foraging Conditions and Nesting

CEPP PACR Adaptive Management Uncertainty #75: How much will hydrologic restoration and vegetation management result in increases in wading bird foraging conditions? (Driver or Uncertainty type: hydro-ecological)

This uncertainty is related to the CEPP PACR objectives of: 1) restoring more natural water level responses to rainfall to promote plant and animal diversity and habitat function and 2) reducing water loss out of the natural system to promote appropriate dry season recession rates for wildlife utilization. It relates to all regions and features of the TSP, but the greatest opportunities for learning are immediately downstream of the conveyance features downstream in northern WCA-3A. By addressing this uncertainty in combination with the one above (Aquatic Prey Density), this CEPP PACR adaptive management plan is expected to increase GE wading bird populations.

What is expected to be learned by addressing this uncertainty, i.e., how will CEPP PACR benefit from addressing this uncertainty? Addressing this uncertainty provides information that will enhance the ability of CEPP PACR to restore critical, keystone populations of wading birds such as egrets, ibis, herons, storks and cranes in terms of their abundance, spatial distributions and reproductive viability. Wading birds are not utilizing the ENP for foraging or nesting as they did 100 years ago. The CEPP PACR adaptive management monitoring plan will provide a way to determine more specifically the values of hydrological parameters (hydroperiod, depth, frequency of dry down) and ecological parameters (prey density, vegetation, exotics) that are necessary to restore and sustain wading bird populations throughout the Greater Everglades.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured: Central to this uncertainty is the hypothesis that 1) restoration of more natural ridge and slough patterns coupled with appropriate recession rates will result in an increase in wading bird foraging conditions, 2) restoration of multi-year hydroperiods to northern WCA 3A will result in increased density of aquatic prey, earlier nesting and increased fledgling success, and 3) restoration of short hydroperiod wetlands will increase dry season prey availability, and promote earlier nest initiation. A Wading Bird Habitat Suitability Index (HSI) Model (Hohner 2016) and a Wood Stork HSI (LoGalbo et al. 2012) will be calibrated to provide input for guiding strategies and determining project performance expectations based on expected hydrologic improvements. Specific attributes and expectations include:

- Wading Birds: Increase in foraging conditions within short hydroperiod wetlands and a shift in timing of nest initiation to November/December
- Overall net gain in foraging conditions throughout the project area; 20% increase over baseline of foraging conditions in short hydroperiod wetlands.

Methodology for testing each expectation or hypothesis: The testing of these hypotheses will be done in conjunction with the BACI methodology used for uncertainties related to restoring hydrology for ridge and slough. In this approach, the before period is defined by measurements made 24 months prior to the impact and the after as the period during and following feature completion. Control and impact reflect the regions not influenced and influenced by the structures and features, respectively. The monitoring will use a multidisciplinary approach that directly couples the monitoring of hydrology, aquatic fauna, water quality, wading bird foraging and nesting success. Detailed methodology for assessment of Wading Bird performance is available in the RECOVER Performance Measure Documentation Sheets (GE-21 and GE-22) for Wetland Trophic Relations and Bancroft et al. (2002). Attribute-specific methodologies will include:

- Hydrology: Hydroperiods, stage and depths across the landscape before, during and after foraging will be calculated from USGS and SFWMD stage gauges and interpolated using USGS EDEN kriging techniques.
- Aquatic Prey: Use protocols developed for RECOVER MAP to measure dry season prey availability. Aquatic prey populations will be monitored using one square meter throw traps and will be collected before and after wading bird dry season foraging events downstream of structures and features.
- Wading Birds: Bird foraging counts, nest location, nesting success and fledgling success will be conducted using bi-weekly or monthly overflights of foraging and nesting locations as per Bancroft et al. (2002)

How results will be reported, and the triggers/thresholds that indicate good CEPP PACR performance or need for adaptive management action: The BACI statistical design will be used to formulate conclusions, address the uncertainties, and make recommendations. Results will be provided on an annual basis to CEPP PACR Project Managers, agency leads, and the general public as part of the SFER.

Conclusions and recommendations for adaptive management actions will be provided every 2-3 years after integration with monitoring results from RECOVER, CEPP monitoring, and other agencies such as USGS, USEPA, USFWS, etc. This integration, reported by RECOVER, will evaluate the triggers/thresholds that indicate good performance based upon established and approved RECOVER Performance Measures. Specifically, restoration targets for mainland nesting patterns as stipulated in the CERP Documentation Sheet GE-22 Wetland Trophic Relationships and based upon work by Ogden, Bancroft and Frederick (1997), Ogden (1994), and Gawlik et al. (2004). These include the following:

- CEPP (PACR) is expected to increase wading bird nesting pair numbers and foraging in northern WCA-3A. This will contribute to total system minima targets of 4,000 pairs of Great Egrets, 10,000 to 20,000 combined pairs of Snowy Egrets and Tricolored Herons, 10,000 to 25,000 pairs of White Ibis, and 1,500 to 2,500/3,000 pairs of Wood Storks.
- Shift the timing of nesting in mainland colonies to more closely match pre-project conditions. Specific recovery objectives would be for storks to initiate nesting no later than January in most years (as early as December in some years), and for ibis, egrets and herons to initiate nesting in February - March in most years (especially in ecotone colony locations).
- For storks, an annual reproductive productivity for all colonies combined of greater than 1.5 chicks per active nest.

Management options that may be chosen to improve performance and assess the role of hydrology and ecology for wading bird restoration: Feedback to management will include providing information that can inform project decisions such as timing of delivering water, or routing water through an area slightly differently than originally specified. Adaptive management options would be considered if 3-year moving averages of nesting success were not showing an increase or if after 3 years there is not an overall gain in foraging conditions throughout the project. Suggested adaptive management options listed below are not in any particular order and can be implemented simultaneously, as appropriate. Options that may be considered for a future increment of CERP are suggested in the management options matrix.

- Concurrent or series testing of vegetation management options (e.g., fire, harvesting, herbicide, physical stress) downstream of conveyance features in northern WCA-3A.
- Increase operational flexibility to maximize flow velocities downstream of conveyance features in northern WCA-3A.
- Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8.

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Table D.1-5. Greater Everglades Management Options Matrix – Northern Water Conservation Area 3A. See caption for Table D.1.3 for further explanation.

Uncertainty ID	Time until Changes are Measurable*	Indicator or Attribute	Specific Property to be Monitored	Decision Criteria: Confirmation of CEPP PACR Performance or Trigger(s) for Management Action	Management Action Options
73, 5	3 years	• Weather • Hydrology	• Rainfall • Flow Direction and Volume • Flow Velocity • Hydroperiod	• Flow directionality improvement from current west to east flow back to north to south historic flow direction • Long-term average annual flow increase into northern Water Conservation Area 3 of 210,000 acre-feet • Hydroperiod targets based on CERP planning targets and agency input • Pulsed velocities reaching 2.5 cm/second or greater downstream of HRF for 4 weeks or more total during average and wet rainfall years	• Adjust operations along the northern boundary of WCA 3A by redistributing water into the S8. • Increase operational flexibility to maximize flow velocities downstream of conveyance features in northern WCA-3A. **Potential considerations for future CERP and non-CERP restoration projects:** Gap half of the C-11 extension spoil mounds; leave remaining in place to compare slough restoration rates; Retrofit the S-336G to the L-6 Diversion to deliver more water to the HRF.
5, 73	3-10 years	• Soil Oxidation • Peat Accretion • Fire Frequency	• Soil Moisture Content • Peat Accretion • Fire Mapping • Radiometric Dating • Soil Decomposition	• Statistically significant increase soil moisture content • Organic soil content increase • Sediment elevation increase in ridges and tree islands • Statistically significant decrease in fire frequency	
73,76	3-10 years	• Biogeochemistry	• Water Quality • Soil Dynamics • Periphyton	• Nutrient accumulation rates no greater than baseline in sawgrass plain areas and sloughs • Nutrient concentration increases in ridges and/or tree islands compared to marsh • No statistically significant nutrient increase in periphyton biomass, nor decrease in periphyton diversity • Sediment floc mobilization in sloughs	• Adjust operations along the northern boundary of WCA-3A by redistributing water into the S8. • Improve reservoir and STA operations to increase water quantity while decrease nutrients loads. • Concurrent or series testing of vegetation management options (e.g., fire, harvesting, herbicide, physical stress) downstream of the NW-WCA 3A HRF • Increase operational flexibility to maximize flow velocities downstream of conveyance features in northern WCA-3A **Potential considerations for future CERP and non-CERP restoration projects:** Fill, plug, or gap ditches and agricultural canals; spoil mound removal and vegetation clearing; adjust operations along the northern boundary of WCA 3A by redistributing water into the S8 or into a new HRF east of the Miami Canal; retrofit the S-336G to the L-6 Diversion to deliver more water to the HRF.
73, 76	5-20 years	• Ridge and Slough and Tree Islands	• Vegetation Community • Structure – Vegetation Mapping • Ridge and Slough Structure, Bimodality • Tree Island Formation	• No increase in area expansion and density of cattail • Vegetation transition in Northwest WCA from woody herbaceous vegetation to sawgrass on ridges and water lily in sloughs • Ridge and slough spatial patterning beginning to form landscape • Measurable differences in bimodality of ridges and sloughs.	
9	3-5 years	• Aquatic fauna	• Crayfish and Small Fish Density • Large Fish Density	• Increased crayfish, small and large fish densities, following improved hydroperiods	
10	4-6 years	• Alligator	• Relative density • Body condition	• Decreased variability in alligator body condition • Increased relative density of alligators	
75	4-6 years	• Wading Birds	• Foraging conditions • Nesting timing, success, and area	• Increased foraging conditions (concentration of aquatic fauna [prey]) in central WCA • 3A (20% increased area over baseline conditions) Shift in timing of nesting to November/December • Decreased wood stork nesting in WCA 3A (move to SRS)	
73, 76, 77	3-5 years	• Terrestrial mammals	• Species Diversity • Deer Abundance	• No change in upland species diversity in Northeast WCA 3A • No change or increases in deer abundance in Northeast WCA 3A	• Adjust operations of HRF feature to improve stages in Northeast WCA 3A for upland species.

*The "timeframe to detect changes…" does not imply that changes will be complete in that timeframe; rather, they provide an estimate of time needed to begin to be able to distinguish effects of the TSP. These time frames are indications of response speeds, not limits on how long the monitoring will be conducted.

D.5 Implementation of Adaptive Management

Adaptive management provides an interdisciplinary, integrated, structured process for lowering risk, increasing certainty, and informing decisions. For adaptive management to be successful in ensuring the delivery of intended benefits and avoid unintended negative impacts of CEPP PACR, adaptive management activities should continue beyond project planning for the entire project-life cycle from completion of the PIR through all aspects of monitoring, engineering, design, construction, operations, and maintenance components. In addition, mechanisms must be in place to collect, manage, analyze, synthesize, coordinate, and integrate new information into management decisions. Adaptive management implementation can only succeed when decision makers have sufficient funding and staffing resources to implement the adaptive management and monitoring plans. In addition, success requires political and stakeholder support to implement the adaptive management decision methodology and to adjust management decisions based on what is learned.

Per the Programmatic Regulations for the Comprehensive Everglades Restoration Plan (2003), an adaptive management process has been developed for CERP that guides system-wide CERP adaptive management and project level adaptive management (CGM 56 2010; RECOVER 2011b). This detailed CERP guidance adheres to WRDA 2007 and the WRDA 2007 implementation guidance provided by USACE in 2009 in that it focuses on using monitoring information to inform projects and project components by resolving uncertainties and providing mechanisms to efficiently incorporate new knowledge in project planning, design, and implementation. CEPP has and will use this framework to implement adaptive management. Doing so will allow CEPP PACR to both take advantage of and contribute to work being done system-wide and by other projects. Because new information is continually becoming available, CEPP PACR adaptive management and monitoring plan must be recognized as a living document that is improved upon through incorporation of new information. As each project component is designed and implemented, specific adaptive management strategies and monitoring should be reviewed and adjusted as necessary.

To facilitate implementation of the CEPP PACR Adaptive Management Plan, RECOVER scientists will coordinate the adaptive management monitoring, analysis, and reporting. RECOVER will include expertise from multiple agencies and disciplines, such as, hydrologists, engineers, and water managers; in other words, while RECOVER will be the central organizing entity of the adaptive management monitoring, analysis, reporting, and elevating of options to adjust CEPP PACR, RECOVER will continually coordinate with others to ensure that a full suite of experts is included. Project funds during pre-construction engineering and design (PED), construction, and operations and maintenance will support RECOVER's coordination efforts and the adaptive management strategies described in this CEPP PACR Adaptive Management Plan. CEPP PACR funds will be used to fund monitoring directly related to adaptive management monitoring needs and the funds are not designed to replace RECOVER's system-wide monitoring and science efforts. However, the RECOVER system-wide monitoring information will be used in combination with CEPP PACR's monitoring to best address key questions about achieving restoration success. The intent is to have complementary efforts that maximize efficiency of monitoring. RECOVER will be responsible for ensuring that the adaptive management and monitoring plans are implemented and that the information is appropriately managed and integrated into the CERP decision process as outlined in the Adaptive Management Integration Guide (RECOVER 2011b).

Because of the fast track of the CEPP PACR planning process, it will be particularly important that RECOVER include scientists, engineers, and water managers in refinement of the monitoring and adaptive management plans during the project design, construction, and operating phases of the project. This section identifies which adaptive management activities will occur during these phases of CEPP PACR implementation and how they relate back to the project's adaptive management plan. Unless otherwise noted RECOVER will be engaged in all activities. Adaptive management will be reiterated in the coming phases of CEPP PACR, and the Adaptive Management Plan will be reviewed and updated. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given the new knowledge, key questions, monitoring thresholds/triggers, and adaptive management options proposed in this Plan may need refinement. Therefore, items included in this plan are not guaranteed to be included or funded as-is, but will be refined and considered again prior to implementation.

Adaptive management was incorporated during CEPP's planning with adaptive management experts integrally involved throughout the planning process. The CEPP PACR Adaptive Management Plan was adapted from the CEPP plan, modifications were made to reflect the components of the CEPP PACR, but all of the same scientific understanding and collaboration which were critical to the CEPP AM plan were utilized and streamlined for the CEPP PACR effort. All of the items in the CERP "Project Level Adaptive Management Checklist" were considered and/or incorporated during the planning, with the following exceptions: a conceptual ecological model (CEM) was not used in the Everglades Agricultural Area to develop hypotheses, since an approved model does not exist; scientific and local knowledge was used in lieu of developing a model for this area. CEMs were used for the other project areas including Lake Okeechobee, Northern Estuaries, Greater Everglades, Southern Coastal Systems, and the Total System (http://www.evergladesplan.org/pm/recover/cems.aspx). A cost effectiveness/incremental cost analysis of the future adaptive management options was not conducted due to time constraints during planning. Adaptive management activities on the checklist that will take place during and after the project's implementation are described here in the Adaptive Management Plan (CERP adaptive management checklist: http://www.evergladesplan.org/pm/pm docs/adaptive mgmt/062811 am guide final.pdf). The following subsections identify how adaptive management has been and will be incorporated into each CEPP project phase: planning, design, construction, and operations and maintenance.

D.5.1 How Adaptive Management Activities were Applied during CEPP PACR Planning

The checklist of adaptive management activities (RECOVER 2011b) focuses on gathering sound information to develop a project's goals, objectives, and vision; involving agencies and stakeholders; identifying concerns and uncertainties; coordinating with interagency science groups during planning; addressing uncertainties as possible with robust and flexible project design; and identifying key uncertainties, monitoring, and management options that relate to the key uncertainties in order to systematically gather information to address them. Highlights of CEPP PACR's incorporation of these adaptive management principals include the use of extensive scientific knowledge and modeling during all steps of the study. CEPP, on which this plan is a modification of, also had a robust interagency and public participation process throughout the study. Concerns and uncertainties were identified in an initial step for CEPP, discussed throughout the USACE "In Progress Review" meetings, and discussed throughout the interagency and public participation process. During screening of management measures to develop alternative plans, screening criteria included flexibility (the speed, ease, efficiency that a management measure could move water to adjust to changing real-time conditions such as storms or extreme events), robustness (the ability to function effectively in the face of broad-scale, uncertain future conditions such as climate change [NRC 2007]), and future compatibility (the efficiency with which this management measure or configuration would complement future restoration work). Finally, a team developed the adaptive management plan to prioritize the remaining uncertainties and describe in the plan how they may be addressed through the life the CEPP PACR and inform CERP implementation.

D.5.2 How Adaptive Management Activities will be Applied during CEPP PACR Implementation

RECOVER will work with the project managers to develop work plans and monitoring scopes of work in coordination with other technical resource providers as needed to provide the budget, schedule, and details to execute the adaptive management strategies identified in Annex D. At a minimum, one RECOVER scientist should be dedicated to overall all coordination of the monitoring and adaptive management efforts. Additional technical expertise should be engaged as needed. Adaptive management activities will be implemented in sequence with the project components being implemented (see **Table D.1-6**). Work plans will include all necessary activities, resources needed, and schedule for completion so that they can be resourced appropriately and tracked by the project manager for progress and execution as part of the project schedule and implementation plan during design, construction, and operations.

Project components will be implemented in a staggered fashion due to budget (amount of funds available each year), regulatory requirements (permits and compliance monitoring feedback), and CEPP PACR dependency constraints (state and federal projects required prior to implementation of a specific project component). Time needed to conduct certain adaptive management activities and tasks to inform subsequent project component is incorporated in the implementation schedule and the Strategies section of the CEPP PACR Adaptive Management Plan. Each adaptive management strategy work plan will explain the timing needed to observe, understand, and report restoration performance results from any design tests, pilot projects, and/or response to phases of project components or full project components being implemented.

D.5.3 Design

Adaptive management activities will also be executed during the preliminary engineering and design (PED) phase of the project. Adaptive management strategies that may involve pilot projects, operational tests, and phased implementation as described in this adaptive management plan will be discussed during value engineering and detailed design to determine the full scope of each test, project construction phase and implementation. RECOVER team members tasked with overseeing CEPP PACR adaptive management will coordinate with the engineers and water managers to ensure project designs, tests, and project operations manual allow flexibility for adaptive management implementation, as well as ensure monitoring plan designs, thresholds-triggers, and reporting is consistent with engineering design and water management needs. Adaptive management strategies will also involve updates to monitoring and assessment plans to better develop experimental designs, monitoring locations, and analysis methods, as well as initiate baseline monitoring data. Some adaptive management activities will need to begin early enough to allow development of the monitoring plan design and to implement monitoring contracts to support establishment of a minimal baseline before construction of CEPP PACR project components are completed.

Monitoring and Experimental Design

RECOVER and other agency monitoring that is being relied upon to inform the CEPP PACR implementation as identified in the adaptive management plan will be reviewed to determine if changes in scope and frequency are needed to better capture project effects. The activities described here fall within the approved CEPP PACR adaptive management budget. Specific monitoring identified in the monitoring and adaptive management plan will require scopes of work, schedules, and assessment protocols to be developed and coordinated by RECOVER to determine monitoring location and experimental design details to update the monitoring plan. Data analysis and modeling may be needed to inform the statistical sampling design needed for monitoring to be able to test project hypotheses. Before and after control designs will be specified in the monitoring plan update, consistent with the parameters identified in each strategy and within the constraints specified by regulatory permits. CEPP PACR monitoring plan design will use existing data where possible, e.g., RECOVER and other agency monitoring efforts. Adaptive management strategies maybe updated with more detailed decision trees to outline the decision-points associated with triggers/thresholds identified in each strategy. Decision trees will describe who receives reports, who provides guidance on decisions associated with the results, and what potential adjustments might occur. Updated monitoring plans will be coordinated for approval by implementing agencies and concurrence by participating agencies and Tribes.

Baseline Monitoring

In cases where there is not sufficient pre-project data monitoring, contracts will need to be initiated prior to construction of specific CEPP PACR components. Final assignment of agency monitoring responsibilities will be made after State and Federal regulatory permits are issued for a component. RECOVER, USACE, and SFWMD monitoring points-of-contact will be identified to coordinate and implement monitoring with in-house agency resources or via contracts with CERP partner agencies and/or contracted universities or consultants to most efficiently and effectively execute the monitoring plan designs. Designated contacts will ensure that results are shared with the partnering agencies and non-governmental stakeholders for the duration of the monitoring plan. In addition, prior to construction of any component and/or test, a baseline monitoring report will be developed by RECOVER and coordinated with the project team and stakeholders, as stated in the PIR monitoring and adaptive management plan.

Pre-construction Engineering and Design (PED)

Project component designs will be developed and coordinated with RECOVER to ensure project component designs are consistent with the testing objectives identified in the adaptive management plan strategy. Further data analysis or review of other project design and monitoring information may be required to inform the design of CEPP PACR project. In addition, monitoring locations that need to be installed prior to construction for baseline monitoring will be coordinated with the PED team to ensure they are aligned properly. The PED team will share project component plans and specifications with the RECOVER. Monitoring contract schedules will be aligned with project construction schedules and operating protocol as defined in the project component's operational strategy and consistent with the experimental design outlined in the adaptive management plan. RECOVER CEPP PACR point of contacts will also be responsible for conveying results from annual monitoring reports to the PED team to help determine options for improving project designs, particularly for the blue shanty and seepage management features, but also for additional project components when deemed relevant and necessary.

Project Operating Manuals

Project operating manuals are developed during design by water managers in coordination with engineers, and hydrologists to specify the operating criteria for each structure. Water managers and engineers will coordinate with RECOVER to understand what hydrologic analysis is needed to inform operational criteria to be used as part of adaptive management tests. In addition, RECOVER will work with water managers, planners, and hydrologists to ensure flexibility is incorporated into the project operational plan to allow for potential needed adjustments in the future consistent with regulatory constraints and NEPA analysis. RECOVER will work with water managers to identify the monitoring information, triggers and process to be included in the project operating manual that will inform operational adjustments.

D.5.4 Construction

Construction schedules, construction contract language, and implementation progress will be coordinated with RECOVER to ensure that appropriate flexibility is included as needed to be effective in fulfilling the intent of the adaptive management plan. Schedules and implementation should include monitoring and operational tests consistent with the adaptive management strategies described in the adaptive management plan in order to learn from project component implementation. In some cases, when agreed to by the implementing agencies, adaptive management strategies may require adjustment to construction schedules to be able to learn from implementation of one phase to inform additional phases. This logic will reduce uncertainty and risk, could reduce cost, and will need to be incorporated into the construction schedule and contracting approaches to ensure this flexibility.

D.5.5 Post Construction and Operations, Maintenance, Repair, Replacement, and Rehabilitation

Post Construction Monitoring

CEPP PACR–specific project monitoring, RECOVER system-wide monitoring, and other agency monitoring will be assessed by RECOVER to determine the restoration performance related to key project components or groups of components The timing outlined in each strategy will determine when data analysis and reporting should occur based on the temporal and spatial scale of the parameters being assessed. The triggers and thresholds outlined in the management option matrices and adaptive management strategies will guide the frequency of reporting and whom the reports are intended to inform. For example, strategies developed to address higher risk uncertainties may require more frequent reporting to CEPP PACR implementing agencies and associated regulatory agencies to ensure constraints are addressed. Other strategies will have monitoring implemented after a particular project component is constructed **for a specific timeline to report results to inform CEPP PACR operations or construction of subsequent project components.**

Post Construction Assessment, Reporting, and Linking to Decision-Making

CEPP PACR assessment results will be reported to the implementing agencies and partner agencies as part of the RECOVER system-status report, South Florida Environmental report, or more frequently if needed. The process for reporting results to decision-makers is provided in the CERP science feedback to decision-making diagram in the CERP Adaptive Management Integration Guide (Figure 3-9, RECOVER 2011b).

As part of assessing and reporting CEPP PACR's performance, annual State of the Central Everglades meetings will be coordinated by RECOVER to discuss assessment results. Scientists, hydrologists, engineers and water managers will present results of structural and operational changes (Drivers) and corresponding hydrological (Stressors), ecosystem processes (Effects), and ecological response (Attributes) specific to implemented project features, tests, and/or operational changes. The meeting goal will be to understand status and trends and potential causes of performance issues and/or success, as well as discuss the reality of what options are available to improve performance if needed. The meetings could occur in late summer or early fall after completing a water year (ending April 30). The meetings will be performance focused. The meetings will require coordination among RECOVER entities overseeing monitoring (CEPP PACR project funded, RECOVER, and non-agency funded), and trained facilitation is recommended to ensure the technical meeting fulfills the CEPP PACR's assessment reporting goals. RECOVER will work with the South Florida Ecosystem Restoration Task Force's Science Coordination Group to determine if that forum should host the technical meeting to encourage broader non-governmental stakeholder participation.

No later than 1 to 2 months after the annual State of the Central Everglades meeting, an environmental coordination meeting will be held with managers to discuss with managers any performance issues and to communicate success. This meeting will also be used to agree on the appropriate forum to make decisions about options to adjust CEPP PACR implementation and operations.

Monitoring results will be reported in the context of the triggers/thresholds identified in the adaptive management strategies, e.g., if performance remains within the triggers/thresholds that are provided to indicate need for adjustments, then the operations may continue or the next project component may be constructed based on the demonstrated results. Constraint triggers/thresholds that are "triggered" will be reported to implementing agencies and associated regulatory agencies with suggestions of management options to implement, as stated in the adaptive management plan management options matrices (MOMs), to be evaluated by the agencies to decide what action is needed. Results of multiple monitoring trends will be integrated as part of a multiple lines of evidence analysis (Burton et al. 2002; RECOVER 2006) to inform the potential need for adjusting implementation or documenting success.

Suggested options to adjust CERP implementation fall into several categories, listed here by level of effort required to implement:

1. Operational Decisions: Operations decisions are weekly/monthly, but get reported and summarized and reported at annual meetings. Annual meetings also are a forum to discuss potential upcoming operations decisions (e.g., wet vs. dry years going into El Niño or La Niña years);
2. NEPA Covered Options, No Modeling Needed: CEPP PACR adaptive management plan options that are covered by NEPA and do not require additional modeling or analysis beyond what has been discussed by scientists and managers;

3. NEPA Covered Options, Requires Modeling: CEPP PACR adaptive management plan options that are covered by NEPA but may require model runs to determine best option;
4. Not NEPA Covered: CEPP PACR adaptive management options that have not yet undergone sufficient NEPA analysis and therefore require additional environmental review and public comment, and potentially additional modeling.
5. Not Included in CEPP PACR adaptive management plan: In some cases, the monitoring results may indicate the need for an option not identified in the adaptive management plan or PIR/EIS. This may result in agency-approved temporary adjustment to implementation and operations to avoid the constraint while potential project adjustments are further scoped, analyzed, approved, and budgeted for implementation. If additional technical expertise is required in RECOVER, an ad-hoc team could be formed to identify performance issues and options in a post authorization change report or make suggestions for a future CERP project.

The USACE Jacksonville District in consultation with Federal and State resource agencies and the USACE South Atlantic Division (SAD) and the South Florida Water Management District will guide decisions on determining whether restoration success has been achieved or additional operational, structural, or other contingency options identified in the adaptive management plan MOMs need to be implemented.

D.6 CEPP PACR Adaptive Management Plan Cost Estimate

Identification of the CEPP PACR monitoring contained in Annex D was guided partly by two objectives. First, it must be complete from a CEPP PACR perspective in that it must provide the monitoring required to address specific needs. Second, it must be integrated with other Everglades monitoring to take advantage of existing monitoring efforts, knowledge, and information and thereby leverage dollars committed and spent elsewhere to avoid redundancies and insure cost-effectiveness. These two objectives guided development of the adaptive management plan, hydrometeorological monitoring plan, water quality monitoring plan, and the ecological monitoring plan. Where possible, CEPP PACR will rely on existing monitoring resources such as physical instrumentation, stations, locations, servicing, and analysis efforts funded by RECOVER, CERP sponsors, and partner agencies. Therefore, the monitoring described in the CEPP PACR Adaptive Management and Monitoring plan is limited to the additional, marginal increase in monitoring resources and analysis efforts needed to address specific questions. The cost estimate for the adaptive management monitoring for CEPP can be found in **Table D.1-6**. Monitoring costs are not anticipated to change for implementation of the CEPP PACR.

Table D.1-6. CEPP Adaptive Management Monitoring Cross-walked with Other Monitoring Programs

CEPP monitoring costs are shown here as if all monitoring will take place in one 10-year window. Costs here are a "worst case," whereas the actual monitoring schedule is expected to be staggered over the CEPP PACR implementation schedule and would therefore cost the project less per year. Dollar amounts shown here have not been updated with CEPP project-wide contingency amounts. These costs were provided before CEPP project contingencies were applied. *It should not be assumed that the added contingency amounts will be available specifically to fund monitoring efforts*.

Region	Uncertainty	ID#	Attributes to be Monitored	RECOVER 1-Yr Cost	Other Agency 1-Yr Cost	CEPP 1-yr Cost*	Sampling Frequency	Notes
Lake Okeechobee	Lake O littoral and near shore vegetation: potential effects Lake stages with CEPP	#3	littoral and near shore vegetation coverage	$ -	$47,000	$23,500	Current monitoring ranges from daily (Lake stages) to 3x per year (veg transects)	Assumptions based on need for additional labor to due analysis pursuant to CEPP objectives/constraints. SFWMD already pays for monitoring.
Northern Estuaries Region (NE) St. Lucie Estuary (SLE)	Do reductions of high volume fresh water discharges result in measurable increases in submerged aquatic vegetation (SAV) coverage in the St. Lucie estuary (SLE)?	1	SLE SAV	$45,000	$ -	$45,000	6 summer months, 1 winter	
NE SLE	Will the increased frequency of low flow exceedences and timing in the SLE have a detrimental impact on oyster communities by increasing levels of predation and disease during extreme dry times? (ID#48)	45, 48	SLE Oysters	$100,000	$ -	$ 10,000	Monthly, accept live /dead counts 4x/year	

Region	Uncertainty	ID#	Attributes to be Monitored	RECOVER 1-Yr Cost	Other Agency 1-Yr Cost	CEPP 1-yr Cost*	Sampling Frequency	Notes
NE SLE	To what extent will the reduction in the frequency and magnitude of high flows to the SLE help reestablish historic oyster beds on the south fork SLE? (ID#45)	1,45, 48	SLE Oyster and SAV mapping	$ -	$ -	$15,000	$75,000 every 5 years	
NE SLE	To what extent will the reduction in the frequency and magnitude of high flows to the SLE stabilize conditions enough to improve benthic habitat in the south fork St. Lucie estuary? (ID#46)	46	SLE Benthos	$85,000	$ -	$ -	quarterly	
NE SLE	see above	1, 45, 48, 46	SLE Salinity stations	$ -	TBD	$ -	daily	SFWMD and County salinity stations
NE SLE	see above	1, 45, 48, 46	SLE WQ	$ -	$40,867	$ -	monthly	SFWMD and County WQ stations
NE Caloosa-hatchee River Estuary (CRE)	Will the reduction in low flow exceedences in the Caloosahatchee estuary help re-establish healthy Vallisneria beds in the upper Caloosahatchee estuary? (ID#49)	2, 49	CRE SAV	$68,000	$ -	$ -	6 summer months, 1 winter	

Region	Uncertainty	ID#	Attributes to be Monitored	RECOVER 1-Yr Cost	Other Agency 1-Yr Cost	CEPP 1-yr Cost*	Sampling Frequency	Notes
NE CRE	Do reductions of high volume fresh water discharges result in measurable increases in SAV coverage and oyster acreage and health in the Caloosahatchee estuary? (ID#2)	2	CRE Oyster	$190,000	$ -	$ -	Monthly, accept live /dead counts 4x/year	
	see above	1, 49	CRE Oyster and SAV mapping	$ -	$ -	$25,000	$125,000 every 5 years	
	see above	1, 49	CRE Salinity	$ -	TBD	$ -	daily	SFWMD and County salinity stations
	see above	1, 49	CRE WQ	$ -	$20,433	$ -	monthly	monthly SFWMD
Greater Everglades (GE) Northern Water Conservation Area (WCA) 3A	Will CEPP PACR reduce soil oxidation and peat fires in Northern WCA 3A?	5	Soil Moisture Content; Peat Accretion; Fire mapping; Community Structure; Radiometric Dating; Soil Decomposition; Weather; Hydrology	$30,000	$ -	$100,000	Monthly, Quarterly; 1 GRTS every year	Northern WCA 3A; Fire mapping; 2 N-S transects; 2 E-W transects; 6 General Randomized Tessellated Stratification (GRTS) panels; Hydro/met stations.

Region	Uncertainty	ID#	Attributes to be Monitored	RECOVER 1-Yr Cost	Other Agency 1-Yr Cost	CEPP 1-yr Cost*	Sampling Frequency	Notes
Northern WCA 3A	Will CEPP hydroperiods, depths and flow velocities reestablish ridge and slough landscapes, including tree islands? -- Will Biogeochemical response be altered by changes in the timing and distribution of CEPP hydrology?	63, 73 and 76	Tree Island Attributes (Peat Accretion, Soil Nutrients, Community Structure, GW flows); Ridge & Slough Attributes (Community Structure, Floc analysis, periphyton, sediment movement, flow velocities); Canal Attributes	$ -	$60,000	$250,000	Large flow events, monthly; annual	Northern WCA-3A - Other SFWMD and EDEN.
GE WCA 3A (NW, NE)	How much will hydrologic restoration and vegetation management in Northwest WCA 3A, WCA 3B and NESRS result in increases in prey densities (aquatic fauna).	75, 9	Aquatic fauna density; Large fish density	$500,000	$ -	$50,000	Five times per year	WCA 3A (NW, NE)
GE WCA 3A (NW, NE)	How much will CEPP improve terrestrial wildlife and alligator relative density and body condition in northern WCA 3A?	10	Alligator relative density; Alligator body condition; Deer abundance; Wildlife Diversity	$ -	$ -	$85,000	Twice a year (Spring and Fall)	CEPP (2 NW, 1 NE, 1 S routes)

Region	Uncertainty	ID#	Attributes to be Monitored	RECOVER 1-Yr Cost	Other Agency 1-Yr Cost	CEPP 1-yr Cost*	Sampling Frequency	Notes
Northern WCA 3A	How much will hydrologic restoration and vegetation management result in increases in wading bird foraging conditions and increased nest number and success of Wood Storks and Roseate Spoonbills?	75	Prey availability, Integration/refinement of existing modeling tools/application after construction	$400,000	$ -	$120,000	One season (dry)	Northern WCA 3A
CEPP-wide Invasives and Nuisance Species Management Plan (INSMP)	How will CEPP PACR influence the introduction and growth of non-native invasive and native nuisance species populations within the project area, and will the species influence the predicted landscape and performance of CEPP PACXR?	59	See INSMP	$ -	$ -	$ -	Daily, Monthly, Biannually	See INSMP
CEPP PACR subtotal per year				**$2,624,000**	**$2,409,300**	**$2,437,500**	**CEPP PACR Total**	**$24,375,000**

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PART 2. CEPP PACR Water Quality Monitoring Plan

Water Quality Monitoring

for

CEPP PACR

(Approval date for
RECOVER
QAOT
EMCT

Authoring Organization's Representative **Date**
(Monitoring plan coordinator)

Lead USACE Project Manager **Date**

Lead SFWMD Project Manager **Date**

Representative, Local Sponsor (Monitoring Organization) **Date**

Representative, Federal Sponsor (Monitoring Organization) **Date**

Project Quality Assurance Officer **Date**

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GLOSSARY/ACRONYMS

ADaPT – Automated Data Processing Tool software.

ADR – Automated Data Review

Assessment – to interpret responses in natural and/or human systems based on data acquired though monitoring activities.

BWRF – Biweekly if Recorded Flow – Sampling frequency to collect sample on bi-weekly basis if flow has occurred during the past week.

Ca – calcium

CEPP – Central Everglades Planning Project

CEPP PACR – Central Everglades Planning Project Post Authorization Change Report

CERP – Comprehensive Everglades Restoration Plan

CERPRA – Comprehensive Everglades Restoration Plan Regulation Act

cfs – cubic foot per second

CGM54 – CERP Guidance Memorandum 54

CID – CERP Integrated Database

CLQM – Chemistry Laboratory Quality Manual

CoC – Chain of Custody

Constraint – a condition that is to be minimized or avoided in the plan formulation and selection process to ensure that the project component does not result in undesirable changes in the project area or downstream waters. Example: The component shall not cause or contribute to a violation of state water quality standards.

Data Qualifiers – a code that is added to data to serve as an indication of the quality of the data.

DQA – Data Quality Assessment

Data Quality Objectives (DQO) – a process that identifies the intended use of the data including the types of decisions that will be made based on the results. The analytes of interest, corresponding action levels, sampling design and quality control measures are also identified as well as data repositories into which the data will be entered, the mechanisms used to ensure that the data are accurately entered into a database and to verify that the data in the database are correct, and the level of data quality acceptable for this project.

DO – dissolved oxygen

DOC – dissolved organic carbon

DOI – Department of Interior

EAA – Everglades Agricultural Area

EB – Equipment Blank, collected to monitor on-site sampling environment, sampling equipment decontamination, sample container cleaning, the suitability of sample preservatives and analyte-free water, sample transport and storage conditions and laboratory processes.

EFA – Everglades Forever Act

EM – Engineering Manual: USACE documents that provide guidance on various aspects of project design and implementation.

ENP – Everglades National Park

F.A.C. – Florida Administrative Code

FB – Field Blank, collected to monitor on-site sampling environment, sample container cleaning, the suitability of sample preservatives and analyte-free water, sample transport and storage conditions and laboratory processes.

FCEB – Field Cleaned Equipment Blank, collected to monitor on-site sampling environment, sampling equipment decontamination in the field, sample container cleaning, the suitability of sample preservatives and analyte-free water, sample transport and storage conditions and laboratory processes.

FDEP – Florida Department of Environmental Protection

FDOH ELCP – Florida Department of Health Environmental Laboratory Certification Program

FEB – Flow Equalization Basin

FSQM – Field Sampling Quality Manual

Local Sponsor – the agency responsible for matching the Federal funding available for a project. The South Florida Water Management District (SFWMD) is the local sponsor for the majority of CERP projects.

LOPA – Lake Okeechobee Protection Act

Matrix – refers to the material from which the sample is taken, such as surface water, ground water, pore water, sediment, soil or air.

MeHg – Methyl mercury, a highly toxic form of mercury which may be bioaccumulated along food chains.

Monitoring – all of the activities required to acquire, process, store, retrieve and analyze data used to assess the status of water resources. It includes data collection, data analysis, data validation, and data management.

Monitoring Data – data that are collected for the purpose of determining the effects of CERP projects at a given location.

Monitoring Plan – the plan to acquire additional meteorological, hydrologic, hydraulic, water quality or ecological data. It includes considerations of sampling location, frequency, method, parameters and duration. It is based on the elements identified in the development of data quality objectives for the project.

Na – sodium

NELAP – National Environmental Laboratory Accreditation Program

NPS – National Park Service

non-ECP – non-Everglades Construction Project

NOx – nitrate + nitrite

Objective – a measurable element of the goal(s) of a project or plan. Project objectives and constraints are identified in the Project Management Plan (PMP).

OPO4 – orthophosphate

PACR – Post Authorization Change Report

Permit Requirement – certain analytes are sampled, tested and results reported to State and/or Federal agencies as a condition of a permit to build or operate a project.

PIR – Project Implementation Report

PLMP – Project-Level Monitoring Plan

Project-level – A project has a defined scope, quality objectives, schedule, and cost. Project-level activities refer to those that are within the scope of a specific project.

QA – Quality Assurance: the system of management activities and quality control procedures implemented to produce and evaluate data according to pre-established data quality objectives.

QAOT – Quality Assurance Oversight Team, comprised of representatives from USACE, SFWMD, FDEP, and USEPA, ultimately responsible oversight of the implementation of the quality system for CERP.

QASR – Quality Assurance System Requirements, the CERP Quality manual that establishes minimum criteria for environmental data quality.

QC – Quality Control: The system of measurement activities used to document and control the quality of data so that it meets the needs of data users as specified by pre-established data quality objectives.

QMP – Quality Management Plan

RECOVER – REstoration COordination and VERification (RECOVER) is a process that evaluates and assesses CERP performance by linking scientific and technical information throughout the planning and implementation period to ensure that a system-wide perspective is maintained throughout the restoration program.

RECOVER AT – The RECOVER Assessment Team is a standing, interagency, interdisciplinary team of scientists and resource specialists who are responsible for achieving the five primary tasks of RECOVER: 1) create, refine and provide documentation for a set of conceptual ecological models for the total system and a set of attribute-based biological performance measures for the Comprehensive Plan; 3) design and review the system-wide monitoring and data management program needed to support the Comprehensive Plan; 4) use the information coming from the system-wide monitoring program to assess actual system responses as components of the Comprehensive Plan are implemented and produce an annual assessment report describing and interpreting these responses; and 5) coordinate all scientific peer reviews of RECOVER documents.

RS – Replicate samples defined as two additional samples collected in addition to the routine sample. Sampling Frequency – how often samples are collected.

Sampling Methods – the methods used to collect samples in the field. The methods should be standard methods, methods based on a standard operating procedure, or a method that has been approved by the participating agencies.

SEDD – Staged Electronic Data Deliverable

SFWMD – South Florida Water Management District

STA – Stormwater Treatment Area

SOP – Standard Operating Procedures standard

SO_4 – sulfate

TFe – total iron

THg – Total mercury

TN – total nitrogen

TOC – total organic carbon

TP-Rule – Total Phosphorus Rule

TS – total sulfur

USACE – United States Army Corps of Engineers

USEPA – United States Environmental Protection Agency

WCA – Water Conservation Area

WBS – Work Breakdown Structure: The WBS specifies a hierarchy of tasks and activities necessary to fulfill the objectives of the project. The WBS is structured in levels of work detail, beginning with the deliverable itself, and is then separated into identifiable work elements.

WQB – Water Quality Bureau

Zone of Influence – the area over which a project alters or impacts the environment.

Additional terms and definitions for CERP can be found in CGM 13 – Acronyms and Glossary of Terms. http://www.cerpzone.org/documents/cgm/cgm_013.03.pdf

D.0 Executive Summary

The Central Everglades Planning Project Post Authorization Change Report (CEPP PACR) water quality monitoring plan presented herein was developed by the South Florida Water Management District (SFWMD) based on the previous work of an interagency team comprised of representatives from the SFWMD, United States Army Corps of Engineers (USACE), Department of Interior (DOI), and Florida Department of Environmental Protection (FDEP). In developing this plan, the SFWMD reviewed the ongoing monitoring efforts within the study area as of November 2017 to determine what additional monitoring may be required to demonstrate compliance with existing and anticipated requirements. The monitoring stations are preliminarily identified in this plan since final designs have not been prepared for any of the project features. As such, this plan incorporates the best information available; however, as the project is designed and implemented, this plan will require revision. To accommodate imprecise information, a risk-based 44% contingency was incorporated into the monitoring plan cost estimate. The estimated first year cost of the water quality monitoring presented herein is consistent with the cost presented in CEPP. Additional monitoring costs for the CEPP PACR are estimated first year cost was $265,123, the 5-year cost was estimated to be approximately $1,129,395, and the 50-year costs were estimated to be approximately $10,725,582. Generally, Comprehensive Everglades Restoration Plan (CERP) water quality monitoring is cost-shared for the life of the project as long as the monitoring is specified in a permit or other regulatory agreement.

D.1 Introduction

This document serves as a reference for monitoring surface water quality for the CEPP PACR (hereinafter referred to as Project) including authorized CEPP project features and new features proposed in the TSP. Monitoring will be conducted to evaluate the Project's performance regarding restoration goals and regulatory requirements. Specifically, the Project is intended to send additional surface water south from Lake Okeechobee through the Everglades Agricultural Area (EAA) and on to Everglades National Park (ENP). The additional water will restore historical hydrologic patterns within the Everglades freshwater wetlands, and improve the wetlands and salinity patterns in the nearshore region of Florida Bay.

The area of influence includes Lake Okeechobee, Caloosahatchee Estuary, St. Lucie Estuary, EAA, Water Conservation Areas (WCA), ENP, and the southern estuaries. **Figure D.2-1** shows a map of the study area which includes the areas of influence.

D.2 Project Description

The Project features include the following elements:

1. Storage and treatment
    a. A-2 Reservoir (10,500 acres, approximately 23 feet deep) located in the EAA north of the Stormwater Treatment Area (STA) 3/4 and adjacent to the A-1 Flow Equalization Basin (FEB)
    b. A-2 STA (6,500-acre) to the west of the A-2 Reservoir
    c. Canal conveyance improvements in the Miami and North New River
2. Northern distribution and conveyance (northern WCA-3A)

   a. Hydrologic restoration feature, 3-mile-long spreader canal located west of S-8 Structure
   b. Backfill Miami canal from S-8 to Interstate 75
3. Southern distribution and conveyance (southern WCA-3A/B, ENP)
   a. Increased S-333 capacity from 1,500 to 3,000 cubic foot per second (cfs)
   b. Two 500 cfs gated structures in L-67A west of Blue Shanty
   c. Blue Shanty training levee in WCA-3B
   d. Degrade of L-67C levee in Blue Shanty flowway
   e. One 500 cfs gated structure east of Blue Shanty and 6,000 feet of degraded L-67C levee
   f. Degrade L-29 levee in Blue Shanty flowway
   g. New divide structure (S-333B) west of western bridge
   h. Degrade of L-67 extension levee
4. Seepage management (L-31N levee)
   a. Increase S-356 from 500 to 1,000 cfs
   b. Partial seepage barrier (5 miles long) along L-31N
   c. Modification of G-211 flood control operations

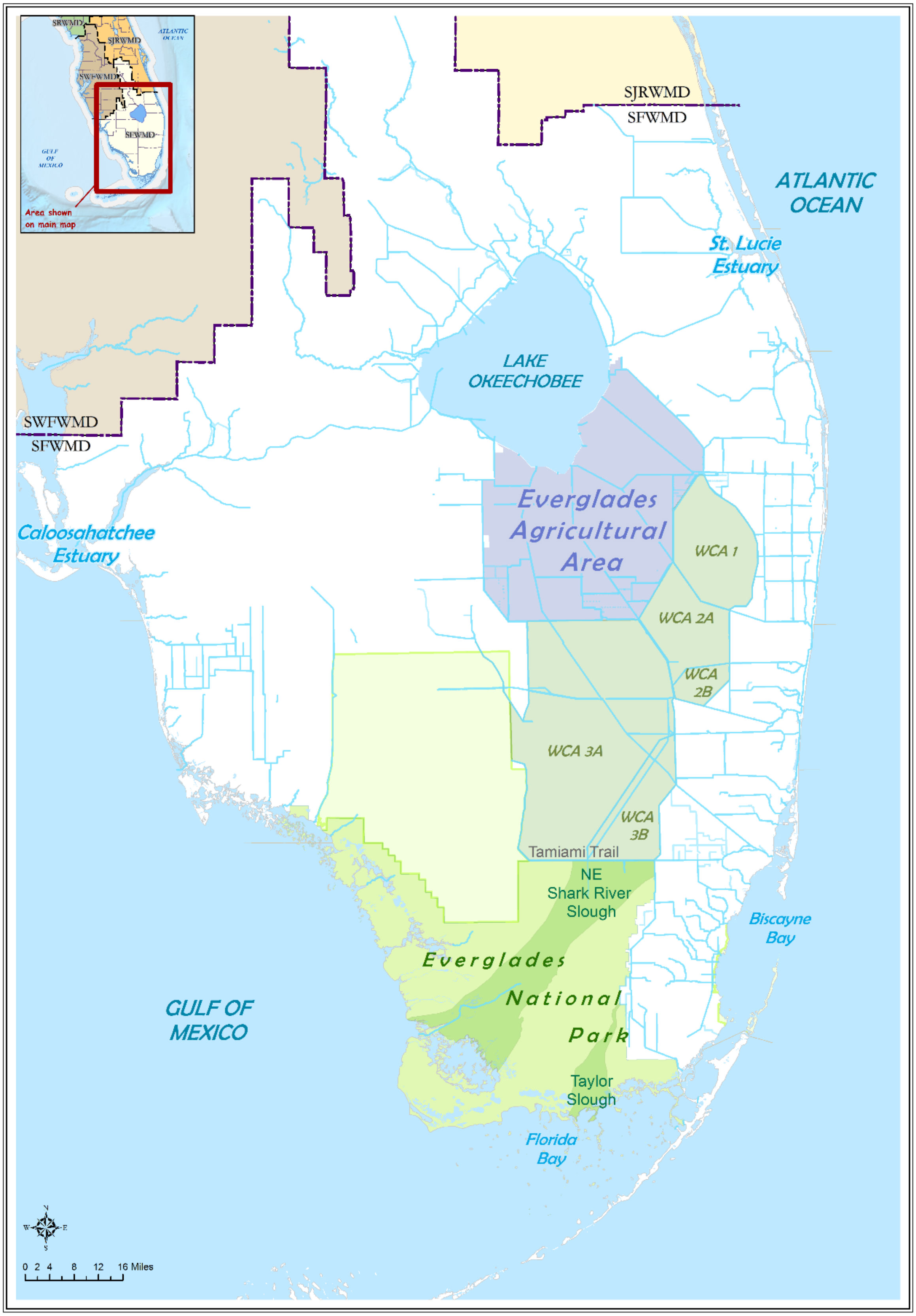

Figure D.2-1. Central Everglades Planning Project Post-Authorization Change Report Study Area

D.3 Project Objectives

The monitoring stations described herein are referenced to satisfy requirements of the CERP Project Implementation Report (PIR) and requirements of (issued or pending) Department of the Army 404 permits and/or State of Florida 373.1502 Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permits for Start Up and Operational Phase Monitoring. This CEPP PACR monitoring plan (Plan) provides an outline for quantifying the quality of surface water entering and downstream of the project area for a period of ten years and may be updated to meet permit requirements as necessary.

Surface water samples have been collected and analyzed for multiple constituents and at various frequencies within South Florida from stations adjacent to or nearby the targeted project features. These baseline data are compiled in the South Florida Water Management District's (SFWMD) DBHYDRO database and in the annual South Florida Environmental Report

The water quality data obtained under this program will be used to:

1. Evaluate water quality status and trends;
2. Assess compliance with Federal and State water quality statutes, the Everglades Forever Act (EFA), and the applicable Everglades Consent Orders; and
3. Guide mid- and long-term resource management decisions as part of the adaptive management plan for the Project.

D.4 Active Mandates and Permits

Water quality monitoring of inflows to the Everglades Protection Area is generally governed by the 1992 Consent Decree, and EFA permits, most notably the Non-Everglades Construction Project permit and the STA permits. Monitoring of marsh stations is generally governed by the 1992 Consent Decree and the Total Phosphorous Rule (TP-Rule). Project features may also require the establishment of new monitoring locations; however, in many instances, existing monitoring stations are sufficient to provide requisite data, in these cases the existing monitoring will be utilized to demonstrate project benefits or compliance with water quality standards. The permits and/or agreements that will govern new sampling requirements for this project will be developed through the permitting process. Since the final design and placement of the features have not been established at the time of this Plan development, certain details of the actual permit required new monitoring may not exactly match the information presented in this plan.

D.5 Monitoring Components

D.5.1 Project Baseline Monitoring

Baseline monitoring is necessary to establish pre-project conditions in areas where no prior sampling has been conducted in the past. Fortunately, the Project area has an extensive monitoring history that can be referenced as pre-project conditions, with relatively few gaps. To fill those informational gaps, baseline sediment monitoring will be conducted in northern ENP to determine the impact of water diversion and canal backfilling on sediment phosphorus content in affected areas.

D.5.2 Construction Monitoring

Construction monitoring will be limited to turbidity sampling as required by FDEP construction permits. This monitoring is not included in this Plan since it is normally carried out by the construction contractor.

D.5.3 Post-Construction Monitoring (Effectiveness Monitoring)

Post-construction monitoring will assess the compliance of project features with State and Federal water quality statutes and applicable Everglades Consent Orders. The list of monitored parameters generally includes total phosphorus (TP), ortho-phosphorus (OPO4), total nitrogen (TN), nitrate + nitrite (NO_x), calcium (Ca), sodium (Na), sulfate (SO_4), dissolved oxygen (DO), pH, color, specific conductance, temperature, and turbidity. Monitoring protocols and parameter lists vary from station to station; therefore, they will be summarized in their respective sections below.

D.5.3.1 Components

New monitoring stations proposed as part of this project were selected based on a review of the ongoing monitoring and the expected compliance requirements associated with the planned project features. Staff from SFWMD, USACE, DOI, and FDEP were consulted to ensure that the new monitoring stations were consistent with the permit requirements and not duplicative of ongoing monitoring at existing stations.

D.5.3.2 Duration

D.5.3.2.1 Life Cycle

The USACE project life-cycle for the Project is defined as 50 years. This monitoring plan includes a conservative estimate of funding for a scenario where water quality monitoring takes place for the life of the Project (50-years). The duration of cost-shared project related monitoring required for compliance with the EFA, non-Everglades Construction Project (non-ECP), Settlement Agreement, or future CERPRA or Lake Okeechobee Protection Act (LOPA) permits is assumed to be 50 years for this estimate. Project level monitoring may continue after this period; however, this is not addressed in this plan. Changes to the project water quality monitoring efforts are keyed to future changes to any of the controlling laws, settlements, or permits. Since project construction will occur over a period of 10 years or so, monitoring efforts at some project features will not begin for several years after congressional authorization.

The monitoring plan will be periodically reviewed for effectiveness and modified as allowed under permitting constraints. As part of an adaptive management approach to this project, it is expected that the requirements to monitor parameters and frequencies may be changed throughout the life of this project. If monitoring reduction is warranted, demonstration that a parameter or group of parameters no longer represents a source of concern will be required.

The original water quality monitoring plan was initiated by the Water Quality Sub-team of the CEPP, and technical review was provided by Comprehensive Everglades Restoration Plan REstoration COordination and VErification (RECOVER) Group, Coordination and Verification staff of the SFWMD and USACE. Development of this plan is required as part of the CEPP PACR document. The CEPP PACR development phase calls for sections detailing the water quality monitoring and adaptive assessment methods for the TSP. The plan was originally prepared under the assumption that water quality monitoring efforts directly funded by this project will last a total of 50 years. While CERPRA permits generally are granted for a period of 10 years, for the purposes of the costs provided here, it is assumed that the required monitoring will not change for subsequent permits.

D.5.3.2.2 Termination Conditions

The water quality monitoring plan may be modified per the needs of the project and will be completely reassessed after 5 years from initiation. The plan may be changed to reflect any future design changes or permit requirements. It also may be terminated according to permit expiration dates or changes to the project objectives. The plan will be reviewed and modified annually or more frequently, if necessary, to reflect new monitoring requirements. Decisions to adjust monitoring will be coordinated through the project partners as well as the FDEP.

This CEPP PACR monitoring plan was developed assuming that major, ongoing monitoring programs that are not funded directly by the Project would continue to supply data relevant to the Project. Should any of these programs be discontinued or significantly curtailed, then the Federal and local sponsors of the Project will reevaluate monitoring priorities and may redistribute funds for the benefit of the Project, even potentially not funding elements of this monitoring plan.

D.5.3.3 Integration with Existing Inventory

Extensive monitoring programs and stations already exist in much of the Project area. To prevent duplication of work, leverage existing stations, and optimize proposed sampling stations, a review of the relevant existing monitoring stations and programs was carried out, and maps of these stations are presented below. New monitoring proposed under this project will be integrated with the existing inventory of monitoring.

D.6 Inventory of Existing Monitoring Networks

New water quality monitoring efforts associated with the Project are contemplated for the central and southern portions of Everglades so a review of the relevant existing monitoring efforts in these areas was conducted. **Figure D.2-2 through D.2-5** show the relevant existing monitoring network for the central Everglades portion of the study area. The monitoring at the stations shown in these figures is required to demonstrate compliance with multiple mandates, including the Non-ECP permit, the 1992 Consent Decree (commonly referred to as the "Settlement Agreement") and/or the EFA (TP-Rule).

Figure D.2-2 shows the existing structure monitoring locations within WCA-3. Monitoring at these structure locations is generally required by the Non-ECP permit. **Figure D.2-3** shows the existing structure monitoring locations within ENP, along the L-29 levee (S12s, S333, S334, S355A/B, S356) and along the L-31N/C-111 levee canal (S332s, S176, S-18C, S-197). **Figure D.2-4** shows the existing marsh monitoring locations within WCA-3, and **Figure D.2-5** shows the existing marsh monitoring locations within ENP. On these two figures, the monitoring stations identified with a circle are monitored as required in the TP-Rule (Florida Administrative Code [F.A.C.] 62-302.540) and those identified with diamonds are required as part of the Settlement Agreement.

The Project does not include any features in the Caloosahatchee or St. Lucie Estuaries. Consequently, no new monitoring of these areas is proposed and the existing monitoring was not reviewed.

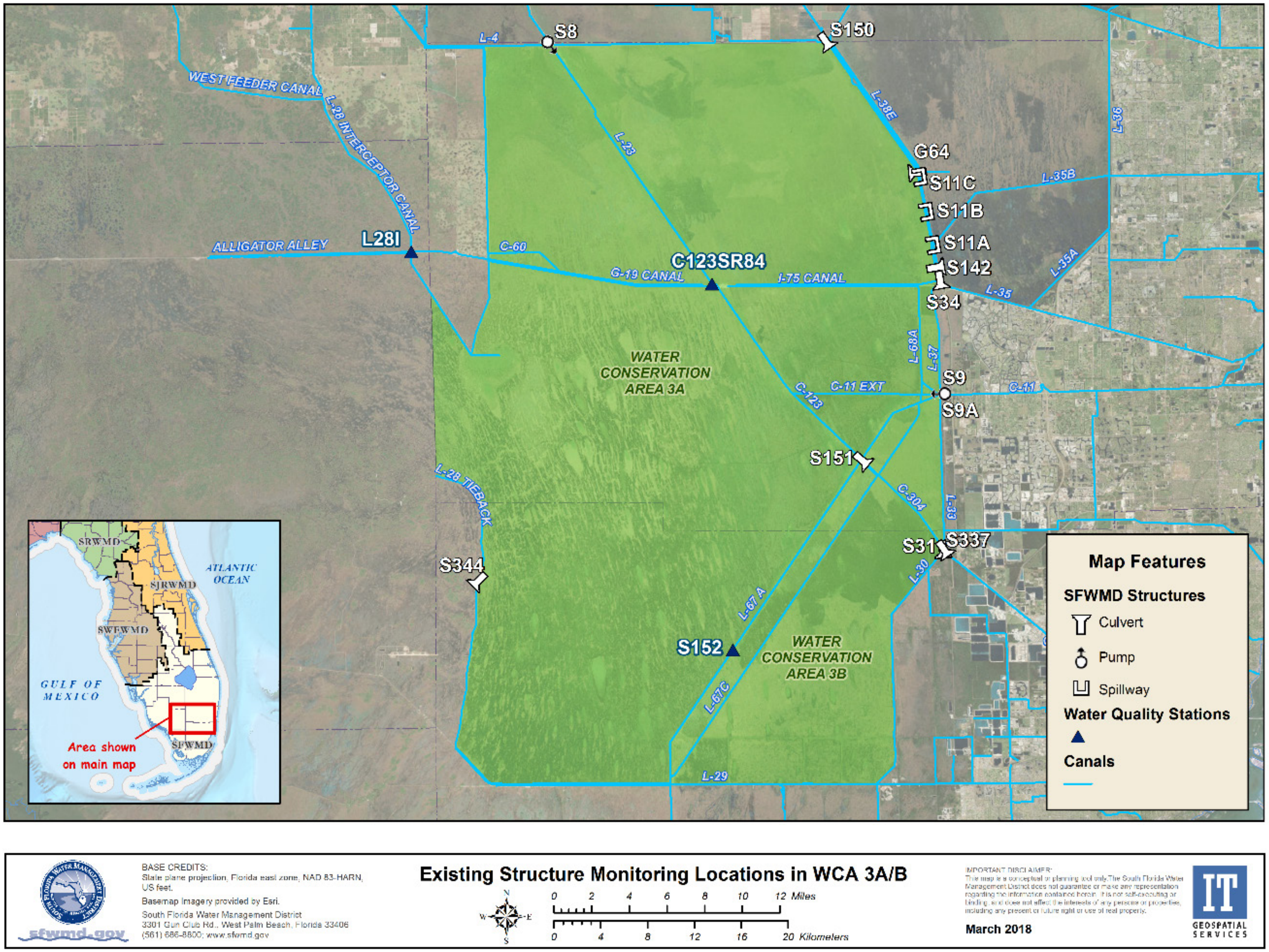

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Figure D.2-2. Existing Structure Monitoring Locations in WCA 3A/B

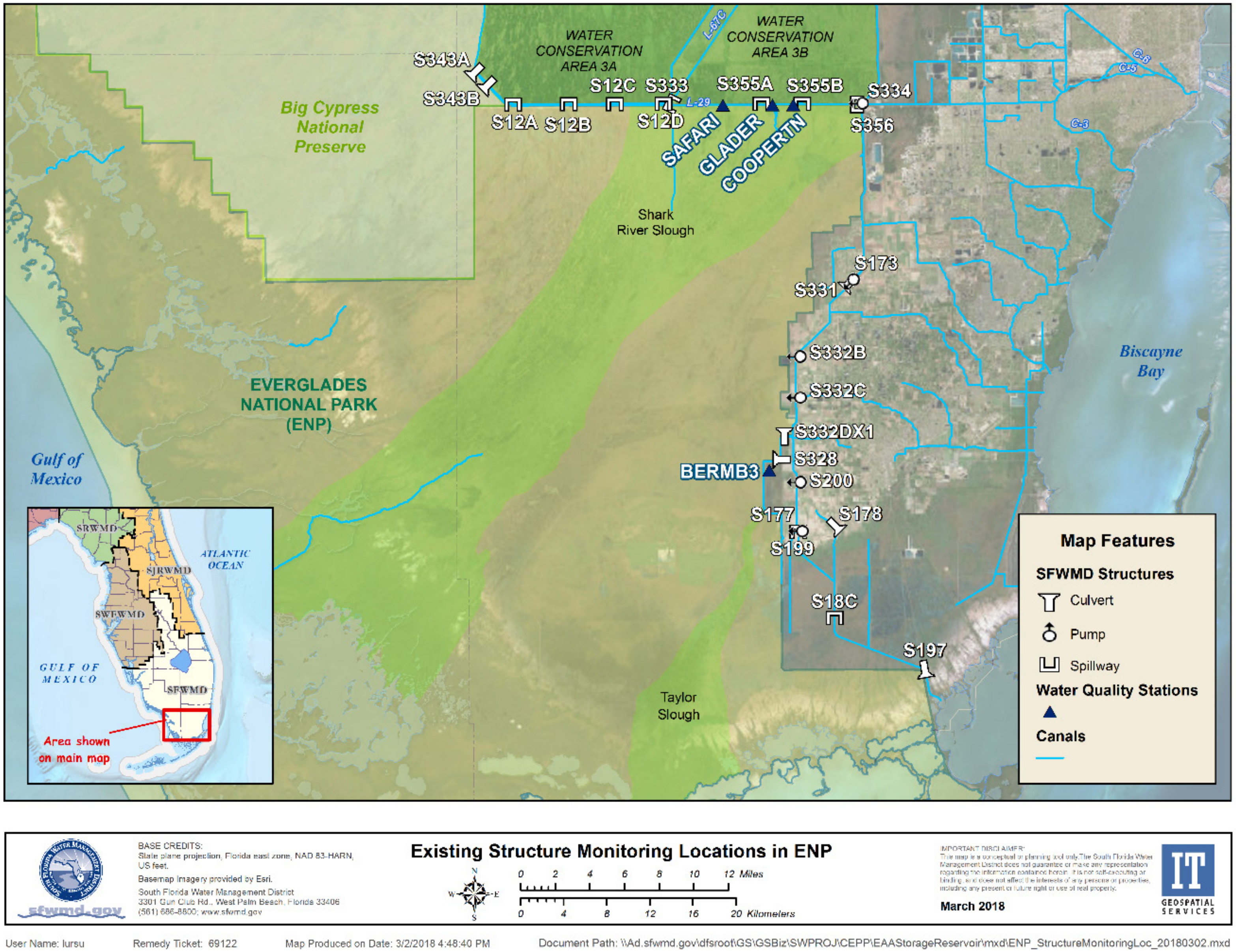

Figure D.2-3. Existing Structure Monitoring in ENP

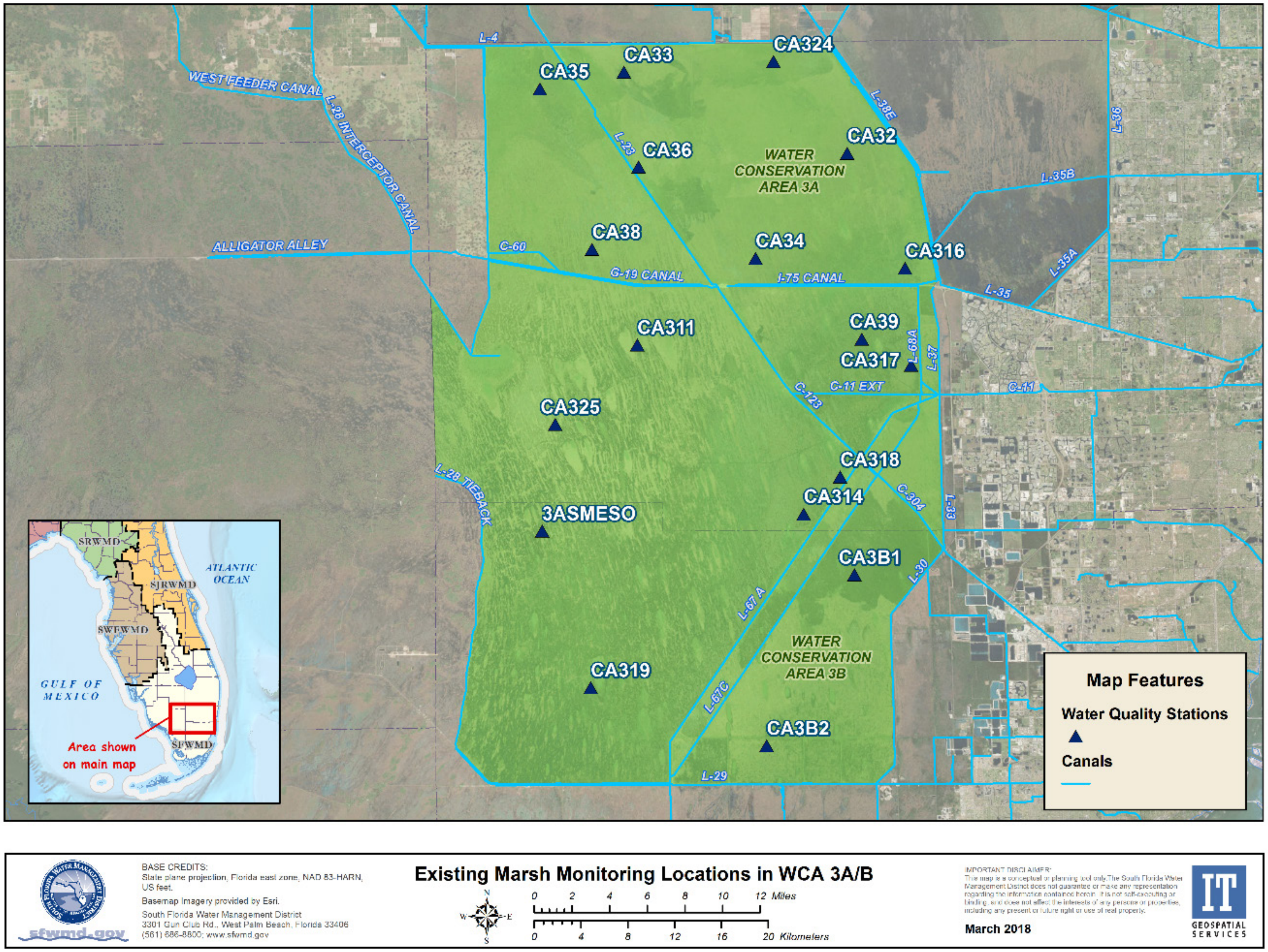

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Figure D.2-4. Existing Marsh Monitoring Locations in WCA-3A/B

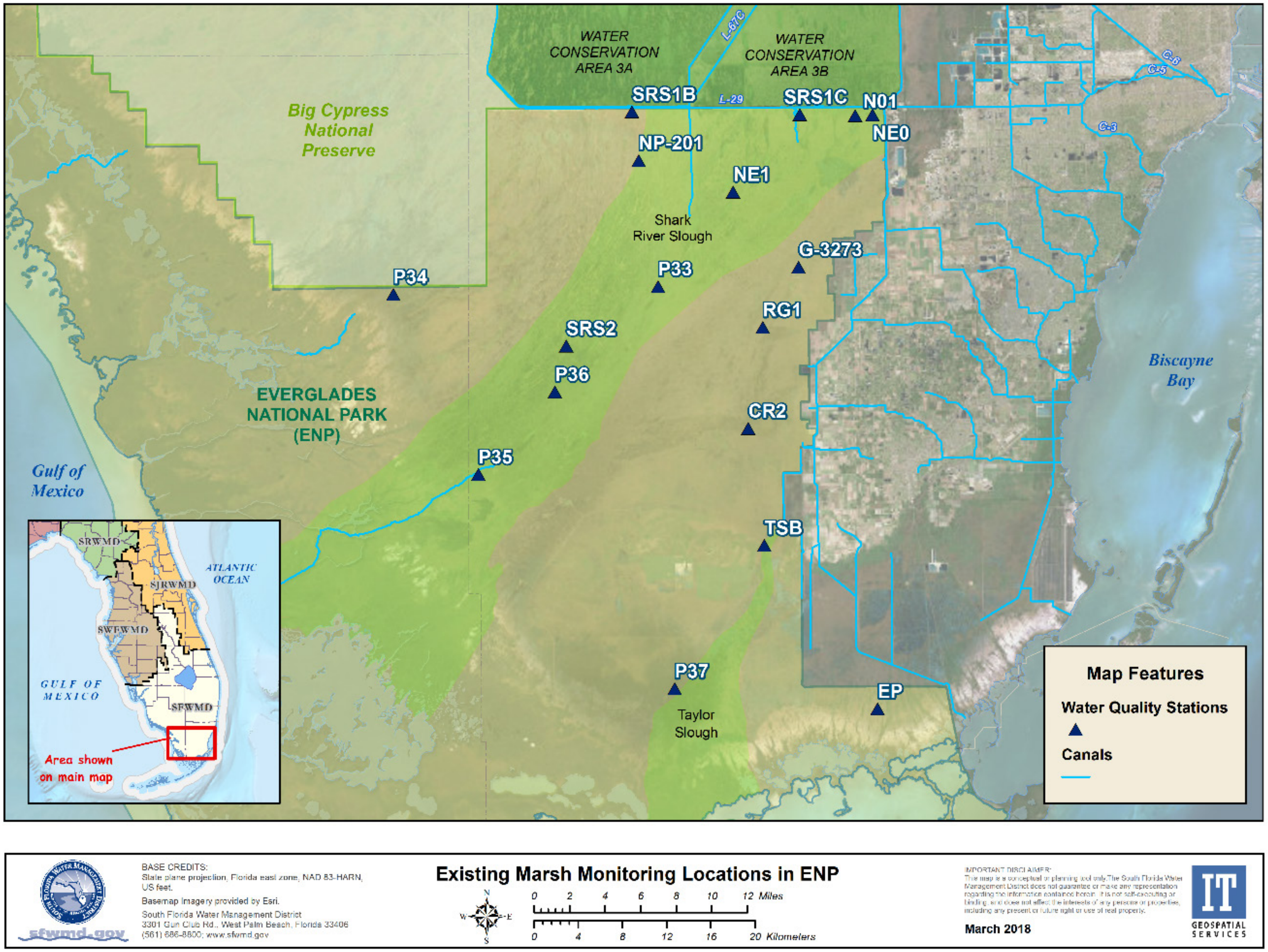

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Figure D.2-5. Existing Marsh Monitoring Locations in ENP

D.7 Post Construction Monitoring

A description of new or leveraged monitoring for each project feature is provided below.

D.7.1 Geographic Location of New Monitoring Stations

The exact number and location of the new monitoring stations has not yet been determined. After Project authorization and design, this Plan will be revised to include this information for each new station.

D.7.2 Access and Authority

New monitoring stations located at water control structures will be accessed via existing levees or public roadways. Sampling in the WCAs and ENP will be conducted using airboats and/or helicopters. To perform environmental sampling within the ENP, a Scientific Research and Collecting Permit will first be obtained from the National Park Service (NPS), or work will be performed by NPS personnel.

D.7.3 Lake Okeechobee, St. Lucie River and Caloosahatchee River

No new monitoring is proposed for these water bodies.

D.7.4 A-2 Reservoir and A-2 STA

Water quality monitoring at the inflows and outflows of the A-2 Reservoir and A-2 STA will be required by construction and operation permits. This compliance monitoring will consist of sampling for nutrients, mercury and other toxicants.

D.7.4.1 Routine Nutrient Monitoring

As a placeholder, it is suggested that a total of four structures (EAA inflows and outflows) will be needed. These structures will be monitored weekly for specific conductance, pH, DO, temperature and TP, TN, and with an autosampler for TP as well. A single STA discharge will be monitored for an extensive parameter list and with an autosampler as well. A structure moving water from the reservoir to the STA will be monitored using only grab samples. An STA end structure will also be monitored. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP. Therefore, estimated annual costs for monitoring this component are $261,879 which includes vehicle costs, staff time, and supplies, as well as analytical costs. Capital costs were estimated at $170,625 in CEPP and can be assumed the same for the CEPP PACR. **Table D.2-1** describes the new structures for surface water monitoring of the A-2 Reservoir and A-2 STA.

Table D.2-1. New Structure Surface Water Monitoring for the A-2 Reservoir and A-2 STA

Locations	Sample Type	Frequency	Parameters
4 EAA Exchange Stations	Grab and autosampler	Weekly	Specific Conductance, Temperature, pH, DO, TP, TN, ACF-TP (Autosampler composite flow Total Phosphorus)
1 Reservoir to STA	Grab	Weekly and Quarterly	Specific Conductance, Temperature, pH, DO, TP, TN. Total Dissolved Phosphorus(TDP), OPO4, TN, NOx, NH4, SO4, Cl, Ca, TSS, and quarterly DOC
3 STA Ends	Grab	Weekly	Specific Conductance, Temperature, pH, DO, TP, OPO4, Ca, and quarterly DOC
1 STA Discharge	Grab and autosampler	Weekly, Biweekly, and Quarterly	Specific Conductance, Temperature, pH, DO, TP, ACF-TP, Biweekly TDP, OPO4, TN, NOX, NH4, SO4, CL, CA, TSS, and quarterly DOC

D.7.4.2 Mercury and Other Toxicants Monitoring

To ensure that project construction and operation does not allow contaminants to create a hazard to wildlife, an adaptive monitoring strategy has been adopted for mercury and other toxicants. This monitoring scheme is described in *A Protocol for Monitoring Mercury and Other Toxicants* (hereafter referred to as the *Protocol*). Specific monitoring requirements for this project are described below.

D.7.4.2.1 Mercury

Mercury is a pervasive contaminant in South Florida, being sourced primarily through atmospheric deposition which then accumulates in sediments. Flooding of sediments and the establishment of an aquatic food-web can provide a pathway to mobilize mercury from the sediments into the surface water and biota. To ensure that project construction and operation does not create a hazard to wildlife, a phased/tiered approach for monitoring mercury in sediment, surface water, and fish has been adopted. A summary of the monitoring program for the Project is provided in **Table D.2-2.**

D.7.4.2.2 Other Toxicants

The Phase I and Phase II Environmental Site Assessments identified several toxicants that may be of concern in the footprint of the Project. These include arsenic, atrazine, copper, dieldrin, and selenium. Toxaphene may also be a contaminant of concern if the Woerner Turf Parcel is included in the footprint of the Project. These toxicants will be included in the monitoring program for the Project.

D.7.4.2.3 The Phased/Tiered Approach

Phase 1 – Tier 2: Initial Startup Monitoring Prior to Discharge will include a one-time surface water, sediment, and mosquitofish sampling event for toxicants. If action levels identified in the *Protocol* are not exceeded, the Project may proceed to flow-through operations, at which time Phase 2 – Tier 1: Routine Monitoring During Stabilization Period would commence. Phase 2 – Tier 1 monitoring consists of quarterly surface water and mosquitofish monitoring for a duration of three years for mercury and one year for other toxicants. Large-bodied fish are also monitored annually for the first three years. If action levels identified in the Protocol are not exceeded after the first three years of monitoring, the Project would advance to Phase 3 – Tier 1: Routine Operational Monitoring. Surface water monitoring would be discontinued, the frequency of mosquitofish collection would be reduced to semiannually, and frequency of large-bodied fish collection would be reduced to one collection event every three years. If fishes collected under Phase 3 – Tier 1 have not exceeded action levels by year 9, project-specific monitoring would be discontinued. All three phases of the mercury and other toxicants monitoring are summarized in **Table D.2-2**.

Table D.2-2. Mercury and Other Toxicants Monitoring for the A-2 Reservoir

Phase	Matrix	Locations	Frequency	Parameters
Phase 1 - Tier 2: Initial Startup Monitoring Prior to Discharge	Sediment	5 interior stations	One-time	arsenic, atrazine, copper, dieldrin, selenium, toxaphene, total mercury (THg), methylmercury (MeHg), total organic carbon (TOC), total sulfur (TS), total iron (TFe)
	Surface water	Inflows and outflows	One-time	arsenic, atrazine, copper, dieldrin, selenium, toxaphene, calcium, magnesium
	Mosquitofish	1 Interior composite and 1 Downstream Station	One-time	arsenic, atrazine, copper, dieldrin, selenium, toxaphene, THg
Phase 2-Tier 1: Routine Monitoring During Stabilization Period	Surface Water	Inflows and outflows	Quarterly for One Year	arsenic, atrazine, copper, dieldrin, selenium, toxaphene, calcium, magnesium
			Quarterly for Three Years	THg and MeHg
	Mosquitofish	1 Interior Composite and 1 Downstream Station	Quarterly for One Year	arsenic, atrazine, copper, dieldrin, selenium, toxaphene,
			Quarterly for Three Years	THg
	Large-bodied Fish	1 Interior Composite and 1 Downstream Station	Annually for One Year	arsenic, atrazine, copper, dieldrin, selenium, toxaphene
			Annually for Three Years	THg
Phase 3 – Tier 1: Routine Operational Monitoring	Mosquitofish	1 Interior Composite and 1 Downstream Station	Semiannually for Six Years	THg
	Large-bodied Fish	1 Interior Composite and 1 Downstream Station	Triennially for Six Years	THg

CEPP estimated start-up costs for monitoring for the first year of this component at $44,762, which includes vehicle costs, staff time, capital costs and supplies, as well as $21,362 of analytical costs. Ongoing monitoring of mosquitofish (5 years) was estimated to annually cost $3,678 including $798 of analytical costs. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP.

D.7.5 Northern WCA 3A Spreader Canal West of S-8

A 3-mile-long spreader canal is proposed south of the L-4 canal and west of the S-8 structure. This spreader canal will discharge from the EAA into the WCAs and will be subject to the requirement of a CERPRA permit and the Settlement Agreement. However, all waters being distributed by this canal are sourced either from STA-5/6 or STA-3/4 via G-404 and G-357. S-8 serves as a surrogate monitoring station for water quality at G-404 and G-357. The canal is adjacent to the Rotenberger Wildlife Management Area, but all discharges from this body are directed into the Miami Canal to the east. Consequently, all waters in the proposed distribution canal are already monitored either at the STA-5/6 discharge structures or the S-8 complex and this monitoring should be leveraged to supply needed data on the discharges of the spreader canal. No new monitoring is proposed.

D.7.6 Miami Canal Backfill

Backfilling the northern portion of the Miami Canal will impact marsh hydrology in the vicinity of the canal. The Project water quality monitoring team has reviewed the existing marsh monitoring efforts and determined that it is sufficient in the vicinity of the backfilled canal; therefore, no new monitoring is proposed.

D.7.7 L-67 A / C Features

Three (3) new structures are proposed for the L-67A levee and partial levee degrading is proposed for the L-67C levee. This will require a CERPRA permit monitoring condition, and be subject to the Settlement Agreement. Depending on policy and legal implications, the two new structures west of the Blue Shanty levee may be used to calculated Settlement Agreement compliance for Shark River Slough. No new monitoring is proposed for the cuts in the L-67C canal. **Table D.2-3** shows the locations and sampling scheme for the new structures in the L-67A levee.

The estimated cost of conducting this sampling was $73,649 for CEPP, which includes staff and vehicle time, capital equipment and supplies, as well as $16,553 for analytical costs. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP.

Table D.2-3. Surface Water Monitoring for New Structures in the L-67A Canal

Locations	Sample Type	Frequency	Parameters
S-631, S-632, S-633	Grab Sample	BWRF	Specific Conductance, pH, DO Temperature, TP, OPO4, TN, NO_X, TSS, Ca, Cl
	Grab Sample	Q	Turbidity, SO_4

D.7.8 L-67 Extension Backfill

Filling of the L-67 Extension Canal may impact water quality in the northern ENP marsh as well as impact ponding and sedimentation south of the S-12D structure. The Project water quality monitoring team reviewed the ongoing marsh monitoring network south of Tamiami Trail and determined that the existing station P33 would provide sufficient monitoring in this area, and that the existing monthly frequency and parameter list is adequate.

The team also determined that biennial sediment cores downstream of the S12D structure are necessary to monitor changes in sedimentation and sediment content. In order to provide baseline data, this collection will begin year one, prior to backfilling. **Table D.2-4** contains a list of the planned sediment sampling parameters and frequencies.

The estimated cost of sediment marsh monitoring was $8,811 for CEPP, which includes staff time, helicopter use, and $2,851 for analytical expenses. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP. This monitoring is scheduled to begin at the initiation of the construction of the backfill work so that there is sufficient time to collect baseline sediment samples.

This monitoring is only planned biennially, and, therefore, estimates extended into 5-year time frames only impact the odd number years.

Table D.2-4. New Sediment Monitoring South of the S-12D Structure

Locations	Sample Type	Frequency	Parameters
SRS-S1, SRS-S2, SRS- S3	Sediment Grab Sample	Biennially	TP, SO4, TOC, TN, organic matter, bulk density, and depth

D.7.9 Blue Shanty Flow-way

Construction of the Blue Shanty Flow-way includes construction of a training levee from the L-29 Levee north to the L-67A levee along the existing Blue Shanty Canal right-of-way, construction of a new divide structure (S-333B) in the L-29 levee just west of the western Tamiami Trail Bridge, and the degradation of the L-29 levee between the S-333 and S-333B structures. Existing monitoring at the S-333 structure, combined with new monitoring of the new L67A/C structures, will provide sufficient data on conditions in the Blue Shanty Flow-way and at the S-333B structure; therefore, no new monitoring is proposed.

D.7.10 L-29 Degrade

The L-29 levee will be degraded between the S-333 Structure and the new L-29 Canal divide structure. Monitoring downstream of this area will be done to document impacts to marsh areas. **Table D.2-5** provides a summary of the monitoring at the planned marsh station.

The estimated cost of monitoring at this location was $19,425 per year for CEPP which includes staff time, helicopter use, and $4,593 for analytical expenses. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP.

Table D.2-5. Monitoring for L-29 Degrade

Locations	Sample Type	Frequency	Parameters
L-29 Degrade Marsh Monitoring	Grab Sample	Monthly	Specific Conductance, Color, pH, DO, Temperature, Turbidity, TSS, TP, OPO4, TN, NO_X, NO_2, NH_4, Alkalinity, Ca, Cl, K, Mg, Na, SO_4

D.7.11 L-31N Seepage Cutoff Wall and Operational Changes to G-211

The L-31N Seepage Cutoff Wall will be placed within the levee cross-section and the operations of the G211 structure will be modified. The Project water quality monitoring team determined that these project features will not require new monitoring since any changes to surface water quality will be reflected in the ongoing monitoring at the nearby structure monitoring location S331-173. No new monitoring is proposed.

D.7.12 S-356 Flow Capacity Increase

The plan includes increasing the S-356 capacity from 500 cfs to 1,000 cfs. The Project water quality monitoring team determined that the existing Settlement Agreement monitoring efforts at this structure were sufficient. No new monitoring is proposed.

D.7.13 S-333 Flow Capacity Increase

The plan includes increasing the S-333 capacity from 1,500 cfs to 3,000 cfs. The Project water quality monitoring team determined that the existing Settlement Agreement monitoring efforts at this structure are sufficient. No new monitoring is proposed.

D.8 Project Reporting

Reporting for project monitoring conducted to comply with the Settlement Agreement, Non-ECP permit, or EFA will be accordance with the applicable requirements. Project monitoring that is not tied to those requirements will be reported on in accordance with the applicable CERPRA permit requirement.

D.8.1 Frequency

Monitoring results will be reported no less frequently than annually.

D.8.2 Content and Format

The content and format of the monitoring reports have either been previously established by the applicable permit or settlement. In the case of yet to be issued permits, the content and format will be determined at the time of permit issuance.

D.8.3 Report Recipients and Broader Distribution

The recipients for the monitoring reports include: 1) regulators from the United States Environmental Protection Agency (USEPA) and FDEP; 2) scientists from local, State, and Federal agencies; and 3) non-governmental organization scientists and the general public. Distribution of the reports will be via email and web link.

D.8.4 Revisions and Modifications

[This section is reserved for future changes as they are made and should be referenced throughout the document as revisions occur. Sections should be added chronologically. As revisions are made, a note should be added to the corresponding section of the plan.]

D.9 Administration and Implementation of the Monitoring Plan

Training or Certification: Field and laboratory training requirements are specified in the FDEP Standard Operating Procedures (SOPs) and the District's Field Sampling Quality Manual (FSQM) for the field and in the National Environmental Laboratory Accreditation Program (NELAP) standard and Chemistry Laboratory Quality Manual (CLQM) for the laboratory.

D.9.1 Organization Structure and Responsibilities

Overall project organization and responsibilities are detailed in the SFWMD Water Quality Bureau (WQB) Quality Management Plan (QMP). Field activity responsibilities are detailed in the District's FSQM. Laboratory analysis and data validation responsibilities are detailed in the District's CLQM. These documents define the procedures used by SFWMD personnel to meet the FDEP's Quality Assurance Rule, F.A.C. 62-160. Refer to these documents for details on key personnel and relevant responsibilities.

D.9.2 Staff

D.9.2.1 Monitoring Program Manager (or Project Manager)

The monitoring program manager is responsible for overseeing the monitoring procedures and determining Reporting Leads. This person will make sure all Leads and Managers are following procedure.

Name: To Be Determined (TBD)

Address:

Telephone:

Email address:

D.9.2.2 Monitoring Field Project Manager

The field project manager for this project is *[INSERT: name]*. The field project manager is responsible for maintaining this document and making sure that any changes are well documented and communicated to the field staff and other parties as necessary.

Name: TBD

Address:

Telephone:

Email address:

D.9.2.3 Monitoring Field Lead

Name: TBD

Address:

Telephone:

Email address:

D.9.2.4 Analytical Lead/Contract Manager

Name: TBD

Address:

Telephone:

Email address:

D.9.2.5 Quality Assurance Lead

Name: TBD

Address:

Telephone:

Email address:

D.9.2.6 Reporting Lead

Name: TBD

Address:

Telephone:

Email address:

D.9.3 Program Implementation

This Plan is part of a Federal-State cost shared project. The USACE is likely to be responsible for constructing most of the project features. Monitoring efforts during start-up as well as regular operation will likely be conducted by the SFWMD given its extensive experience conducting on-going environmental monitoring.

D.9.4 Partnerships

The SFWMD may choose to engage local governments or private contractors to conduct the monitoring outlined in this Plan.

D.9.5 Program and Protocol Review

Review Summary (to be completed by RECOVER QAOT)

[List the reviews that the monitoring plan has undergone (i.e. RECOVER, QAOT) and the reviews that are expected in the future (i.e. scope of work (SOW) review by the QAOT and any Standard Operating Procedures (SOPs) that need to be reviewed by the QAOT). Additionally, technical representatives of the respective monitoring units of the Federal and local sponsor should review SOPs and SOWs. Also list if there will be any periodic reviews (annually, biannually, etc), and by whom. Items that might be considered in a periodic review:

- *Are the right parameters or indicators being monitored?*
- *Are the SOPs appropriate, do they need to be modified, or new SOPs developed?*

- *Is the project management structure working effectively or are changes in roles and responsibilities required?*
- *Do the project results demonstrate the verity of conceptual models, restoration hypotheses, and restoration techniques utilized? If not, how will findings be utilized and findings made in monitoring program review?].*

D.10 Cost Estimates

The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP. The costs presented in the sections to follow were developed for CEPP.

D.10.1 Cost Assumptions

Costs for these projects were based on several assumptions. These included the use of the SFWMD Analytical Laboratory and technician annual salaries of $45,000. It was assumed a vehicle costing $42,000 would be needed, as would a multi-parameter Field Instrument for $7,500. Appropriate supplies and consumable were estimated for each project. Analytical costs were increased by 20 percent to account for QC samples.

Monitoring of stations within the ENP was assumed to be carried out through a contract with the NPS and was budgeted accordingly.

It should be noted that detailed costs described here were calculated using the best available information at the time of writing.

As a reminder, the sediment monitoring associated with the L-67 Backfill is only planned biennially, and, therefore, estimates extended into 5-year time frames only impact the odd number years.

D.10.2 Cost

Estimated costs are provided below in **Table D.2-6.**

Table D.2-6. Estimated Project Water Quality Monitoring Cost

Feature	Monitoring Description	Annual Cost	1-Year	5-year	50-year
A-2 Reservoir/A-2 STA					
	All Monitoring	$261,879	$432,504	$1,480,020	$14,800,200
L-67A/C Structures					
	Structure Compliance	$73,503	$73,503	$367,515	$3,675,150
L-29 Degrade					
	Marsh Water Quality	$19,425	$19,425	$97,125	$971,250
L-67 Extension Backfill					
	Marsh Sediment (Biennial)	$8,811	$8,811	$26,433	$264,330
Total, Field Work and Analytical Cost			**$250,813**	**$1,057,395**	**$10,005,582**
Reporting Cost			**$14,400**	**$72,000**	**$720,000**
Total Cost (includes 44% Contingency)			**$265,123**	**$1,129,395**	**$10,725,582**

D.11 Monitoring Control and Documentation

D.11.1 Impetus for Monitoring

Monitoring for this project, both leveraged and new, will fall under a variety of mandates and permits, including the Settlement Agreement, the TP Rule, the non-ECP Permit, and various CERPRA permits. Additional requirements may include the EAA Rule and other similar requirements.

D.11.2 Data Quality Objectives

While it is recognized that data quality objectives (DQOs) are typically developed separately for each specific monitoring project, all mandated monitoring conducted by the SFWMD must meet the objectives conveyed in the FDEP's Quality Assurance Rule, 62-160 F.A.C. The SFWMD has adopted a uniform set of DQOs following criteria detailed within the "Analytical Methods and Default QA/QC Targets" table of the SFWMD's CLQM. For those samples analyzed by the FDEP Laboratory, the SFWMD has adopted the DQOs within the most recent version of the FDEP's Laboratory Chemistry Quality Manual.

Water quality and sediment samples, including field testing and field quality control samples, are collected in accordance with the FDEP Quality Assurance Rule, 62-160 F.A.C. and the current version of the FSQM (SFWMD-FIELD-QM-001). Applicable sections of the FSQM include, but are not limited to, field sample collection procedures, decontamination procedures, field testing, quality control requirements, and documentation requirements.

The DQOs of the field testing parameters for this project are specified in the field testing section of the FSQM. This manual is updated annually, and therefore, the most recent version of the FSQM details the specific field testing data quality objectives for this project at the time of sample collection.

Samples are analyzed according to the provisions within the FDEP Rule 62-160 F.A.C. and the CLQM. This manual is annually updated, and therefore, the most recent version of the CLQM details the specific laboratory analyses' DQOs for this project at the time of sample collection

Data not meeting the quality objectives must be qualified using standard FDEP qualifier codes (F.A.C. 62160) and corrective actions may be taken as outlined in the SFWMD's FSQM and CLQM and Data Validation and Reporting Sections SOPs.

D.11.3 Sampling Methods

Monitoring proposed for this project is primarily required for compliance with existing or future permits or the Settlement Agreement. In addition to demonstrating compliance with water quality criteria, the data collected under this plan is referenced in the CEPP PACR Adaptive Management Plan. Discussion of decision-criteria is found in that plan.

Sampling methods will follow well-defined methodologies that have been approved by Federal and state regulatory agencies. The SFWMD's FSQM shall be used for all water quality and sediment sampling procedures. Once the DQOs are established, the Quality Assurance System Requirements (QASR) should be consulted to identify the analytical methods that will meet the project objectives. Methods specified in the CLQM or their equivalent shall be used when specified.

The laboratory that processes the samples collected in this plan will report data using ADaPT (Automated Data Processing Tool) software. Staged Electronic Data Deliverable (SEDD) (http://www.epa.gov/fem/pdfs/sedd_adr_imp_overview.pdf) or the Automated Data Review (ADR) software may be used in addition to ADaPT.

Each discrete sample will be assigned a unique sample identification number that ensures that it can eventually be retained as a unique database record linked to a specific location. All these activities regarding a sample will be documented in a format that assures that the resulting data are traceable and of known and documentable quality.

D.11.4 Laboratory Qualifications

Laboratories used in this plan will be certified by the Florida Department of Health Environmental Laboratory Certification Program (FDOH ELCP). At the time the laboratory(s) are selected, this plan will be updated to include the laboratory certifications by the test method, analytes/parameters and matrix that are reported for the project. As specified by QASR Chapter 4.0, laboratories used for analysis of CERP environmental samples will be pre-approved and subjected to comparative testing if available, such as the performance evaluations overseen by the Quality Assurance Oversight Team (QAOT). These requirements shall be defined in the laboratory's contract or work order with the contracting agency.

D.11.5 Rationale for Indicator Selection

Field and Laboratory analytes are collected per the requirements of the EFA, Settlement Agreement, and anticipated CERPRA and EFA permits. The focus of the monitoring efforts is on the collection of macronutrients as they are used as indicators of restoration success or project impact.

D.11.6 Sampling Frequency and Duration

Sampling frequencies proposed in this monitoring plan are either directly the result of the requirements of the EFA, Settlement Agreement, or Non-ECP permit, or are anticipated to be required for future EFA or CERPRA permits.

D.11.7 Assessment Process and Decision Criteria (Triggers and Thresholds)

Assessment frequency is annual as established by the requirements of the EFA, Settlement Agreement, or Non-ECP permit. Decision criteria are established by the compliance values from these cited permits and settlements.

D.11.8 Standards and Ethics

Every person performing field sampling must commit to following project-specific requirements, SFWMD's FSQM, field SOPs, QASR requirements, and other instructions as issued, to ensure that samples collected are of known and documented quality and are defensible.

D.11.9 Sample Submission

Requirements for sample handling, custody, and analysis holding times are detailed in the SFWMD's *Chemistry Laboratory Quality Manual and FDEP SOPs (DEP-SOP-001/01).*

D.11.10 Chain of Custody

The Chain of Custody (CoC) must accompany all samples submitted to internal or external laboratories. A CoC form documents the possession of the samples from the time of collection to receipt in the laboratory. A CoC form will be utilized and must be signed by the collector before it is relinquished to the laboratory. Field documentation must conform to the requirements specified in FDEP SOP FD1000 and the field documentation section of the SFWMD FSQM.

D.11.11 Quality Control of Samples

D.11.11.1 Field Quality Control Samples

Field quality control samples will comply with the Field Quality Control section of the FSQM, FDEP requirements (DEP-SOP-001/01), and those developed in the DQO process. All requirements in the FDEP's Quality Assurance Rule should also be followed.

D.11.11.2 Laboratory Quality Control

Laboratories must meet National Environmental Laboratory Accreditation Conference requirements, the requirements detailed in Chapter 4 of the CERP QASR (http://www.evergladesplan.org/pm/program_docs/qasr.aspx), and applicable requirements as detailed in FDEP's Quality Assurance Rule, 62-160 F.A.C. All laboratory and applicable quality control data shall be submitted to the District in the ADaPT compatible format.

D.11.12 Field Record and Data Review

Field record and data review procedures are specified in the SFWMD FSQM and associated SOPs Responsibilities of the Laboratory Data Validation

Data validation shall be performed in accordance with the requirements detailed in Chapter 5 of the CERP QASR. When preparing the ADaPT file the laboratory will review the data for completeness and accuracy.

D.11.13 Data Storage and Archiving

Long-term maintenance and management of digital information are vital to all Project-Level Monitoring Plan (PLMPs). Maintaining and managing digital data, documents, and objects that result from projects and activities is the responsibility of all parties involved. CERP Guidance Memorandum 54 (CGM54) will be followed to help ensure the continued availability of crucial project information and permit a broad range of users to obtain, share, and properly interpret that information. After the data validation process, all data are maintained so that end users can retrieve and review all information relative to a sampling event. Field notes are maintained on an internal server either by scanning actual field note pages or by uploading narratives from field computers path to server. All analytical data and field conditions are sent to the SFWMD database (DBHYDRO) for long-term storage and retrieval. If data are not suitable for DBHYDRO they will be entered into the CERP Integrated Database (CID) on CERPZone through the Morpho interface.

SFWMD or its surrogate shall maintain records of field notes and copies of all records relative to the chain of custody and analytical data. It is the responsibility of the SFWMD or its surrogate to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. Upon completion of the project, the collecting agency shall provide all original field notes to the District's WQB for permanent archival.

Records shall be maintained for the life of the project and 5 years thereafter, in a manner that will protect the physical condition and integrity of the records. Storage shall follow the District's records storage procedure. Access to archived methods shall be through designated records custodian. Corrections of data or records shall follow the established SFWMD SOPs.

D.12 Documentation

Field records shall be documented in accordance with the procedures specified in the SFWMD FSQM.

D.13 Quality Assurance and Quality Control Oversight

D.13.1 Laboratory and Field Audits

Audits will be performed according to the SFWMD FSQM and associated SOPs. Audit reports will be provided to the project manager. The authority of the auditor to stop work for processes that impact the quality of the data will also be defined, along with how and to whom the audit findings are reported and distributed.

D.14 Data Analyses and Records Management

The SFWMD has adopted a uniform set of DQOs following criteria detailed by the table entitled *Field Quality Assurance Objectives* found in the field testing section of the FSQM and within the "Analytical Methods and Default QA/QC Targets" table of the CLQM.

D.14.1 Data Quality Evaluation and Assessment

The data quality assessment (DQA) process uses scientific and statistical data evaluation procedures to determine if the data are of the right type, quantity, and quality to support their intended use. The DQA process is discussed in the QASR Chapter 11 and detailed guidance is described in EPA QA/G9R, *Data Quality Assessment: A Reviewer's Guide* (EPA 2006a) http://www.epa.gov/quality/qs-docs/g9r-final.pdf.

The Science Policy Council has defined general data quality assessment factors (EPA, 2003) (http://www.epa.gov/osa/spc/pdfs/assess2.pdf) that should be considered during the DQA process. These include soundness, applicability and utility, clarity and completeness, uncertainty and variability, and evaluation and review.

Reporting on mercury and pesticides or other toxicants should be done under the supervision of professionals with a record of published research in these areas using approved guidance such as the QASR Manual and CGM 42 Toxic Substances Screening Process - Mercury and Pesticides.

D.15 Adaptive Management Considerations

Please reference the Adaptive Management Plan for the CEPP PACR project, **Annex D Part 1**.

It is the intent that this monitoring plan will be carried out within the context of an adaptive management strategy that will allow for appropriate changes based on new, better understanding of mercury cycling, fate and transport as conveyed in the guidance contained in the *Protocol*.

PART 3. CEPP PACR A-2 Reservoir and A-2 STA Hydrometeorological Monitoring Plan

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HYDROMETEOROLOGICAL MONITORING

D.1 Project Organization

This South Florida Water Management District (SFWMD or District) hydrological monitoring project follows all standard operating procedures (SOPs) for site installation, data collection, data processing and quality assurance/quality control (QA/QC) established by Infrastructure Management Bureau's Supervisory Control and Data Acquisition (SCADA) Instrumentation & Telemetry Section and Hydro Data Management Section.

D.2 Project Description

This hydrological monitoring plan is developed so that all inflows and outflows to and from the A-2 Reservoir and the A-2 STA can be quantified. Flow data is a key piece of information in calculating nutrient loads flowing in and out of the A-2 STA.

The project includes a 10,500-acre above-ground storage reservoir (A-2 Reservoir) and a 6,500-acre STA (A-2 STA). The A-2 Reservoir would be designed to have a normal full storage depth of approximately 22.6 feet of water (240,000 Acre-Feet of storage). Water could be sent to the A-2 STA, A-1 Flow Equalization Basin (FEB), or to the existing STA-3/4. The project includes an inflow-outflow canal for the A-2 Reservoir located along the northern boundary of the project area from the North New River (NNR) to the Miami Canal. The project will provide water storage and treatment capacity south of Lake Okeechobee in the EAA to further reduce damaging discharges to the Northern Estuaries and deliver additional flow to the Greater Everglades. Hydrological data are collected to satisfy the mandated monitoring requirements in accordance with the water quality permit.

This plan details permit mandated monitoring requirements. Modifications to this monitoring plan may be requested in response to any future design changes, and/or changes to project objectives. Monitoring reductions may also be requested to stations and frequencies if monitoring demonstrates that specific parameters are not required or can be estimated by other means. This plan will be reviewed and/or modified as needed to reflect necessary changes.

D.3 Monitoring Location

For this A-2 Reservoir and A-2 STA hydrological monitoring project, all monitoring sites will be located at existing or proposed flow structures, such as pumps, spillways or culverts. Flows approaching the A-2 Reservoir will be conveyed by SW-2 (Miami Canal) and SW-3 (NNR Canal) spillways. The main inflow to the A-2 Reservoir will be coming from the P-1 pump station. A few culverts around the reservoir could be used as inflows or outflows (C-1, C-9, and C-10). SW-1 is the overflow spillway from the reservoir. Inflows to the A-2 STA will be coming from C-3 and C-4 culverts (A-2 Reservoir), while outflows from the A-2 STA are from C-7 and C-8 culverts to a conveyance canal, and through C-2 to the Miami Canal. C-5 and C-6 culverts are the STA internal structures.

Table D-1 provides the station names, a description of the monitoring locations, as well as monitoring parameters for all inflow and outflow structures respectively. The locations of the flow monitoring sites are depicted on the maps in **Figure D-1**. In the event that piezometers in the reservoir dam or groundwater wells around the project footprint are going to be installed, monitoring of these would be addressed as more information becomes available. As such, these are not currently included in this document. Four rain gages are currently being used in the vicinity of the project. They are G373-R, installed at the G373 structure at the southwest corner of the project, EAA5 on the east side of the A-1 FEB, NNRC.SFS at the northeast corner of the A-1 FEB, and EAA2 approximately 6.5 miles north of the A-1 FEB along U.S. Highway 27. No new rain gages are contemplated for this project.

Table D-1. Hydrological Monitoring Sites at the A-2 Reservoir and A-2 STA

Site	Parameter	Latitude	Longitude	Description
C-1	Head Water Stage (HW)	TBD	TBD	C-1 Culvert Headwater
	Tail Water Stage (TW)			C-1 Culvert Tailwater
	Gate Openings (G)			C-1 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-2	Head Water Stage (HW)	TBD	TBD	C-2 Culvert Headwater
	Tail Water Stage (TW)			C-2 Culvert Tailwater
	Calculated Flow (Q)			Culvert Flow calculated from HW & TW
C-3	Head Water Stage (HW)	TBD	TBD	C-3 Culvert Headwater
	Tail Water Stage (TW)			C-3 Culvert Tailwater
	Gate Openings (G)			C-3 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-4	Head Water Stage (HW)	TBD	TBD	C-4 Culvert Headwater
	Tail Water Stage (TW)			C-4 Culvert Tailwater
	Gate Openings (G)			C-4 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-5	Head Water Stage (HW)	TBD	TBD	C-5 Culvert Headwater
	Tail Water Stage (TW)			C-5 Culvert Tailwater
	Gate Openings (G)			C-5 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-6	Head Water Stage (HW)	TBD	TBD	C-6 Culvert Headwater
	Tail Water Stage (TW)			C-6 Culvert Tailwater
	Gate Openings (G)			C-6 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-7	Head Water Stage (HW)	TBD	TBD	C-7 Culvert Headwater
	Tail Water Stage (TW)			C-7 Culvert Tailwater
	Gate Openings (G)			C-7 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations

Table D-2. Hydrological Monitoring Sites at the A-2 Reservoir and A-2 STA (continued)

Site	Parameter	Latitude	Longitude	Description
C-8	Head Water Stage (HW)	TBD	TBD	C-8 Culvert Headwater
	Tail Water Stage (TW)			C-8 Culvert Tailwater
	Gate Openings (G)			C-8 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-9	Head Water Stage (HW)	TBD	TBD	C-9 Culvert Headwater
	Tail Water Stage (TW)			C-9 Culvert Tailwater
	Gate Openings (G)			C-9 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-10	Head Water Stage (HW)	TBD	TBD	C-10 Culvert Headwater
	Tail Water Stage (TW)			C-10 Culvert Tailwater
	Gate Openings (G)			C-10 Gate Openings
	Calculated Flow (Q)			Culvert Flow calculated from HW, TW, & Gate Operations
C-11	Head Water Stage (HW)	TBD	TBD	C-11 Culvert Headwater
	Tail Water Stage (TW)			C-11 Culvert Tailwater
	Calculated Flow (Q)			Culvert Flow calculated from HW & TW
P-1	Head Water Stage (HW)	TBD	TBD	P-1 Pump Headwater
	Tail Water Stage (TW)			P-1 Pump Tailwater
	Pump Operations (P)			P-1 Pump Speed
	Calculated Flow (Q)			Pump Flow calculated from HW, TW, & Pump Operations
SW-1	Head Water Stage (HW)	TBD	TBD	SW-1 Spillway Headwater
	Calculated Flow (Q)			Spillway Flow calculated from HW only (possibly free flow)
SW-2	Head Water Stage (HW)	TBD	TBD	SW-2 Spillway Headwater
	Tail Water Stage (TW)			SW-2 Spillway Tailwater
	Gate Openings (G)			SW-2 Gate Openings
	Calculated Flow (Q)			Spillway Flow calculated from HW, TW, & Gate Operations
SW-3	Head Water Stage (HW)	TBD	TBD	SW-3 Spillway Headwater
	Tail Water Stage (TW)			SW-3 Spillway Tailwater
	Gate Openings (G)			SW-3 Gate Openings
	Calculated Flow (Q)			Spillway Flow calculated from HW, TW, & Gate Operations
SW-4	Head Water Stage (HW)	TBD	TBD	SW-4 Spillway Headwater
	Tail Water Stage (TW)			SW-4 Spillway Tailwater
	Gate Openings (G)			SW-4 Gate Openings
	Calculated Flow (Q)			Spillway Flow calculated from HW, TW, & Gate Operations

Figure D-1. Map of Structures with Proposed Gages

D.4 Data Collection Procedures

Hydrologic data will primarily be collected by electronic instrumentation and transmitted via Remote Terminal Units (RTUs) to an existing control center. In some cases, data can also be collected manually. All raw data whether manually or electronically collected, will be checked for quality assurance (QA) according to standardized SFWMD protocols, and all data meeting QA criteria will be archived in an existing database (DBHYDRO).

D.4.1 Monitoring and Preventive Maintenance

The SCADA Instrumentation & Telemetry Section is responsible for installing, maintaining, and repairing hydrological monitoring instrumentation. Regular preventive maintenance is implemented to maintain monitoring equipment and facilities in satisfactory operating condition. Systematic inspection, detection, validation, verification and correction of incipient failures are conducted to ensure the quality of data collected.

D.4.2 Data Processing and Engineering Support

Hydro Data Management Section is responsible for processing all raw hydrometeorological data collected from field RTUs, conducting flow measurement, rating analysis and flow computation, and implementing quality assurance/quality control and data change.

D.5 Data Quality Objectives

Developing Data Quality Objectives (DQOs) is an integral and important part of a systematic planning process that is designed to ensure that the final results can be used for the purpose for which the data were generated. This systematic planning process for purposes of these discussions on environmental data quality is the quality system that each organization must develop, implement and evaluate on a continuing basis.

The data will be used to measure project performance, water quality-related goals and objectives and to comply with monitoring requirements of an operational permit. The DQOs to be considered include accuracy, precision, sampling frequency, availability, completeness, reporting frequency, and timeliness. These are addressed in CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated 7 December 2010.

D.5.1 Monitoring Data Elements/Indicators/Cost Estimate

Hydrometeorological and hydraulic monitoring will collect, at a minimum, groundwater and/or surface water stages measured at each of the new structures; gate openings at gated structures; and pump revolutions per minute (RPMs) at pump stations (to be used in calculating flows). Specific gages are described in **Table D-2,** which provides summary information on the gages, parameters, sensor types, collection frequency, and pertinent notes to ensure the hydrometeorological monitoring is completed as needed. Data will be recorded at the noted structure locations within the project area, recorded and transmitted based on existing network coverage as possible. The hydrologic and meteorological data collection equipment used for this project would be installed as part of the construction contract or a separate contract with construction funding. Hydrometeorological parameters such as surface and ground water stages require accurate estimates of the water elevation height compared to a known reference. All new surface and ground water monitoring installations will be surveyed to a first order accuracy using the nearest geodetic benchmark. Reference elevations will be reported in both the North American Vertical Datum of 1988 (NAVD 88) and National Geodetic Vertical Datum of 1929 (NGVD 29) datums. Several of the structures are located within close proximity to each other and/or existing gages, and therefore a reduction in the total number of new gages that are needed can be made. The particular gages that may be eliminated due to redundancy are noted in the table. A map of the structures with their proposed gaging requirements is presented in **Figure D-1**. Other gages used in the operations of the system as a whole (such as water levels in the Water Conservation Areas) are not shown on the map.

The U.S. Army Corps of Engineers (USACE) Jacksonville District receives data from various sensors and data collection platforms to monitor surface water flows and levels. Automated timed processes provide provisional near-real-time data required for water management operations. Additional data are also received through an interagency data exchange program among the South Florida Water Management District (SFWMD), the U.S. Geological Survey (USGS), and Everglades National Park (ENP).

Including the addition of a project-wide contingency cost, the cost estimate for one year of hydrometeorological monitoring during Operational Testing and Monitoring Period (OTMP) is $2,490,000, and the monitoring will cost $195,000 annually during OMRR&R. These estimates and contingencies were also reported in the CEPP PIR in Section 6, Table 6-9 and in Annex D. The monitoring costs for the CEPP PACR were assumed to be consistent with CEPP.

Table D-2 lists the necessary gaging parameters to be collected as part of the CEPP PACR, which are in addition to current monitoring stations. The headwater and tailwater stage gages located directly upstream and downstream of the structures, respectively, along with the gate openings, are used in computing flows through structures, as well as assisting in determining the operations. The 15-minute frequency is the USACE required standard for these parameters. SFWMD utilizes breakpoint data frequency for hydrometeorological data. Breakpoint data for a pump are collected when changes to the RPMs are made, up to a frequency of 1 minute. The shaded table rows are for gages that may be unnecessary due to the proximity of other gages; potential alternate gages are listed in the notes.

Table D-2. A-2 Reservoir and A-2 STA Gaging Needs

Gage	Parameter	Sensor Type	Frequency	Notes
C-1 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation; P-1 pump tailwater can possibly be used as HW
C-1 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation; P-1 pump headwater can possibly be used as TW
C-1 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-2 HW	Stage, headwater	SDI encoder	Breakpoint	C-8 TW can possibly be used as HW
C-2 TW	Stage, tailwater	SDI encoder	Breakpoint	G373 HW can possibly be used as TW
C-3 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-3 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-3 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-4 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-4 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-4 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-5 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-5 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-5 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-6 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-6 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-6 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-7 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-7 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-7 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-8 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-8 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-8 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-9 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-9 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-9 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-10 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-10 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-10 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
C-11 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
C-11 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation

Table D-2. A-2 Reservoir and A-2 STA Gaging Needs (continued)

Gage	Parameter	Sensor Type	Frequency	Notes
P-1	Pump RPMs	Inc. in controls	Breakpoint	Located at pump
P-1 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
P-1 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-1 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-2 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-2 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-2 Gate	Gate position Stage, tailwater	Pos. Indicator	Breakpoint	Located on the gate
SW-3 HW	Stage, headwater Gate position	SDI encoder	Breakpoint	Located near structure, platform installation
SW-3 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-3 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate
SW-4 HW	Stage, headwater	SDI encoder	Breakpoint	Located near structure, platform installation; G720HW can possibly be used
SW-4 TW	Stage, tailwater	SDI encoder	Breakpoint	Located near structure, platform installation
SW-4 Gate	Gate position	Pos. Indicator	Breakpoint	Located on the gate

D.5.2 Procedures and Methods

Measurements will be recorded in the manner outlined in CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated 7 December 2010.

To summarize, surface water stages will be measured using an SDI encoder at each monitoring location. The accuracy required is ±0.02 feet for critical sites and ±0.03 feet for non-critical site. The reported resolution will be 0.01 feet and the instrument range will be 0-20 feet. The precision will be ±0.01 feet. The sampling frequency will be breakpoint data at no more than 15 minutes, at 0, 15, 30, and 45 minutes past each hour (e.g., at 1500 hrs, 1515 hrs, 1530 hrs, etc.).

Groundwater stages will be measured using an SDI encoder at each monitoring location. The accuracy required is ±0.03 feet. The reported resolution will be 0.01 feet and the instrument range will be 0-30 feet. The precision will be ±0.01 feet. The sampling frequency will be breakpoint data at no more than 15 minutes.

Rainfall will be measured with an accuracy of ±0.01 inches. The reported resolution will be 0.01 inches and the precision will be ±0.01 inches. The sampling frequency will be 15 minutes.

Gate positions will be measured using gate position indicators with an accuracy of ±0.05 feet, a reported resolution of 0.01 feet, and a gate position range of either 0-75 inches or 0-550 inches. The precision required is ±0.02% full stroke. The reporting frequency will be breakpoint data at no more than 15 minutes.

Pump RPMs will be measured with an accuracy of ±25 RPM and a reported resolution of 1 RPM. The pump RPM range will be 0-3,000 RPMs. The reporting frequency will be 1-360 samples per hour with breakpoint data including pump on/off/change in state information.

Computed flows will have an accuracy uncertainty limit of 95% C.I. The accuracy will be ±10% for inland spillways, ±15% for culverts, and ±10% for pumps. The velocity instrumentation will have a precision of ±0.01 feet/second. The reporting frequency will be breakpoint data at no more than 15 minutes.

The hydrologic and meteorological data collection instruments utilized for this project will be installed as part of the construction contract or under separate contract. Water stage measuring devices will be affixed to a platform in a manner to discourage vandalism and natural or unnatural intrusions (inclement weather, animals, etc.). Water surface elevation measuring devices will use SDI encoders for measuring values. Gate positions will be measured using gate position indicators. Flow calculation equations that are used to compute flow on site with certain instrument types, such as a programmable data logger, will be developed under the supervision of the sponsoring agencies hydrology and hydraulics monitoring units during the execution of this monitoring plan. Stream gauging measurements may be made to calibrate the flow equations if needed.

D.6 Data and Records Management

Hydrological data collected from this project will be stored in the District's database DBHYDRO and are accessible through the District's website (http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_menu). The District has established structures, policies, and procedures that manage data through a full life cycle to ensure the highest quality data products. Data and records management generally encompasses collection requirements, storing, quality assurance (processing and post-processing), and change requests. The data management program at the District encompasses all the steps required for accurate data to be loaded into DBHYRDO.

D.7 Rationale for Indicator Selection

The indicators selected for inclusion are required under CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated 7 December 2010. The headwater and tailwater values are used, along with gate openings or pump RPMs, to determine the flow of water through the structure.

D.8 Sampling Frequency and Duration

The sampling frequency and duration is governed by CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated 7 December 2010.

Surface water stages recording frequency will be breakpoint data at no more than 15 minutes intervals, at 0, 15, 30, and 45 minutes past each hour (e.g., at 1500 hrs, 1515 hrs, 1530 hrs, etc.).

Groundwater stages recording frequency will be breakpoint data at no more than 15 minutes.

Rainfall recording frequency will be 15 minutes.

Gate positions recording frequency will be breakpoint data at no more than 15 minutes.

Pump RPMs recording frequency will be by break point, with a minimum of one (1) recording per hour up to 360 recordings per hour.

Computed flows computing frequency will be breakpoint data at no more than 15 minutes.

D.9 Assessment Process and Decision Criteria (triggers and thresholds)

Trigger elevations for surface water will take into consideration the design headwater and tailwater at the gages' respective structures to ensure that design limits are not reached. In addition, the decision criteria will be further refined as the operations of the TSP are developed.

D.9.1 Data Collection

D.9.1.1 Sample/Data Collection Standards and Ethics

No samples will be collected for hydrometeorological monitoring. Data will be collected following the required standards as described in this document.

D.9.1.2 Sample Submission

No samples will be collected for hydrometeorological monitoring.

D.9.1.3 Chain of Custody

No samples will be collected for hydrometeorological monitoring.

D.9.1.4 Quality Control Samples

No samples will be collected for hydrometeorological monitoring.

D.9.1.5 Data Validation

The USACE data validation process is subject to ER 1110-2-8155, *Hydrometeorological Data Management and Archiving*, dated 31 July 1996 and ER 1110-2-249, *Management of Water Control Data Systems*, dated 31 August 1994. The USACE data validation methods may be accomplished by automated or manual means. This process may include estimating values for missing or erroneous data.

The SFWMD procedures are described in their 2008 South Florida Environmental Report, Appendix 2-1: Hydrological Monitoring Network of the SFWMD. The following paragraph is from a relevant section of that document.

> "Several standard operating procedures (SOPs) were developed for data processing by the District...Many of these procedures and processes are automated. The Data Collection/Validation Preprocessing System (DCVP) database provides for the storage and extraction of preliminary time-series data for further inspection. Once data is extracted from DCVP, it is subjected to an initial QA/QC check in order to ascertain or improve data quality. This is accomplished through the use of the Graphical Verification Analysis (GVA) Program, a software tool which provides analysts with a graphical user interface in which to plot, edit, and apply quality tags and comments to data. The GVA application is used for the validation of the data. Once data has undergone analysis in GVA, it is uploaded into the DBHYDRO database, finalizing the preprocessing stage..."

D.9.1.6 Raw Data

Data collected by the SFWMD will be kept as raw archive files. The adjusted (QA/QC'd) data will be stored as processed archive files. Data collected by the Corps is maintained in Oracle databases and further computations are applied to generate addition databases of computed data.

D.9.1.7 Data Processing

The USACE data validation process is subject to ER 1110-2-8155, *Hydrometeorological Data Management and Archiving*, dated 31 July 1996 and ER 1110-2-249, *Management of Water Control Data Systems*, dated 31 August 1994.

The SFWMD procedures are described in their 2008 South Florida Environmental Report, Appendix 2-1: Hydrological Monitoring Network of the South Florida Water Management District.

Data processing should be approached with the same high accuracy standards for all sites/stations regardless of mandate or permit conditions. Flow and meteorological data must be summarized or derived through review, analysis, and interpretation before they can be placed in any meaningful context, then published. Data processing involves multiple steps: (1) data retrieval, (2) data review, (3) data verification and validation, (4) data analysis of raw time-series data to ensure data quality in support of environmental monitoring and assessment activities, (5) interpretation of analysis, and (6) archival.

D.9.1.8 Data Storage and Archiving

Data collected or obtained by the USACE will be stored and archived in accordance with ER 1110-2-8155, *Hydrometeorological Data Management and Archiving*, dated 31 July 1996. The USACE maintains Oracle databases where all collected and computed Water Management data is stored/archived.

For the SFWMD, after the data validation process (generally within two weeks), all data are archived in a SFWMD database (DBHYDRO) and maintained so that end users can retrieve and review all information relative to a sampling event. If data are not suitable for DBHydro, they will be entered into the CERP Integrated Database (CID) on CERPZone through the Morpho interface. Field notes are maintained on an internal server either by scanning actual field note pages as PDFs (Portable Document Format) or by uploading narratives from field computers as CSVs (Comma Separated Values). All analytical data and field conditions are sent to a database designated by the sponsors for long-term storage and retrieval. The sampling agency or contractor maintains records of field notes and copies of all records relative to the chain of custody and analytical data. It is the responsibility of each agency or contractor to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. For any contracted work, original documents are to be provided to the SFWMD by the project completion date.

D.10 Documentation

For all documents, the following standards should apply:

- Print text, do not use cursive handwriting.
- Dates should be recorded as MM/DD/YYYY.
- Time should be recorded in 24-hour format using local time.
- Logs and notes should be recorded on site and at the time of collection.

- Entries are to be made in waterproof ink.
- Samplers should be properly trained.

D.10.1 Field Notes

No field samples will be collected for hydrometeorological monitoring. Relevant field observations will be noted in a bound waterproof notebook that is project specific. The following information will be entered into the field notes: project name, frequency, trip type, date, collectors, responsibilities, weather, preservation/acids, labs submitted to, sample ID, site ID, time collected, and sample type. Additional comments on observations, equipment cleaning, maintenance, and calibration will also be recorded.

D.10.2 Field Instrument Calibration Documentation

Records of field instrument calibration will be kept and SFWMD or USACE SOPs for calibration will be followed.

D.10.3 Corrections

Corrections to header sheets, field notes, or calibration sheets will only be made by staff who participated in the production of the document. Changes will be made by striking through the error, writing the correction, initialing and dating the change. On occasion, a detailed explanation of the error may be required.

D.11 Quality Assurance and Quality Control

D.11.1 System for Assessing Data Quality Attributes

The standards as set forth under the USACE's and the SFWMD's respective requirements will be adhered to and followed. These are described and/or referenced under Section D.8 of this document.

D.11.2 Data Quality Qualifiers

The data quality standards are outlined in **Section D.7** of this document.

D.11.3 Field Audits

The data quality standards for hydrometeorological data are determined under the Corps and SFWMD's respective guidances and will be followed.

D.12 Data Analyses and Records Management

The USACE process is subject to ER 1110-2-8155, Hydrometeorological Data Management and Archiving, dated 31 July 1996 and ER 1110-2-249, Management of Water Control Data Systems, dated 31 August 1994.

The SFWMD procedures are described in their 2008 South Florida Environmental Report, Appendix 2-1: Hydrological Monitoring Network of the South Florida Water Management District.

Please refer to **Section D.8** of this document for further information.

D.12.1 Data Quality Evaluation and Assessment

The data quality standards for hydrometeorological data are determined under the USACE's and SFWMD's respective guidances and will be followed.

D.13 Adaptive Management Considerations

Where possible, CEPP hydrometeorological data will support adaptive management by contributing data needed to address CEPP uncertainties and future project adjustments. The adaptive management strategies that will leverage hydrometeorological data include but are not limited to optimizing water deliveries from FEB-2 (AM uncertainty ID#4), flows to improve soil conditions and restore ridge and slough areas south of the hydropattern restoration feature and in the Blue Shanty flowway (AM uncertainty ID#5, 6, 73), incremental restoration in WCA 3B (AM uncertainty ID#76, 77), and deliveries south to Everglades National Park and the Lower East Coast (AM uncertainty ID#32, 35,61, 62, and 63).

PART 4. CEPP PACR Ecological Monitoring Plan

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INTRODUCTION TO THE CEPP PACR ECOLOGICAL MONITORING PLAN

The Greater Everglades ecosystem has been significantly altered by human activities. Historically, freshwater flowed in a north-south direction from the headwaters of Lake Okeechobee to Florida Bay. This pattern has been altered by regional drainage of freshwater flow patterns and volumes that has resulted in the loss of ridge-slough pattern in the freshwater wetlands and an inland migration of saline conditions in both the groundwater and surface waters such that the expansion of moderate to high salinity zones have diminished the spatial extent of freshwater wetland habitats, and have allowed the landward expansion of saltwater and mangrove wetlands. Prior to the hydrologic changes described above, freshwater and mangrove marshes provide important habitat for wetland species and are indicators of healthy Everglades and coastal wetlands. Among other things, the hydrologic change to the system has caused a significant degradation of both the freshwater and the estuarine environments that has resulted in the loss of or reduction in populations of important native species that once were abundant in the area, including abundant fisheries, Spoonbills, Wood Storks, and Alligators among other wildlife. Efforts of Central Everglades Planning Project Post Authorization Change Report (CEPP PACR) focus on re-directing flow to re-establish more natural overland flow regimes that will provide appropriate hydropatterns and salinity regimes to re-establish and maintain key habitats within the Everglades, including the Northern Estuaries, Everglades Agricultural Area (EAA), Water Conservation Area 3A, Everglades National Park, and Florida Bay.

The CEPP PACR Ecological Monitoring Plan (CEPP PACR-EMP) mirrors much of the CEPP EMP where impacts to certain regions overlap such as the Northern Estuaries and WCA 3A. This is due to the fact that the hydrology and ecology that would be impacted by the implementation of these two projects are very similar in these regions. Some temporal or spatial components of the monitoring may need to be adjusted as project construction and operation progresses. The primary objective of the CEPP PACR-EMP is to identify the monitoring necessary to inform decision-makers, partner agencies, and the public on achieving restoration success. In other words, to specify what monitoring is necessary to measure and detect the benefits of restoring patterns of freshwater flow, velocity, and water quality in the Central Everglades, Northern Estuaries, and Southern Coastal Systems, per the CEPP PACR project objectives. This monitoring will be leveraged as much as possible to contribute to CEPP PACR adaptive management (**Annex D, Part 1**). The CEPP PACR EMP and CEPP PACR Adaptive Management Plan have been designed to inform each other as much as possible and it is encouraged that any future refinements of the Plans include continual improvements of the streamlining.

The CEPP PACR-EMP will monitor ecosystem responses to changes in hydroperiod depth, duration, and velocity within the Northern WCA-3A that are expected to provide ecological conditions suitable for expanded and intensified wildlife utilization through improvements in wetland habitat functional quality, and improvements in native plant and animal species diversity and abundance. Due to the uncertainties associated with any effort to restore the Northern WCA-3A, the performance targets and the measures of success can only be broadly stated. Nevertheless, these targets and measures need definition to design a monitoring program that is focused and efficient, thereby ensuring that it will provide the kind of information necessary to measure restoration success. The CEPP PACR-EMP will be updated, at the latest, during pre-construction engineering and design to reflect more specific targets and measures of restoration success.

The CEPP PACR-EMP will be closely coordinated with the CERP Restoration Coordination and Verification (RECOVER) Monitoring and Assessment Plan (MAP) to ensure that measures and targets selected by the project teams are consistent with system-wide measures and to avoid duplication of efforts. Furthermore, the CEPP PACR-EMP will ensure temporal and spatial coverage of monitoring parameters that are appropriate to detect changes at the project level. The EMP will fill gaps in the MAP monitoring parameters to address CEPP PACR-specific needs by adding additional project-level parameters not included in the MAP.

The Everglades are periodically inundated or dried out, an environmental characteristic that provides a challenging environment for the plant and aquatic animal communities. Furthermore, measuring restoration and monitoring success are particularly challenging because the Everglades is inherently dynamic in space and time. Monitoring targets provided in this EMP are limited to the scope and scale of CEPP PACR, i.e., they are not full restoration targets for the Everglades restoration program but instead they are attributes that relate directly to the restoration of Northern WCA-3A where the CEPP PACR would provide direct and relatively significant impacts.

D.1 Structure of the CEPP PACR Ecological Monitoring Plan

For each CEPP PACR project objective, monitoring has been identified to measure progress toward success of meeting the objective. **Table D.4-1** summarizes the (1) monitoring attributes, (2) monitoring methodology and frequency, (3) monitoring cost estimates, (4) CEPP-PACR monitoring locations, (5) current MAP monitoring component, (6) current monitoring by other agencies/universities, and (7) performance measures and ecological indicators. The EMP's main goal is to detect the expected improvements from CEPP-PACR features and operations.

The Greater Everglades portion of the CEPP PACR-EMP focuses on one main geographic region: the northern WCA-3A hydropattern restoration feature. The ecological monitoring will include environmental parameters associated with hydrology (flow, stage and hydroperiod), soil parameters associated with soil accretion and subsidence, wetland plant community, and wildlife.

D.2 Objective 1

Restore seasonal hydroperiods and freshwater distribution to support a natural mosaic of wetland and upland habitat in the Everglades System (Table D.4-1A)

Spatial patterning and topographic relief of the ridge-slough-tree island landscape are directly related water flow, including the timing, velocity, hydroperiod, and distribution of sheet flow; therefore, the spatial patterning has been lost in most of the Greater Everglades with drainage and compartmentalization. At the landscape level, the loss of elongated patterns of ridges, sloughs, and tree islands in the direction of the flow is attributed to disrupted sheet flow and changes in water depth. Monitoring for this objective will test the hypothesis that resumption of sheet flow and water depth patterns will reverse the degradation of the ridge-slough-tree island landscape. Similarly, quantification of subsidence, accretion, and sediment transport are required to understand the role that flow direction, velocity, and water depth play in restoring and maintaining the ridge-slough-tree island landscape. Thus, for this objective, two attributes will be monitored: a) soil elevation and accretion along the ridge-slough-tree islands landscape and b) vegetation change along hydrologic gradients. Related hydrologic data will be leveraged from existing monitoring networks and the CEPP PACR Hydrometeorological Monitoring Plan (**Annex D, Part 3**). The monitoring methodology includes the establishment of permanent transects and plots within 2 x 5 kilometer cells denominated GRTS (Generalized Random-Tesselation Stratified). The placement of transects and plots, and specific measurement methodology, will be coordinated with existing GRTS locations in the Everglades that are part of the RECOVER MAP to avoid redundancy and leverage the existing program. This approach provides spatial balance to make better inferences about gradient changes at the landscape level and assumes the existing GRTS monitoring will continue for at least the time needed for CERP PACR. The detailed field methodology to accomplish this objective will be described in more detail once CEPP PACR is authorized.

D.3 Objective 2

Improve sheet flow patterns and surface water depths and durations in the Everglades system to reduce soil subsidence, frequency of damaging fires, and decline of tree islands and decrease salt water intrusion (Table D.4-1B)

This objective has two main components: one is associated with the effect of muck fire events on soil oxidation and subsidence, and the other component is linked to the change in freshwater delivery to coastal areas that has disrupted salinity patterns throughout Florida Bay leading to an overall increase in salt water intrusion along the coastal wetlands that has promoted the encroachment of mangrove plant community into the freshwater wetlands. Monitoring for this objective will test the hypothesis that both organic soil loss and accumulation are in equilibrium as a function of sheet flow and water depth patterns. Similarly, it is expected that improvement of water sheet flow will help to decrease the rate of mangrove expansion into the freshwater wetlands. To accomplish this objective, several attributes will be monitored including soil accretion and soil elevation in mangrove communities, porewater and soil salinity. The monitoring methodology includes the use of Sediment Elevation Tables (SETs) to measure soil accretion and subsidence, establishing transects to measure soil salinity, porewater and soil resistivity. The placement of SETs, and specific measurement methodology, will be coordinated with existing SETs locations in the Everglades that have been part of the RECOVER MAP to avoid redundancy and leverage existing data for comparison. To estimate spatial changes in the ridge-slough-tree island landscape and mangrove migration into the freshwater wetlands, vegetation mapping will be conducted, also in coordination with existing programs for efficiency. The detailed field methodology to accomplish this objective will be described in more detail once CEPP PACR is authorized.

D.4 Objective 3

Reduce high volume discharges from Lake Okeechobee to improve the quality of oyster and SAV habitat in the Northern Estuaries (NE) (Table D.4-1C)

Using CEPP PACR planning model output, areas have been identified within the northern estuaries where the most change is expected due to CEPP PACR. In these areas salinity conditions will improve the habitat for oysters and SAV, which will be the attributes to measure for project success in meeting Objective 3. In addition, these areas present a clear opportunity for adaptive management because the monitoring data will readily inform potential project adjustments. Therefore, monitoring for Objective 3 is an example of overlapping monitoring needs for the CEPP-PACR-EMP and for the CEPP Adaptive Management Plan; this monitoring will also be closely coordinated with and will leverage the RECOVER MAP which monitors these two indicators in the Northern Estuaries. In the Adaptive Management Plan, more detail is provided about the potential management actions that could be taken in response to the data. See the Adaptive Management Plan section (**Annex D, Part 1**) on the Northern Estuaries.

D.5 Objective 4

Reduce water loss out of the natural system to promote appropriate dry season recession rates for wildlife utilization (Table D.4-1D)

Nesting wading birds are an iconic symbol of Everglades health and restoration, and there is relatively extensive knowledge about their habitat needs in the Everglades due to efforts of RECOVER, ENP, and other organizations. Successful nesting of wading birds requires habitat conditions, including wet season prey production and dry season prey availability, which depend on hydroperiods and well-timed water level recession rates. Over the past years, a decrease in wading birds has been observed; this decrease of wading bird nesting colonies in the Greater Everglades including the ENP is attributed to declines in wet season prey production and dry season prey availability. Monitoring for this objective will test the hypothesis that restoration of multi-year hydroperiods in historically appropriate places in the Everglades will result in increased density of aquatic fauna and large fish. Attributes associated with this objective include monitoring aquatic prey populations during the wet season and dry season, and monitoring wading bird nesting success. Hydrologic data that indicate recession rates will be pulled from existing monitoring networks. Field methodology includes throw traps along designed transects established within GRTS cells. Since RECOVER is already monitoring these attributes in the Greater Everglades, their monitoring will be leveraged and the CEPP PACR-EMP will only establish a monitor network in the coastal wetlands. The ability to leverage existing monitoring programs for efficiency assumes the existing monitoring will continue for at least the time needed for the CERP PACR. More detailed field methodology will be described once the project is authorized.

D.6 Objective 5

Restore more natural water level responses to rainfall to promote plant and animal diversity and habitat function (Table D.4-1E)

Florida's two native species of crocodilians, the American alligator and the American crocodile, are important indicators of the health of the Everglades ecosystem because they are linked to two key aspects of the ecology of the Everglades: 1) crocodilians are directly dependent on prey density, especially aquatic and semi-aquatic organisms, and thus they provide a surrogate for status of many other species; and 2) alligators create "alligator holes" across the landscape that have proven to be a keystone feature of Everglades habitat due to the topographic relief that they provide. The alligator holes provide drier and wetter conditions for plants and animals that otherwise would not be able to survive. Monitoring for this objective will test the hypothesis that more natural hydrological patterns with dry downs no more frequent than once every 3-5 years will improve both alligator body condition and relative density of alligators. As part of this objective, several biological attributes will be monitored including alligator and crocodiles density in the landscape, and their body condition. This monitoring complements the bird nesting success monitoring to increase the ability to draw conclusions from both programs. Field methodology includes aerial transects as well as ground surveys that will be coordinated with past and existing crocodilian monitoring efforts for efficiency and comparisons. The detailed field methodology to accomplish this objective will be based on the past and existing methodologies, and will be described in more detail once the CEPP PACR is authorized.

Table D.4-1 (A, B, C, D, E). Table identifies CEPP objectives that are relevant to this CEPP PACR, associated monitoring needs related to achieving project success, monitoring methodology, number of sampling transects and frequency, monitoring location, current monitoring available from other agencies and RECOVER.

A

CEPP-PACR Objective	CEPP-PACR Monitoring attribute s	Monitoring Methodology	Number of Transects/ Plots per GRTs	Monitoring Frequency	Specific CEPP-PACR Monitoring Locations	Current Monitoring (OTHER)	Current Monitoring (RECOVER/CERP)	Performance Measures / Ecological Indicators	Monitoring Targets
Restore seasonal hydroperiods and freshwater distribution to support a natural mosaic of wetland and upland habitat in the Everglades System	Natural Mosaic of Wetlands: Ridge-Slough- Tree Islands Soil Elevation Pattern	Establish Permanent Transects to Measure Wetland Soil Elevation Pattern	Establish 2 GRTS panel in NE-WCA3A,	Each Transect Every Year	NE-WCA3A	Daily, seasonal, annual hydroperiods (EDEN, SFWMD, ENP). Water Distribution (EDEN, SFWMD, ENP). Wetland Vegetation Mapping (RECOVER/MAP)	Landscape Pattern Ridge-Slough-Tree Island in GE	Slough vegetation performance measure, related to tree island viability and restoration	Bi-Modal Ridge and Slough Patterning
		Comprehensive soil elevation survey: 30 new benchmarks	Synoptic Survey	First three years	NW-WCA3A, NE-WCA3A,Central WCA-3A,WCA-3B, NE-SRS and ENP				
	Vegetation change along hydrologic gradients	Establish three GRTS panels	Three Transects per GRTS panel	Each Transect Every Year	NE-SRS, ENP	Daily, seasonal, annual hydroperiods (EDEN, SFWMD, ENP). Water Distribution (EDEN, SFWMD, ENP). Wetland Vegetation Mapping (RECOVER/MAP)			

B

CEPP PACR Objective	CEPP-PACR Monitoring attribute s	Monitoring Methodology	Number of Transects/Plot s per GRTs	Monitoring Frequency	Specific CEPP PACR Monitoring Locations	Current Monitoring (OTHER)	Current Monitoring (RECOVER/CERP)	Performance Measures / Ecological Indicators	Monitoring Targets
Improve sheet flow patterns and surface water depths and durations in the Everglades System in order to reduce soil subsidence, frequency of damaging fires, and decline of tree islands and decrease of salt intrusion (relates to uncertainties 64)	Soil Elevation and Accretion Rates on Tree Islands	Sediment Elevation Tables (SET's)	Three Plots within Ten Tree Island	Annual	N W-WCA3A, NE-WCA3A,	Soil Elevation and Accretion in Four Tree Islands	No Ongoing Monitoring	Soil accretion	2-4 mm yr^{-1} Accretion rates
	Ridge-Slough-Tree Island Landscape Pattern	Hot Spot Vegetation Mapping	N/A	Every 3 Years	N W-WCA3A, NE WCA3A	a) Daily, seasonal, annual hydroperiods (EDEN. SFWMD, ENP). b) Water Distribution (EDEN, SFWMD, ENP). c) Wetland Vegetation Mapping (RECOVER/MAP)	Veg. Mapping	Ridge & Slough Landscape Pattern Target (MAP)	Tree Island Increase Areal extend
	Forest Structure and species composition	4 Permanent Plots and 3 Transects per site	Ten Tree islands	Same Tree Islands and plots Every 5 Years	N W-WCA3A, NE-WCA3A,Central WCA- 3A		Tree Island Condition	Forest structure and plant diversity	Tree Island Increase Areal Extend

C

CEPP PACR Objective	CEPP PACR Monitoring attribute s	Monitoring Methodology	Number of Transects / Sampling Points	Monitoring Frequency	Estimated Annual Cost	Specific CEPP PACR Monitoring Locations	Current Monitoring (OTHER)	Current Monitoring (RECOVER/CERP)	Current Monitoring Annual Cos t (RECOVER /CERP)	Performance Measures / Ecological Indicators	Monitoring Targets
Reduce high volume discharges from Lake Okeechobee to improve the quality of oyster and SAV habitat in the Northern Estuaries	Oyster; recruitment, growth, condition index, predation and disease. Also live/dead counts 4x/yr.	Various metrics	3 Stations per estuary	Monthly and quarterly	300,000	Caloosahatchee River Estuary, St. Lucie Estuary		West and East Coast Oysters	250,000	SAV and Oyster Indicators	No specific target yet
	SAV, shoot count, density, and canopy cover and height	1 m² Quadrants	30 points per site	bi-monthly	375,000	Caloosahatchee River SLE and SIRL		East and West Coast SAV monitoring			
	SAV, *Vallisneria*, and oysters beds mapping	Mapping		Every 5 Years	450,000	Caloosahatchee River Estuary, St. Lucie Estuary,		Once every 5 years			

D

CEPP PACR Objective	CEPP PACR Monitoring attribute s	Monitoring Methodology	Number of Transects / Sampling Points	Monitoring Frequency	Specific CEPP PACR Monitoring Locations	Current Monitoring (OTHER)	Current Monitoring (RECOVER/CERP)	Performance Measures / Ecological Indicators	Monitoring Targets
Reduce water loss out of the natural system to promote appropriate dry season recession rates for wildlife utilization	Dry Season Prey Availability	1-m² Throw traps		Dry season	NW-WCA3A, NE- WCA3A,Blue-Shanty Flow-way, WCA-3B, SRS, ENP	a) Daily, seasonal, annual hydroperiods (EDEN. SFWMD, ENP). b) Water Distribution (EDEN, SFWMD, ENP). c) Wetland Vegetation Mapping (RECOVER/MAP)	Dry Season aquatic Fauna	Fish and Macroinvertebrate Indicator	Droughts events at higher than 3-8 years intervals
	Wet Season Prey Production	1-m² Throw traps		Wet season	NW-WCA3A, NE-WCA3A,Blue-Shanty Flow-way, WCA-3B, SRS, ENP		Wet Season Trophic Sampling		

E

CEPP PACR Objective	CEPP PACR Monitoring attribute s	Monitoring Methodology	Number of Transects / Sampling Points	Monitoring Frequency	Specific CEPP PACR Monitoring Locations	Current Monitoring (OTHER)	Current Monitoring (RECOVER/CERP)	Performance Measures / Ecological Indicators	Monitoring Targets
Restore more natural water level responses to rainfall to promote plant and animal diversity and habitat function	Alligator-Crocodiles Density	Spotlight and capture surveys		Dry and Wet seasons	SRS, ENP	a) Daily, seasonal, annual hydroperiods (EDEN. SFWMD, ENP). b) Water Distribution (EDEN, SFWMD, ENP). c) Wetland Vegetation Mapping (RECOVER/MAP) d) Crocodiles and wading bird monitoring in ENP (timing/location/success/# for bird spp) e) Monitoring Alligator nest in ENP	No Ongoing RECOVER Monitoring	Crocodilian Stoplight Indicator	Count Density >1.7 Body Condition 2.11-2.27
	Adult Alligator-Crocodiles body condition	Capture surveys		Dry season			No Ongoing RECOVER Monitoring		
	N umber of nesting birds and species	aerial and ground surveys.		Monthly during the Breeding Season	NW-WCA3A, N E- WCA3A,Blue-Shanty Flow-way, WCA-3B, SRS, ENP		Wading Birds (UF-USGS-FAU-Audubon). Monitoring includes LO, WCA's, ENP, BB, Florida Bay	Wading Bird Stoplight Indicator	4,000 of nesting bird pairs of Great Egrets; 3,000 pairs of Wood Stork; 10,000 pairs of white ibis
	Timing of Bird Nesting	aerial transects and ground surveys.		Monthly during the Breeding Season					
	Location and Distribution of Bird nesting sites	aerial transects and ground surveys.		Monthly during the Breeding Season					
	Bird Nesting Success	aerial transects and ground surveys.		Monthly during the Breeding Season					

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