COMPREHENSIVE EVERGLADES RESTORATION PLAN

LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT

REVISED DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

July 2019

Annex E

ANNEX E
REPORTS PROVIDED BY RECOVER TO SUPPORT THE LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT REVISED DRAFT PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATMENT

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EXECUTIVE SUMMARY

Annex E contains documentation of four reviews performed by the interagency REstoration COordination and VERification team (RECOVER) system-wide science team, per CERP Programmatic Regulations guidance:

- RECOVER System-Wide Evaluation: Lake Okeechobee Watershed Restoration Project (LOWRP)
- RECOVER Consistency Review: Lake Okeechobee Watershed Restoration Project (LOWRP) Project Goals and Objectives and Performance Measures
- RECOVER Consistency Review: Lake Okeechobee Watershed Restoration Project (LOWRP) Adaptive Management Plan
- RECOVER Review of the Lake Okeechobee Watershed Restoration Project (LOWRP) Draft Project Operating Manual (DPOM)

RECOVER SYSTEM-WIDE EVALUATION: LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT (LOWRP)

The RECOVER system-wide evaluation of the Lake Okeechobee Watershed Restoration Project (LOWRP) performance provides the evaluation required for all of the Comprehensive Everglades Restoration Plan (CERP) projects under the 2003 programmatic regulations. This report is a broad-scale evaluation of ecological effects of the LOWRP alternatives on Lake Okeechobee, Lake Okeechobee Watershed, the Northern Estuaries (St. Lucie Estuary and Caloosahatchee Estuary), and Lake Okeechobee Service Area (LOSA). The scope of the review covers all areas expected to be improved by LOWRP including areas outside of the LOWRP project boundary which fall within the overall CERP program area. The review includes the use of a broad range of evaluation tools, performance measures, and best professional judgment that reach beyond the tools and expertise of the traditional USACE planning process. The tools and professional backgrounds of the reviewers represent decades of experience studying and modeling the ecology of south Florida. The purpose of the review is three-fold: (1) to provide insight into whether some alternatives performed better ecologically than others; (2) to indicate whether alternatives may lead to unintended ecological conditions; and (3) to investigate the effects of LOWRP alternatives that could potentially conflict with the goals of CERP on a regional scale. The following key findings are provided:

System-wide Performance: All areas affected by the LOWRP can be improved by the proposed alternatives. These include the Northern Estuaries), Lake Okeechobee, Lake Okeechobee Watershed, and the Lake Okeechobee Service Area. However, model results reveal little difference in the performance of the project alternatives. When considering the performance of the alternatives across all affected areas, Alternative 2Cr performs the best from an ecological and hydrological standpoint. However, these slight differences in performance are most likely ecologically insignificant.

Adaptive Management: LOWRP project features formulated to achieve incremental system-wide restoration benefits in the near term may not function as well as those with full CERP implementation as envisioned in the 2000 Yellow Book Plan. Adapting project features or adding additional restoration projects in the future, in order to achieve the full set of restoration benefits envisioned by CERP may be required. To that end, adaptive management provides a means to learn during implementation and operations through monitoring and assessment in order to ensure restoration performance, while minimizing impacts, addressing uncertainty, and reducing risk overall.

Full CERP Implementation Consistency: Because modeling resources and capability did not allow for full system-wide CERP runs, RECOVER was unable to provide a complete understanding of how LOWRP would

function as part of full CERP implementation. LOWRP project features formulated to achieve incremental system-wide restoration benefits in the near-term may not function as well once all of CERP is implemented as envisioned in the Water Resource Development Act of 2000. This may require adapting project features, such as additional storage reservoirs or additional aquifer storage and recovery (ASR) wells, to achieve the full set of restoration benefits stated under CERP as additional CERP projects are implemented. Nonetheless, the LOWRP project represents an important near term-incremental step towards restoration of the south Florida Everglades ecosystem.

Future CERP Increments: Future increments of CERP, as it relates to the restoration of the Lake Okeechobee Watershed, should focus on the need for more storage and regulatory release schedules to meet full CERP restoration goals for water quantity, quality, timing, and distribution throughout the lake and associated Everglades regions discussed in this review.

Climate Change: The need for more reliable sources of storage may become more apparent as a result of anticipated changes in climate. The National Climate Assessment and Development Advisory Committee's National Climate Assessment 2014 final report identifies sea level rise, increasing temperatures resulting in an increase in frequency, intensity, and duration of extreme heat events, and decreased water availability as key messages regarding climate change in the southeast United States and Caribbean. These factors may lead to increased evapotranspiration rates, changes in rainfall intensity, seasonal timing, and amounts. Atlantic cyclone activity is also anticipated to increase. Future planning efforts should evaluate scenarios of these climatic drivers and regional stressors to determine plans that are robust enough to address climate variation. In addition, scientists and managers should continue monitoring and associated analyses to understand the effects of climate change on system-wide indicators that are envisioned to be restored under CERP.

Northern Estuaries: Modeling of the hydrology, salinity, and associated ecology of the St. Lucie Estuary and Caloosahatchee River and Estuary, referred to collectively as the Northern Estuaries, only showed slight numeric differences in performance among the project alternatives. However, the evaluation metrics associated with the Lake Okeechobee Regulatory Schedule sows appreciable improvement from project alternatives compared to the future without project (FWO) scenario. Again, there is little difference in performance between project alternatives regarding regulatory releases. With little separation amongst project alternatives, any differences in performance are not likely to be ecologically significant. Although storage capacity fluctuates among alternatives, no specific alternative distinguishes itself in regards to better performance, suggesting other CERP projects considered as model key assumptions provide the observed model-predicted benefits according to the criteria set forth for the Northern Estuaries, rather than from LOWRP.

Lake Okeechobee: Modeling showed minimal differences between the performances of project alternatives. Project alternatives reduce the frequency of extreme low lake stages but slightly increase the frequency of extreme high lake stages. Project alternatives also reduce the duration of stages in the lower end of the ecologically beneficial range, while reducing the duration of stages at the higher end of the range only slightly. The reduced frequency of extreme low lake stages, shown in all project alternatives, should slightly improve conditions for epipelon and epiphytes, but worsen for *Chara,* which can expand far offshore during droughts. The slight increase in extreme high lake stages may increase cyanobacteria abundance and reduce coverage of submerged and emergent vegetation in the wettest of years, at least temporarily and infrequently. Overall, the moderating of lake stages through reductions in extreme lows and

moderate highs should promote the health of the lake by maintaining stages within the ecological range more frequently relative to FWO.

Lake Okeechobee Watershed: LOWRP will increase total wetland acreage by 5,300 acres, which increases the historical wetland acreage to 31%. Any increase in quality wetland acreage in the watershed should provide benefits to lake ecology by improving hydrological conditions for wildlife and vegetation within and adjacent to the project area. Wetlands provide a limited increase water storage, increase habitat connectivity, crucial habitat for refuge and forage, as well as increasing the potential for water quality improvement.

Lake Okeechobee Service Area: An opportunity to improve water supply in the Lake Okeechobee Service Area (LOSA) was identified during plan formulation by reducing water supply cutbacks to existing legal users of Lake Okeechobee. All project alternatives significantly reduce the cutback volume when compared to the ECB and FWO. The frequency of water restrictions equally improves among project alternatives. However, all project alternatives remain in performance deficiency, failing to meet restoration targets for frequency and duration. ALT2CR meets the restoration target for severity. Of the project alternatives, ALT2Cr, outperforms all other project alternatives. However, all project alternatives reduce the impacts of water restrictions compared to the ECB and FWO.

RECOVER provided support throughout the development of LOWRP's Optimized TSP from the earliest stages of LOWRP's planning. RECOVER made use of RECOVER approved performance measures and project performances to assess ecological and hydrological effects. Expertise offered by RECOVER included input from scientists with extensive scientific knowledge of the Everglades, Lake Okeechobee, and associated estuaries. The RECOVER system-wide evaluation of LOWRP alternatives, reported in this document, is intended to inform the selection of the Optimized TSP by the PDT. This evaluation uncovered concerns related to Lake Okeechobee water levels, releases, and stage duration to the ecosystems under the alternative scenarios.

RECOVER CONSISTENCY REVIEW: PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES

The RECOVER team consistency review of the project goals and objects and performance measures for LOWRP fulfilled three requirements as described by the 2003 programmatic regulations. Those requirements were: (1) ensure the project is consistent with CERP's goals and objectives; (2) document consistency of the project performance measures with RECOVER's system-wide performance measures; and (3) suggest improvements to the project performance measures with the intent of improving target or evaluation methods to better evaluate project alternative plans that, if pursued, would contribute to selecting a tentative plan with the best performance by the project in achieving ecosystem restoration goals. In order to address these requirements, the RECOVER consistency review team reviewed the project summary report and performance measures considered for utilization in LOWRP plan formulation. RECOVER determined the goals and objectives of LOWRP are consistent with the goals and objectives of CERP which are: (1) enhance ecological values and (2) enhance economic values and social well-being. The RECOVER consistency review team noted how up-to-date each performance measure was, how frequent each performance measure is used, and if it was a RECOVER approved performance measure. The performance measures utilized by LOWRP for plan formulation and assessment of LOWRP alternative plans were found to appropriate tools for assessing project alternatives and for achieving project success.

RECOVER CONSISTENCY REVIEW: ADAPTIVE MANAGEMENT PLAN

RECOVER supports the LOWRP draft AMMP. These plans utilize the best available science and monitoring currently available. RECOVER acknowledges that items included in the AM Plan are "not guaranteed to be funded as-is, but will be considered again when LOWRP is closer to being implemented." The LOWRP AM is reliant on all existing MAP (2009) monitoring continuing and that any future MAP updates will be incorporated into this AM. LOWRP will fund any monitoring directly related to the AM Plan but is not designed to replace RECOVER's system-wide monitoring and science efforts. However if any LOWRP monitoring (not funded by LOWRP) is eliminated or reduced, LOWRP will need to incorporate that monitoring into the project in order to meet project goals and objectives. All monitoring incorporated in the LOWRP AM Plan will need to be reevaluated over time in order to assess the status and results of on-going monitoring and to address any deficiencies or excesses in monitoring levels or effort.

RECOVER REVIEW OF THE LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT (LOWRP) DRAFT PROJECT OPERATING MANUAL (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LOWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess the most current system-wide scientific knowledge.

RECOVER will continue coordination with USACE and the South Florida Water Management District (SFWMD) during future LOWRP project operations manual updates, as requested.

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E RECOVER REVIEWS

E.1 Transmittal Letter for RECOVER System-Wide Evaluation of Lake Okeechobee Watershed Restoration Project (LOWRP)

Letter appears on the following page.

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

Date: June 15, 2018
To: Project Managers and Planning Technical Leads
Lake Okeechobee Watershed Restoration Project
Comprehensive Everglades Restoration Plan

Dear Project Team Managers and Planning Technical Leads,

RECOVER has completed its regional evaluation of the Lake Okeechobee Watershed Restoration Project (LOWRP) alternative plans and our final report is attached.

RECOVER's evaluation of project alternatives fulfills the following requirements as required by the 2003 CERP Programmatic Regulations 33 CFR Part 385.26(c):

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

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

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

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

Best Regards,

RECOVER Executive Committee
(Patti Gorman, Donna George, Fred Sklar, Agnes McLean, Steve Traxler, Gretchen Ehlinger)

E.2 Introduction

E.2.1 Background and Purpose

This report documents the REstoration COordination and VERification (RECOVER) team system- wide/regional evaluation of the Lake Okeechobee Watershed Restoration Project (LOWRP) required by the Comprehensive Everglades Restoration Plan (CERP) programmatic regulations 33 Code of Federal Regulations 385.20(e)(2). RECOVER is an independent (from the project delivery team [PDT]), interagency, and interdisciplinary team made-up of scientists charged with helping PDTs ensure their project's plans, designs, and performance are fully linked to the goals and objectives of CERP. The purpose of system-wide evaluations are to: (1) inform the PDT of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures (PM), project PMs, and best professional judgment; (3) identify improvements for project performance that would improve system-wide performance; and (4) provide decision-makers required information regarding system-wide performance expectations of specific projects. This report documents the performance of the project alternatives in accordance with these four (4) tenets and highlights the ability of each alternative to meet RECOVER system-wide/regional performance targets and documents expected effects on the natural system.

E.2.2 LOWRP Goals and Objectives

The purpose of CERP is to modify structural and operational components of the C&SF Project to achieve restoration of the Everglades and the south Florida ecosystem, while providing for other water-related needs such as urban and agricultural water supply and flood protection. The sixty-eight (68) components of CERP will work together to benefit the ecological structure and function of the south Florida ecosystem by improving and/or restoring the proper quantity, quality, timing, and distribution of water in the natural system. LOWRP goals and objectives, as described in **Table E-1,** are the same as those outlined in CERP.

LOWRP is composed of increments of project components that were identified in CERP. The term "increment" is used to underscore that this study will formulate portions (scales) of individual components of CERP. It is envisioned that later studies will investigate additional scales of components of CERP to expand upon this initial "increment" to achieve the level of restoration envisioned for CERP. Portions of three of the 68 components of CERP are being evaluated within LOWRP (Section 1.3).

LOWRP goals and objectives (**Table E-1**) are consistent with those of CERP, as described in **Table E-2**. LOWRP focuses on increasing spatial of natural wetland areas while restoring the ecological structure, function, and dynamic processes of these areas and improving abundance and diversity of native plant and animal species.

Table E-1. LOWRP Goals and Objectives.

Goals	
1	Enhance ecological values.
2	Enhance economic values and social well being.
Objectives	
Note: The timeline for the following planning objectives is as soon as practicable after completion of project construction and over a 50-year period of analysis.	
1	Improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often.

2	Improve estuary discharges from Lake Okeechobee to improve the salinity regime and the quality of oyster, submerged aquatic vegetation (SAV), and other estuarine community habitats in the northern estuaries.
3	Increase the spatial extent and functionality of aquatic and wildlife habitat within Lake Okeechobee and the surrounding watershed.
4	Increased availability of the water supply to the existing legal water users of Lake Okeechobee.

E.2.3 Model Assumptions and Project Alternatives

As part of the RECOVER regional evaluation, the "future without project" (FWO) alternative was compared to three projects alternatives (ALTs) aimed at increasing the duration that Lake Okeechobee stage is within the desired ecologic envelope, improving discharges to the St. Lucie Estuary and Caloosahatchee River and Estuary by decreasing the overall volume and the number of events in the high flow categories while maintaining base flows on the low end, increasing spatial extent and functionality of aquatic and wildlife habitat in Lake Okeechobee proper and watershed, and increasing water supply where available as proposed in the following CERP components (**Table E-2**):

- Restore Wetland and Aquatic habitat at Paradise Run (OPE)
- North of Lake Okeechobee Storage Reservoir (A)
- Lake Okeechobee Aquifer Storage and Recovery (GG)

Table E-2. Original LOWRP scope as envisioned in the CERP Restudy compared to the current planning effort.

Component as Described in the Yellow Book	Yellow Book Facility/Project Description	Yellow Book Facility/Project Purpose	Management Measures Carried Forward for LOWRP Planning
North of Lake Okeechobee Storage Reservoir (A)	17,500-acre reservoir with total storage capacity of 200,000 acre-feet in Kissimmee River Region 2,500-acre STA*	Detain water during wet periods for use during dry periods, reduce nutrient loads flowing from the Kissimmee River into Lake Okeechobee, and reduce the duration and frequency of high and low water levels in Lake Okeechobee that damage the lake's littoral ecosystems and necessitate damaging large discharges to the downstream estuaries.	Various 150,000 to 350,000 acre-feet reservoir configurations were considered during initial screening. STAs are not a management measure in the new LOWRP planning effort.

Lake Okeechobee Aquifer Storage and Recovery (GG)	Series of ASR wells adjacent to Lake Okeechobee with a capacity of one billion gallons per day in Glades and Okeechobee counties; assumes 200 wells.	1) Provide regional storage while reducing evapotranspiration and land use; 2) increase water storage for agricultural, urban, and environmental purposes; 3) improve Everglades' hydropatterns; 4) reduce harmful regulatory discharges to the St. Lucie and Caloosahatchee estuaries; and 5) maintain and enhance the existing level of flood protection.	2015 CERP ASR Regional Study reduced the ASR well number to 80 wells that could be constructed within the northern Lake Okeechobee Basin on SFWMD-owned lands based on hydrogeologic conditions.
Restore Wetland and Aquatic Habitat at Paradise Run (OPE)	Convert approximately 3,600 acres of pasture to wetlands at Paradise Run (the reach of the Kissimmee River from S-65E downstream to the outlet at Lake Okeechobee)	Benefits include additional storage of floodwater and improvement in water quality	This component was retained. Wetland restoration sites were considered throughout the Lake Okeechobee watershed basin with a general target of 3,600 acres.

E.2.3.1 Key Assumptions Regarding the FWO

CERP Projects

- IRL-S complete; features operational
- C-43 West Basin Storage complete; features operational
- CEPP complete; features operational

Non-CERP Projects

- Kissimmee River Restoration (KRR) construction complete; features operational
- Kissimmee River Upper Basin (real estate acquisition and operations); features operational
- Herbert Hoover Dike (HHD) complete; features operational
- Natural Resource Conservation Service (NRCS) WRP-WRE complete; features operational
- U.S. Fish and Wildlife Service (FWS) Refuge project complete; features operational
- Florida Department of Environmental Protection (FDEP) Basin Management Action Plans (BMAPs)

Operations

- Modified Lake Okeechobee Regulation Schedule (LORS) 2008 plus CEPP refinements

E.2.3.2 Project Alternatives

Project alternatives were formulated in 2 phases focusing in the area north of Lake Okeechobee. The first phase of formulation focused on water storage, while the second phase focused on wetland restoration. Both phases

were combined to formulate complete project alternatives. All project alternatives affect Lake Okeechobee, the Lake Okeechobee Watershed, the Northern Estuaries, and the Lake Okeechobee Service Area (water supply). Ultimately three project alternatives (ALT1Bshlw, ALT1BW, and ALT2Cr) were compared to the FWO and existing condition baseline (ECB), and are depicted in **Figure E-1**. A detailed description of the alternatives can be found in Section 3 of the Project Implementation Report (PIR). Most of the project features included in each of the LOWRP alternatives are consistent with the components set forth in CERP. Shallow reservoir designs do not measure to the standards set forth for under Yellow Book Component A () for Lake Okeechobee Restoration in CERP. In their 6th Biennial Review (2016), the Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP) acknowledged, "the storage total is far below other estimates of storage requirements to satisfy flow targets in the estuaries." To this end, future restoration of the Lake Okeechobee Watershed may be completed, incrementally, to achieve the final results described in CERP. There is uncertainty with the effectiveness and potential impacts of ASR implementation, which is discussed in more detail in **subsection 1.4.1**. Project features formulated to achieve incremental system-wide restoration benefits in the near term may not function as well as full CERP implementation as envisioned in the 2000 Yellow Book Plan. This may require adapting project features or adding additional restoration projects in the future, in order to achieve the full set of restoration benefits envisioned by CERP. The final array of LOWRP alternatives represents a step forward in the restoration of south Florida ecosystem. Additional information regarding the formulation of the final array of alternatives can be found in **Section 3** of the LOWRP Project Implementation Report/Environmental Impact Statement.

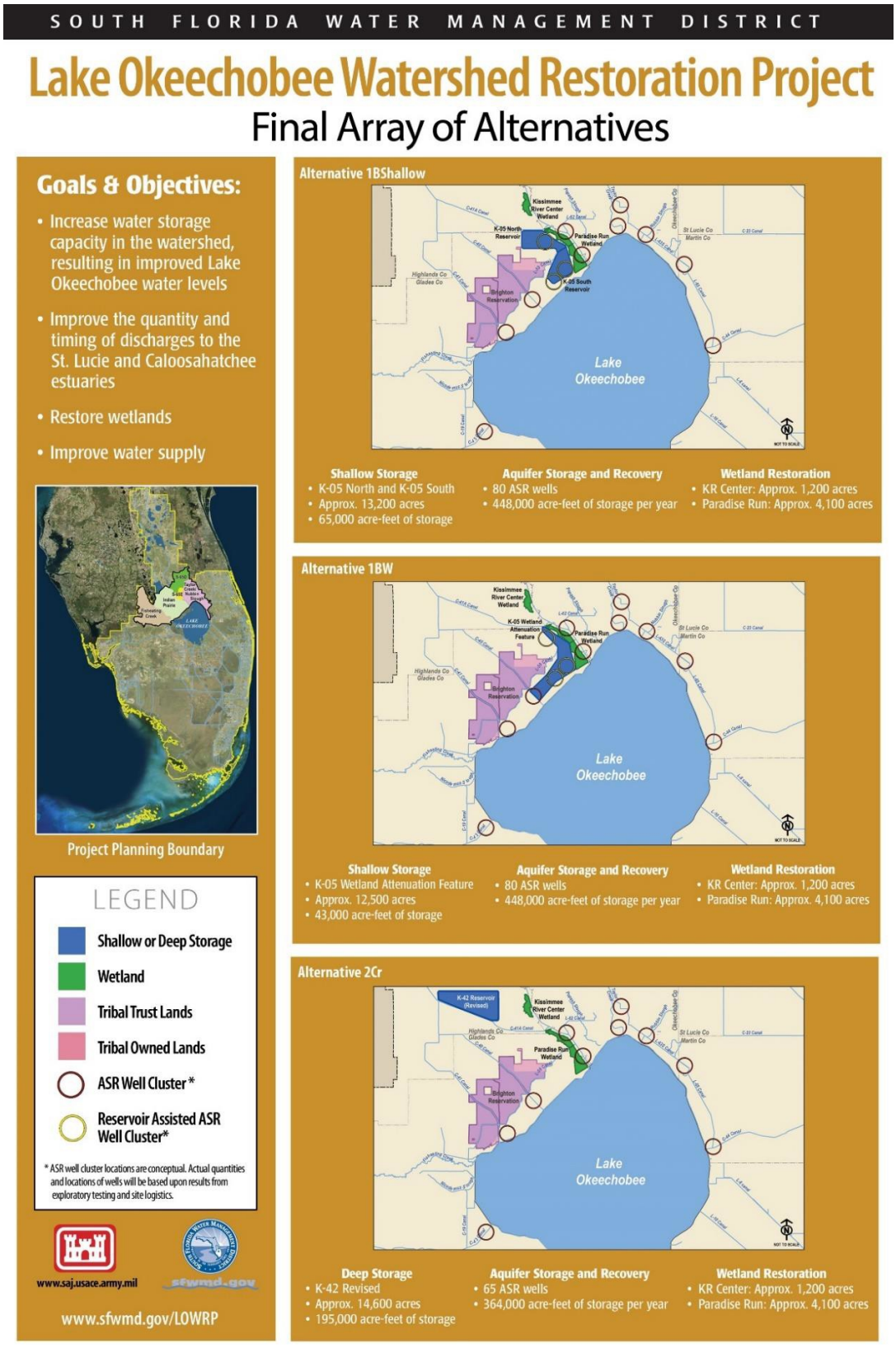


Figure E-1. Final array of alternatives for the Lake Okeechobee Watershed Restoration Project.

E.2.4 Uncertainty

Model uncertainty can be characterized in several forms (RECOVER, 2002), but generally they fall into two categories: knowledge uncertainty or natural variability uncertainty. Knowledge uncertainty relates to errors in how a particular species or parameter will respond to various environmental and habitat conditions. Knowledge uncertainty can be measured using calibration statistics for the hydrologic models which can be propagated to the ecological models that use hydrologic output. The limits of a model's representation of actual factors or conditions can be described in model documentation reports. Natural variability relates to the temporal and spatial uncertainty with each input and output in the model and is further complicated by climate change nonstationarity. The significance of both types of model uncertainty is that it can pose a risk to identifying and implementing the best project plan to achieve restoration goals and objectives. Scenario analysis can be used to evaluate variations of an alternative which is more robust (perform better under a range of future conditions) to help minimize the risk associated with natural variability uncertainty. Adaptive management is another tool that can help reduce uncertainty associated with implementing the best alternative plan and operations to meet restoration performance goals.

E.2.4.1 Knowledge-based Uncertainty

E.2.4.1.1 Planning Uncertainty

The RECOVER regional evaluation made use of plan formulation assumptions about which projects would be implemented for the FWO and LOWRP alternatives (See Section 1.3). If any of these projects are delayed or are not implemented, the results for each alternative could change. This uncertainty is consistent for all project planning alternatives for any restoration project and is minimized by only including projects that have a signed Chief of Engineers Report or those that have been authorized by Congress or state governing bodies.

E.2.4.1.2 Model Uncertainty

The hydrologic model used for LOWRP evaluation is the Regional Simulation Model for Basins (RSM-BN) (version 2.3.2) developed by the Hydrologic and Environmental Systems Modeling Section of the SFWMD. The RSM-BN is a link-node model designed to simulate the transfer of water from a pre-defined set of watersheds, lakes, reservoirs or any waterbody that receives or transmits water to another adjacent waterbody. RSM-BN assumes that water in each waterbody is held in level pools. The RSM-BN model domain covers Lake Okeechobee and four major watersheds related to the northern portion of the project area: Kissimmee, Lake Okeechobee, St. Lucie River, and the Caloosahatchee River and Estuary. The model domain also includes the Everglades Agricultural Area (EAA). Similar to the Central Everglades Planning Project (CEPP), complex environmental systems rely on predictions derived from PMs and ecological indicators. Additional uncertainty exists as to whether they truly capture overall system performance (USACE and SFWMD, 2014). The Everglades is a complex system which requires assumptions based on scientific evidence and best professional judgment in order to formulate a predictive model.

E.2.4.1.2.1 Period of Record Uncertainty

The RSM-BN model uses a 41-year period of record (POR) ranging from 1 January 1965 to 31 December 2005. This POR represents a contrast from the 36-year POR employed in the development of restoration targets for the RECOVER PMs used to evaluate the LOWRP final array of alternatives. Uncertainty is a result of this difference. Where restoration targets are 0 or 100, the change in the length of POR would have no effect and no uncertainty would exist. It is uncertain as to how an extended POR may affect the established targets in these RECOVER PMs

when target values are not 0 or 100. The following performance measures have established targets for a 36-year POR even though modeling used an updated 41-year POR:

- Northern Estuaries Salinity Envelopes RECOVER Performance Measure (RECOVER 2007b)
- Lake Okeechobee Stage Envelope RECOVER Performance Measure (RECOVER 2007a)
- Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area RECOVER Performance Measure (RECOVER 2005)

Additionally, two PMs were also utilized where POR was the same (41 years):

- Lake Okeechobee Ecological Indicator Score RECOVER Performance Measure (RECOVER 2016)
- Lake Okeechobee Watershed Wetlands Restoration Project Performance Measure (LOWRP 2016)

The five-year difference between the 36-year POR used to establish restoration targets and the 41-year POR that LOWRP modeling utilized may not have a profound effect on the modeling results and the performance of project alternatives. However, uncertainty exists because restoration targets are not based on a 41-year POR used in modeling of all performance measures used for LOWRP.

E.2.4.1.3 Performance Measure Uncertainty

The LOWRP regional evaluation is based on technical evaluation performed by members of RECOVER (see **subsection E.7**). This evaluation is performed using both RECOVER-approved PMs, as well as other information (i.e., PMs in development, corresponding assessment data, and other reports) that have not yet completed RECOVER scientific review and approval. RECOVER PM uncertainty is typically described in the RECOVER documentation sheets. The RECOVER PM documentation sheets pertinent to LOWRP can be found in Appendix G of the Lake Okeechobee Watershed Restoration Project PIR/EIS. Those PMs that have been reviewed and approved by RECOVER have more certainty based on scientific agreement, as opposed to other evaluation methods and tools that have not been reviewed and approved by RECOVER and are still being further developed and vetted, such as the project specific PMs used in this evaluation.

E.2.4.1.3.1 Performance Measure Congruity Uncertainty

Congruity of RECOVER PMs is an additional source of uncertainty for LOWRP. RECOVER PMs are developed individually. Application of RECOVER PMs provides an opportunity to better understand how well PMs work cohesively. Inconsistencies from one PM to another are identified for future review/revision. Best scientific judgment is used to address any uncertainty resulting from inconsistencies arising from the application of multiple PMs used to evaluate the outcomes of restoration alternatives.

E.2.4.1.4 Knowledge Uncertainty

The PM models are simplifications of the real relationships between hydrology and a particular indicator of interest. Errors can result based on known and unknown responses of species and habitats to various environmental and other habitat conditions. This type of uncertainty is inherent with any ecosystem restoration project and is minimized by using the best available science to develop and interpret model results. In addition, uncertainty is addressed by proceeding with project implementation through an adaptive management approach that tests hypotheses about the best project design and operations to achieve desired results.

E.2.4.1.4.1 ASR Uncertainty

Aquifer Storage and Recovery (ASRs) wells were first implemented in Florida in 1983. While ASR technology has been available for nearly 25 years, their application has been on smaller scales than called for in the CERP Yellow Book. In 2015, a Final Regional Aquifer Storage and Recovery Technical Data Report was completed for several ASR Pilot Studies including Lake Okeechobee and found that no "fatal flaws" had been observed that would prevent the implementation of ASRs (USACE and SFWMD 2015). This report reduced the uncertainty associated with ASR technology by providing initial understanding of the potential environmental impacts and effectiveness of ASR use, albeit on a smaller scale (5 ASR wells) (USACE and SFWMD 2013). The 2015 report also stated, "The overall number of ASR wells would need to be reduced." LOWRP Plan Formulation further reduced the uncertainty of ASR well use by reducing the number of ASR wells from the 200 in the CERP Yellow Book to a much smaller range of 65-80 planned in the LOWRP alternatives.

In a 2015 review of Everglades ASRs, the National Research Council of the National Academies' Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP) concluded that the "…*use of a modest number of appropriately placed ASR wells will have low-to-moderate adverse effects on aquatic organisms and ecosystems…A more detailed understanding of potential toxicity, especially under chronic exposure and in situ conditions, is needed before incorporating ASR at a regional scale. This additional testing will reduce uncertainties associated with potential hazards to aquatic biota and significantly improve public perception and trust that broad- scale ASR is safe for protection of freshwater resources*"(NRC 2015). In a recent CISRERP ASR Eco-toxicology web conference meeting (February 13, 2018) some CISRERP members reiterated these previous concerns. The 2015 Final Regional Aquifer Storage and Recovery Technical Data Report did show, on a small scale, the lack of ecological impact to aquatic biota and water quality further reducing the uncertainty associated with the use of ASR technology, although some concerns still remain such as arsenic, molybdenum, and coliform, for example (USACE and SFWMD 2013).

The size of the LOWRP ASR system planned for implementation is the source of some uncertainty as it relates to the ecology of the Lake Okeechobee Watershed, Lake Okeechobee proper, and downstream areas associated with the Northern Estuaries. The planned LOWRP ASR system (65-80 wells) will be three (3) to eight (8) times greater than the established Florida ASR systems such as Peace River Manasota Regional Water Supply Authority (21 wells) and the Tampa Aquifer Storage and Recovery Tampa ASR system (10 wells). The LOWRP plan calls for a phased installation of the 65-80 well ASR system. By implementing two (2) to three (3) wells at a time, the project team will be able to evaluate potential environmental impacts to the Upper Floridan aquifer, south lower Kissimmee River, Lake Okeechobee Watershed, Lake Okeechobee proper, and downstream estuaries of the St. Lucie and Caloosahatchee Rivers. As part of this phased evaluation process, RECOVER recommends the project pursue similar ecotoxicological testing of ASR technology as conducted in the ASR pilot studies to address the uncertainty associated with the number of ASR wells planned for implementation by LOWRP.

E.2.4.2 Natural Variability-based Uncertainty

E.2.4.2.1 Climate Change Uncertainty

The RSM model uses a historic forty-one (41) year period of record (1965-2005) of rainfall and hydrology to simulate interaction of surface water/groundwater, evapotranspiration, and water management (movement of water through canals, structures, seepage, overland flow or estuarine flow) to estimate the flow, water depths and durations, and salinities in the estuaries. Project infrastructure (e.g., canals, water control structures) and operations are portrayed in abstraction that generally mimic the intent of the project features while not matching the exact mechanisms by which these operations would be achieved in the actual conditions. Climate change nonstationarity means that the past climatic conditions (41 year period of record for the hydrologic

models) are not indicative of future climatic conditions. Uncertainty exists due to the inability to predict/forecast swings in rainfall from extreme storm events to extreme drought, rising temperatures, salt water intrusion, extent of sea level rise and the impacts resulting from these climate changes.

E.2.5 Evaluation Process and Organization

A RECOVER team (see **subsection E.7**), consisting of members representing the RECOVER regions of Lake Okeechobee, Northern Estuaries, Greater Everglades, and the Southern Coastal Systems, evaluated LOWRP alternatives using approved project PMs, approved RECOVER PMs, best available scientific information, and best professional judgment. This evaluation was performed, utilizing the knowledge and expertise representative of the system as a whole, to help in understanding the regional hydrological and ecological performance of each alternative. This RECOVER system-wide evaluation report is organized by three impact areas associated with LOWRP: (1) Northern Estuaries; (2) Lake Okeechobee and Watershed; Lake Okeechobee Service Area. Impacts to the RECOVER Modules, Greater Everglades and Southern Coastal Systems, are not anticipated as a result of LOWRP. A summary of this RECOVER system-wide evaluation and recommendations are included in the executive summary, found in Annex E of the LOWRP PIR/EIS. Background information on LOWRP goals, objectives, assumptions, and alternatives is included in this section. The following sections describe the evaluation process used to assess each impact area.

E.3 Northern Estuaries

E.3.1 Introduction

The magnitude, timing and distribution of freshwater inflow to the St. Lucie River Estuary (SLE), and the Caloosahatchee River Estuary (CRE) have been disrupted by water management and other anthropogenic alterations of the landscape. These include over drainage of coastal watersheds and artificial connections to Lake Okeechobee for flood control purposes. Projects included in the CERP of which the LOWRP is one, are intended re-establish salinity regimes suitable for the maintenance of healthy, naturally diverse and well-balanced estuarine ecosystems. Accomplishing restoration will require ameliorating inordinate canal discharges (including regulatory releases from Lake Okeechobee) and insuring sufficient dry-season flows necessary to avoid ecologically damaging high and low salinity extremes. Success in meeting restoration expectations will be measured by the degree in which constructed features and operational considerations sufficiently enhance estuarine flora and fauna as appropriate for each of the four estuaries being restored (RECOVER 2007).

This section of the RECOVER review evaluates the RSM-BN predictions of freshwater flows to these two estuaries from LOWRP. To assess the effects of the LOWRP, output from three modeling scenarios is contrasted and compared against targets and two different "base" conditions: (1) ECB and (2) the FWO. The ECB represents the present configuration and operation of the water management system. The FWO scenario simulates a future configuration of the water management system without the LOWRP but with a number of other projects that should benefit the overall system. The final array of LOWRP alternatives are Alternative 1B Shallow (Alt1Bshlw), Alternative 1BW (ALT1BW), and Alternative 2Cr (ALT2Cr).

These simulations assume the current Lake Okeechobee Regulation Schedule (LORS 2008) is in effect. They also assume that the FWO scenario and LOWRP alternatives includes three CERP projects that contribute to restoration of freshwater inflows to the two estuaries: the optimized release guidance component of CEPP, the Indian River Lagoon – South (including the C-44 Reservoir), and the C-43 West Basin Storage Reservoir (**subsection 1.3.1**). The evaluation of the final array of alternatives is based on hydrologic and salinity PMs.

E.3.2 Performance Measures and Evaluation Approach

The model output for each scenario consists of a 41-year time series (1965–2005) of daily freshwater inflows to each estuary. For the CRE, flows at the Franklin Lock and Dam (S-79) at the head of the estuary were provided. These flows integrate the effects of discharges from Lake Okeechobee (S-77) and the Caloosahatchee River (C-43) basin. For the SLE, model output is a time series of total freshwater inflow. This includes flows at the S-80 structure, which integrates the discharge from Lake Okeechobee (S-308), and the C-44 basin as well as an estimate of inflows from other basins in the watershed.

The RECOVER's Northern Estuaries Module Team developed a Salinity PM (RECOVER 2007), against which CERP project alternatives are evaluated. The Northern Estuaries Salinity PM can be found in Appendix G of the LOWRP PIR/EIS.

E.3.2.1 Hydrologic Performance Measures

The Salinity PM for the Northern Estuaries is based on the frequency distributions of mean monthly (CRE) or mean 14-day (SLE) freshwater inflows in the 41-year period model output. Northern Estuaries salinity envelopes do not specify a salinity envelope at specific locations or boundaries in the CRE (RECOVER 2007). Rather, the document refers to generalized beneficial salinity conditions and ranges for each of the valued ecosystem components/ecological indicators in each estuary.

The number of mean monthly or 14-day flows in discrete flow ranges is evaluated. Each range has a finite range of values associated with it. Range categories are defined by the ecological effects that they produce, and represent a gradient of benign to harmful impacts on the estuaries. Simulated alternative conditions with a lower frequency of flows in harmful ranges are considered to cause less damage to estuarine flora and fauna and are considered the better alternative. The RSMBN model used to simulate the three scenarios evaluated here does not estimate salinity in either the SLE or CRE.

E.3.3 Evaluation

E.3.3.1 Caloosahatchee River and Estuary

The CRE is evaluated based upon the number of mean monthly flows that fell into specified flow classes during the 492 month, 41-year period of record for each simulation scenario. Flows less than 450 cubic feet per second (cfs) are considered harmful since these flow levels allow salt water to intrude, raising salinity above the tolerance limits for communities of submerged aquatic plants (tape grass, *Vallisneria americana*), in the upper estuary. Flows greater than 2,800 cfs cause mortality of marine seagrasses (shoal grass, *Halodule wrightii*) and the eastern oyster (*Crassostrea virginica*) in the lower estuary and at flows greater than 4,500 cfs, seagrasses begin to decline in San Carlos Bay (**Figure E-2**). RECOVER's review of the LOWRP is focused on freshwater discharges from the C-43 canal at the S-79 structure. A CERP goal is to reestablish a salinity range most favorable to oysters and SAV by reducing high volume and minimum discharge events to the estuary.

The CERP system-wide PM for Northern Estuaries salinity envelopes targets a mean monthly inflow for the CRE between 450 and 2,800 cfs during all months (RECOVER 2007). A reduction in the number of high flow (damaging) events represents improvement over the base conditions. A reduction in the number of times the flow goes below 450 cfs, which causes salinity in the upper estuary to get too high also represents improvement. See **Table E-3** for flow/salinity metrics used in this evaluation and their expected ecological effects.

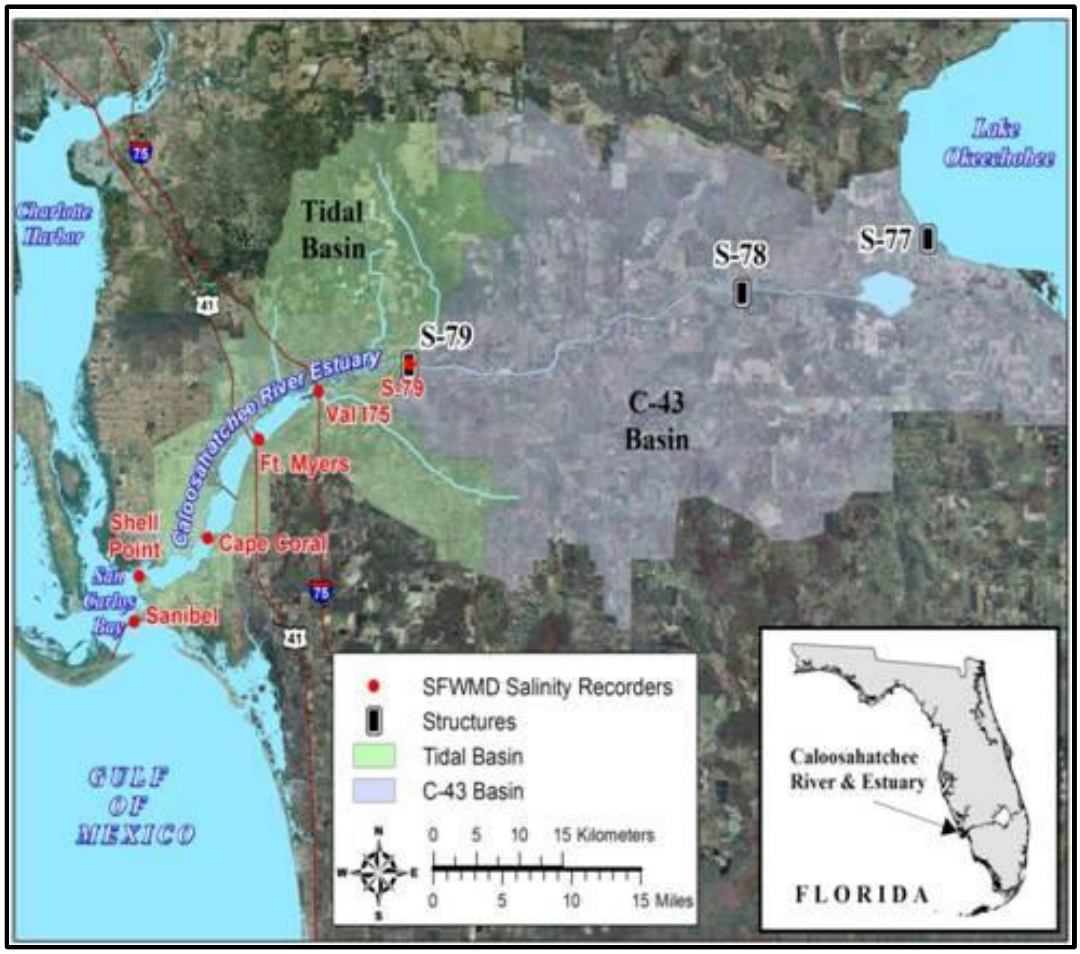


Figure E-2. Map of Caloosahatchee River Estuary showing the location of S-79 structure and C-43 Basin.

The Northern Estuaries Salinity PM (RECOVER 2007) provides an evaluation protocol for the CRE using several Hydrologic Performance Targets (HTs) based on the flow classes summarized in **Table E-4**.The following evaluation of the LOWRP final array of alternatives for the CRE is a comparison of the model outputs (summarized in **Table E-5**) against the PM HTs. Reference to each CRE HT will be cited parenthetically for each major criterion in subsequent sections. To read the full description of each criterion, they can be found in RECOVER (2007) p. 16 – 17.

Table E-3. Northern Estuaries salinity PM hydrological performance targets for the Caloosahatchee Estuary.

Hydrologic Performance Targets (HTs)	Description
HT 1a – 1c	Low Flow Criteria
HT 2a – 2b	High Flow Criteria
HT 3a – 3b	Extreme High Flow Criteria
HT 4	Lake Okeechobee Regulatory
HT 5	Freshwater Inflow Criterion

Table E-4. Table E.2-2: Mean monthly flow classes for the CRE and the anticipated ecological effects.

Mean Monthly Inflow at S-79	Ecological Response	Ranking Criteria
< 450 cfs (Low Flow)	Damage to upper estuary tape grass	Fewer is better
450–2800 cfs (Desired Envelope)	Tolerable range	More is Better
2800–-4500 cfs (High Flow)	Damage to estuary	Fewer is Better
> 4500 cfs (Extreme High Flow)	Damage to estuary and bay	Fewer is Better

Table E-5. Model-predicted performance of baselines and the final array of three LOWRP alternatives using the CRE Salinity PM flow metrics: number of months flow criteria is violated. Targets are included for comparison purposes.

LOWRP Scenario	Low Flow Criterion	High Flow Criterion	Extreme High Flow
Target	0	0	0
ECB	116	94	43
FWO	23	70	30
Alt 1Bshlw	25	60	26
Alt 1BW	24	63	25
Alt 2Cr	23	64	27

E.3.3.1.1 Salinity PM Low Flow Criteria

Table E-6 and **Figure E-3** includes the performance of the Low Flow metric from the CRE component of the Northern Estuaries Salinity PM. For the number of times the mean monthly inflows fall below a low- flow limit of 450 cfs (**HT 1a**), none of the three LOWRP alternatives perform better than the FWO scenario. However, both the three LOWRP alternatives and the FWO perform better than the ECB, with a reduction in the number of mean monthly flows < 450 cfs by approximately 80%, which may be attributed to other operational CERP projects per the modeling assumptions.

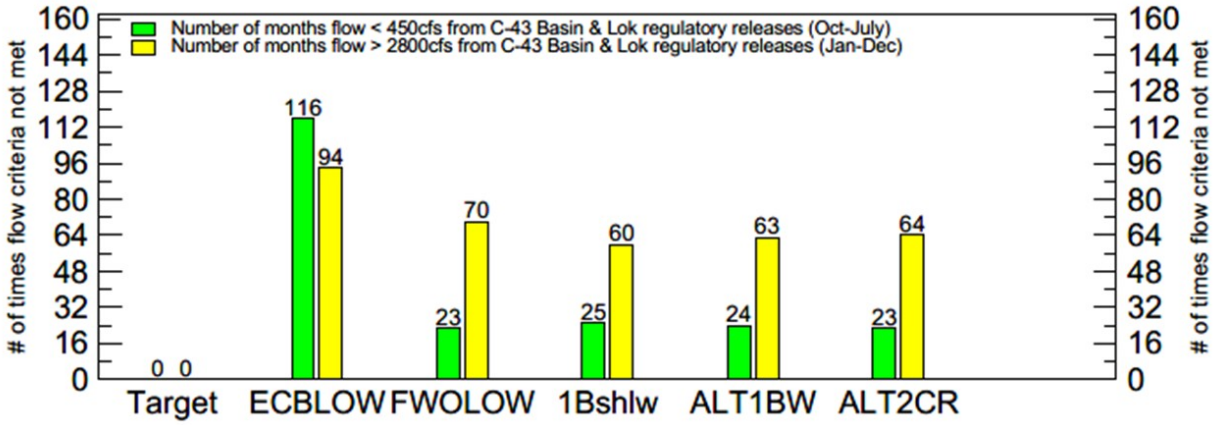


Figure E-3. Model-predicted performance of baselines [Existing Baseline Conditions (ECBLOW) and Future Without LOWRP (FWOLOW)] and the final array of three LOWRP alternatives using the CRE Salinity PM Flow Criteria. Targets are included for comparison purposes.

For the number of consecutive months the mean monthly flows fell below the low-flow limit of < 450 cfs (**HT 1b**), the three LOWRP alternatives perform comparably to the FWO scenario (**Table E-6**). However, all the alternatives and the FWO provide a marked improvement from the ECB to the number of consecutive months mean monthly low-flows fall below < 450 cfs, especially for the frequency of 1 and 2 consecutive months with low-flows (from 75 – 82%). There is also a significant improvement from the ECB for both the LOWRP alternatives and the FWO for the frequency of 7 consecutive months with low-flows (a reduction of 60-100%) (**Table E-6**), which is likely to have substantial positive impacts to the ecology of the upper estuary, which can experience too few freshwater inflows. It is not possible to discern whether some of the improvements are a factor of the LOWRP alternatives, or other CERP project implementation as per the modeling assumptions.

Table E-6. Number of times 1, 2, 3... consecutive months mean monthly flows fall below the Low Flow Criteria (< 450 cfs) in the CRE over the entire POR (1965 - 2005).

No. of Consecutive Months	ECB	FWO	Alt1Bshlw	Alt1BW	Alt2Cr
9					
8	1	1	1		
7	5	1		1	1
6	3			1	
5	1		1		1
4	2				
3	2	1	1	1	1
2	12	1	3	3	3
1	12	3	3	2	2

Northern Estuaries Salinity PM **HT 1c** does not apply in this case, as neither the ECB, FWO, or LOWRP alternatives demonstrate any incidences of mean monthly low-flow < 450 cfs for more than 12 months. A reduction in the number of Low Flow events is beneficial to freshwater species of SAV (i.e., tape grass) in the upper reaches of the estuary, as flows within the desired range of 450 – 2800 cfs should prevent salty conditions from encroaching too far upstream.

E.3.3.1.2 Salinity PM High Flow Criteria

Table E-4 and **Figure E-3** include the performance of the High Flow metric from the CRE component of the Northern Estuaries Salinity PM. The three LOWRP alternatives perform similarly, reducing the number of mean monthly flows > 2800 cfs by 9-15% from the FWO (**Table E-4; HT 2a**), which may or may not be ecologically significant.

Table E-7. Number of times 1, 2, 3... consecutive months mean monthly flows exceed the High Flow Criteria (>2800 cfs) in the CRE over the entire POR (1965 - 2005).

No. of Consecutive Months	ECB	FWO	Alt1Bshlw	Alt1BW	Alt2Cr
9					
8					
7	2	1			
6	1				

5	4	5	1	1	2
4	1		1	3	2
3	5	4	3	3	3
2	6	5	11	10	11
1	23	16	20	17	15

For the number of consecutive months the mean monthly flows exceeded high-flow limit of > 2800 cfs (**HT 2b**), all the LOWRP alternatives perform better than the ECB. However, two of three alternatives perform worse than the FWO (**Table E-7**) by 12 – 20% for just one month of mean monthly exceedances, and all three alternatives perform worse than the FWO by doubling the number of 2 consecutive months of mean monthly exceedances (a 50-55% increase). However, for frequency of 3 or more months of consecutive mean monthly exceedances > 2800 cfs improve across all LOWRP alternatives compared to the ECB and FWO, with no obvious alternative performing appreciably better than the other.

Fewer incidences of these High Flow events, especially during the wet season, is beneficial for marine species of SAV and oysters throughout the estuary and San Carlos Bay by preventing oligohaline-to- freshwater conditions too far downstream. It is difficult to discern the magnitude of potential negative effects to the ecology of the CRE caused by an increase in the frequency of 1 and 2 consecutive mean monthly flows > 2800 cfs. Oysters can withstand extended low-salinity conditions – and indeed can benefit from pulses of low-salinity which improve disease infection rates and intensity (e.g. the protozoan parasite *Perkinsus marinus* (Dermo)) and reduce marine predators – but more than one month of flows > 2800 cfs is likely to be detrimental to oysters and marine species of SAV. Finally, the reduction of 3 or more months of consecutive mean monthly exceedances of the high-flow criterion can only be beneficial for the ecology of the CRE, and perform comparably across all LOWRP alternatives.

E.3.3.1.3 Salinity PM Extreme High Flow Criterion

Table E-4 and **Figure E-4** includes the performance of the Extreme High Flow metric (mean monthly flows > 4500 cfs) from the CRE component of the Northern Estuaries Salinity PM. The three LOWRP alternatives perform slightly better than FWO at reducing the number of mean monthly Extreme High Flows by approximately 10 – 24%, while both the alternatives and FWO are an improvement to the ECB by approximately 30 – 38% (**HT 3a**), which in part may be attributed to other CERP projects becoming operational as per the modeling assumptions.

For the Northern Estuaries Salinity PM **HT 3b**, the frequency of consecutive months with mean monthly flows > 4500 cfs is not explicitly available, but likely captured in the High Flow Criteria of consecutive mean monthly flows > 2800 (**Table E-7**).

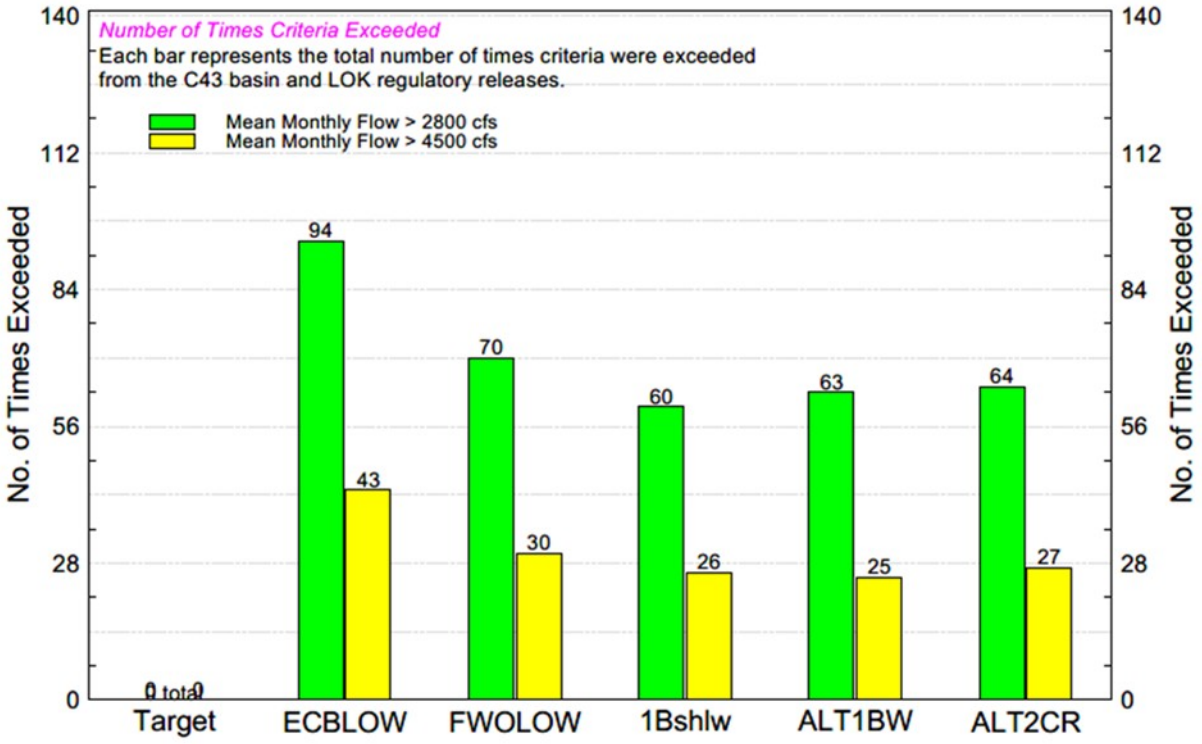


Figure E-4. Number of times the CRE High Discharge Criteria exceeded flows >2800 and >4500 cfs (mean monthly flow 1965 - 2005).

E.3.3.1.4 Salinity PM Lake Okeechobee Regulatory Discharge Criterion

E.3.3.1.5 No model outputs are available to compare the number of days that regulatory discharges from Lake Okeechobee are made to the Caloosahatchee River (HT 4).Salinity PM Freshwater Inflow Criterion

In order to compare the frequency distribution of monthly average freshwater inflows for the entire period of record (POR), **HT 5** states that the LOWRP alternative that maximizes up to 75% of the flows in the 450 – 800 cfs range, and almost all the remaining inflows in the 800 – 2800 cfs range, would be considered the most desirable for the ecology of the CRE.

The model outputs available do not differentiate the frequency of flows in the 450 – 800 cfs range, nor the 800 – 2800 cfs range, and include flows combined from the C-43 Basin and Lake Okeechobee Regulatory Discharges. Instead, the sum of the number of months in which mean monthly flows fell below the low-flow minimum (< 450 cfs) and exceeded the high-flow maximum (> 2800 cfs) were divided by the total number of months in the POR (492 months) (**Figure E-3**). From these quotients, the three LOWRP alternatives performed slightly better than FWO, and both all three LOWRP alternatives and the FWO are a marked improvement on the ECB (**Table E-8**). For the ECB, almost half (50%) of the total inflows fall outside the desired range of mean monthly 450 – 2800 cfs.

Table E-8. The percent of monthly average freshwater inflows outside the desired range of mean monthly 450 - 2800 cfs over the entire POR for all LOWRP scenarios.

LOWRP Scenario	Frequency (%) of Monthly Average Freshwater Inflows Outside of Desired Range
Target	0% (HT5: 75% monthly average flows 450 – 800 cfs; 25% monthly average flows 800 – 2800 cfs)
ECB	43%
FWO	19%
Alt 1Bshlw	17%
Alt 1BW	17%
Alt 2Cr	18%

E.3.3.2 St. Lucie Estuary

RECOVER's review of the LOWRP focused on freshwater inflow to the SLE. This includes flows at the S-80 structure, which integrates the discharge from Lake Okeechobee (S-308), and the C-44 basin as well as an estimate of inflows from other basins in the watershed. The general goal of the CERP is to maintain a salinity range favorable to fish, oysters and SAV, which necessarily requires addressing high volume, long duration discharge events from Lake Okeechobee, the C-23, and C-24 watersheds (**Figure E-5**). A specific goal is to restore oyster populations in the area between the Roosevelt (US-1) and A1A bridges.

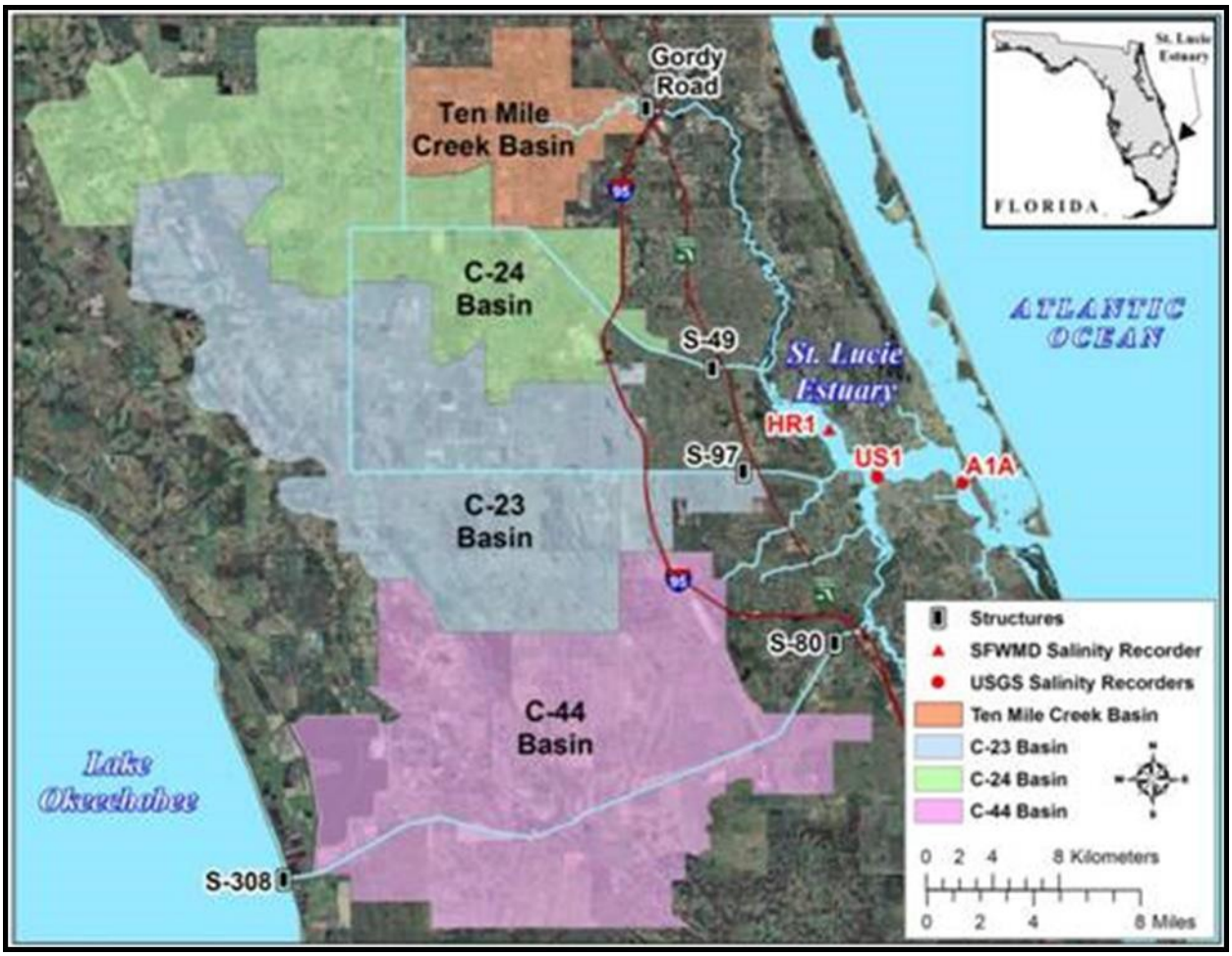


Figure E-5. Map of St. Lucie River Estuary showing locations of watershed basins and water control structures associated with drainage canals in those basins.

The CERP system-wide PM for Northern Estuaries salinity envelopes includes 3 criteria for the St. Lucie Estuary: 1) mean monthly inflow into the SLE of less than 350 cubic feet per second (cfs) from all sources including groundwater and all surface water tributaries (Low Flow criterion); 2) high flow events >2000 cfs from all sources based on a 14-day moving average (High Flow criterion), and 3) regulatory discharge events >2000 cfs from Lake Okeechobee based on a 14-days moving average (Lok Regulatory Releases criterion) (RECOVER 2007). The Salinity PM specifies the full restoration target for the Low Flow criterion as 31 months in a 36-year period. For the High Flow criterion the target is no more than 21 events of flow >2000 cfs based on a 14-day moving average. For the Lok Regulatory Releases criterion the target is zero events of regulatory discharge >2000 cfs [measured at S-80 for SLE (**Figure E-5**) and S-79 for CRE (**Figure E-2**).

Supplemental model output post-processing was provided to further evaluate low flow and high flow conditions. For low flow, the number of times minimum discharge criteria (mean monthly flow <350 cfs) were not met for a given number of consecutive months was determined and evaluated. For high flow, the number of times the mean monthly flow was between 2000 cfs and 3000 cfs, and the number of times the mean monthly flow exceeded 3000 cfs were examined. Additionally, the number of times maximum discharge criteria from the basins (14-day moving average >2000 cfs) were not met for a given number of consecutive months was examined. See **Table E-9** for flow/salinity metrics used in this evaluation and their expected ecological effects.

Table E-9. Salinity PM metrics and targets for the SLE and their expected ecological effects.

Mean Monthly Total Inflow	Ecological Response	Ranking Criteria
< 350 cfs	Salinity too high for optimal oyster health	Fewer is Better
350–2,000 cfs	Tolerable range	More is Better
2,000–3,000 cfs	Damage to estuary	Fewer is Better
> 3,000 cfs	Damage to SLE and Indian River Lagoon	Fewer is Better

E.3.3.2.1 Salinity PM Low Flow Criterion

Figure E-6 and **Table E-10** show the performance of the Low Flow criterion from the SLE component of the Northern Estuaries Salinity PM. All three project alternatives and the FWO scenario scored exactly the same—83 months during the 41-year POR when mean monthly flows were <350 cfs. Compared to ECB, the project alternatives and FWO move the restoration needle only 18% closer to the target. This is likely because LOWRP did not prioritize low flows to the SLE. The modeling assumptions include additional CERP projects as being operational for FWO and the LOWRP alternatives (i.e., Indian River Lagoon-South and the optimized release guidance component of CEPP).

E.3.3.2.2 Salinity PM High Flow Criterion

For the High Flow criterion, the 3 LOWRP alternatives and FWO exhibit little difference in performance, and the differences between scenarios are unlikely to be ecologically significant (**Figure E-7** and **Table E-10**). High Flow events for all project alternatives were approximately half the number of high flow events of ECB, and moves approximately halfway to the restoration target, but so does the FWO, indicating that the other CERP components included in the modeling assumptions account for predicted benefits instead of LOWRP.

E.3.3.2.3 Salinity PM Lok Regulatory Releases Criterion

For the Lake Okeechobee Regulatory Releases criterion, the three project alternatives are not appreciably different from each other (**Figure E-7** and **Table E-10**). Alt1Bshlw performs the best numerically of the three alternatives with 20 events of >2000 cfs regulatory releases from the lake over the 41-year POR. Only 4 events separated the best performing project alternative from the worst performing alternative (Alt2Cr). This separation is probably not ecologically significant. This is the only SLE metric that demonstrates an appreciable improvement of project alternatives compared to the FWO. The project alternatives reduce the number of harmful releases from the lake by 35-45% compared to the FWO. The LOWRP alternatives provided substantial improvement compared to the ECB and moved the restoration needle approximately two-thirds of the way closer to full restoration (i.e., target) compared to the ECB.

Table E-10. Model-predicted performance of baselines and the final array of three LOWRP alternatives using the SLE Salinity PM Flow Criteria. Targets are included for comparison purposes.

LOWRP Scenario	Low Flow Metric	High Flow Metric	LOK Regulatory Releases Metric
Target	31	0	0
ECB	95	99	71

LOWRP Scenario	Low Flow Metric	High Flow Metric	LOK Regulatory Releases Metric
FWO	83	50	37
Alt 1Bshlw	83	52	20
Alt 1BW	83	51	20
Alt 2Cr	83	51	24

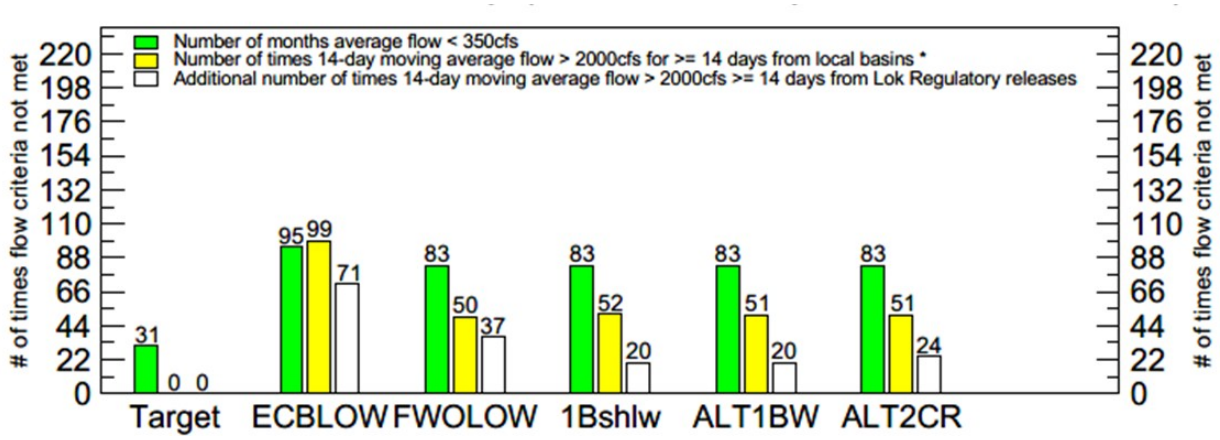


Figure E-6. Model-predicted performance of baselines [Existing Baseline Conditions (ECBLOW) and Future Without LOWRP (FWOLOW)] and the final array of three LOWRP alternatives using the SLE Salinity PM Flow Criteria. Targets are included for comparison purposes.

Table E-11. Number of times 1, 2, 3... consecutive months mean monthly flows fall below the Low Flow Criteria (<350 cfs) in the SLE over the entire POR (1965 - 2005).

No. of Consecutive Months	ECB	FWO	Alt1Bshlw	Alt1BW	Alt2Cr
9	1	1	1	1	1
8					
7	2	2	2	2	2
6	1				
5	3	3	3	3	3
4	3	1	1	1	1
3	3	2	3	3	3
2	8	11	9	9	9
1	14	13	14	14	14

E.3.3.2.4 Consecutive Months of Low Flow

The three LOWRP alternatives had identical scores for the number of times minimum discharge criteria (<350 cfs) were not met for a given number of consecutive months (**Table E-11**), and there was almost no difference between project alternative performance and FWO or ECB performance, and those differences were deemed to be ecologically insignificant.

A reduction in the number of Low Flow events is beneficial to oysters in the middle reaches of the SLE. Flows within the desired range of 350 – 2000 cfs provide optimal salinity conditions for oysters. When flow is too low, salinity increases above the desired optimum and makes conditions more favorable to oyster predators (e.g., crabs, oyster drills, etc.) and to oyster disease (e.g., Dermo). The LOWRP does not reduce the frequency or duration of these harmful low flow conditions compared to FWO.

E.3.3.2.5 Extreme High Flow

Model output shows little difference between LOWRP alternatives for the number of times mean monthly flow into the SLE was between 2000 and 3000 cfs or mean monthly flow was >3000 cfs (**Figure E-7**). It is unclear if differences between the three alternatives are ecologically significant, particularly for flow events exceeding 3000 cfs. All three alternatives performed better than FWO by approximately 28%. All three alternatives performed substantially better than ECB and is 44 – 54% closer to the target for mean monthly flows between 2000 and 3000 cfs, and 50 – 55% closer to the target for mean monthly flows >3000 cfs.

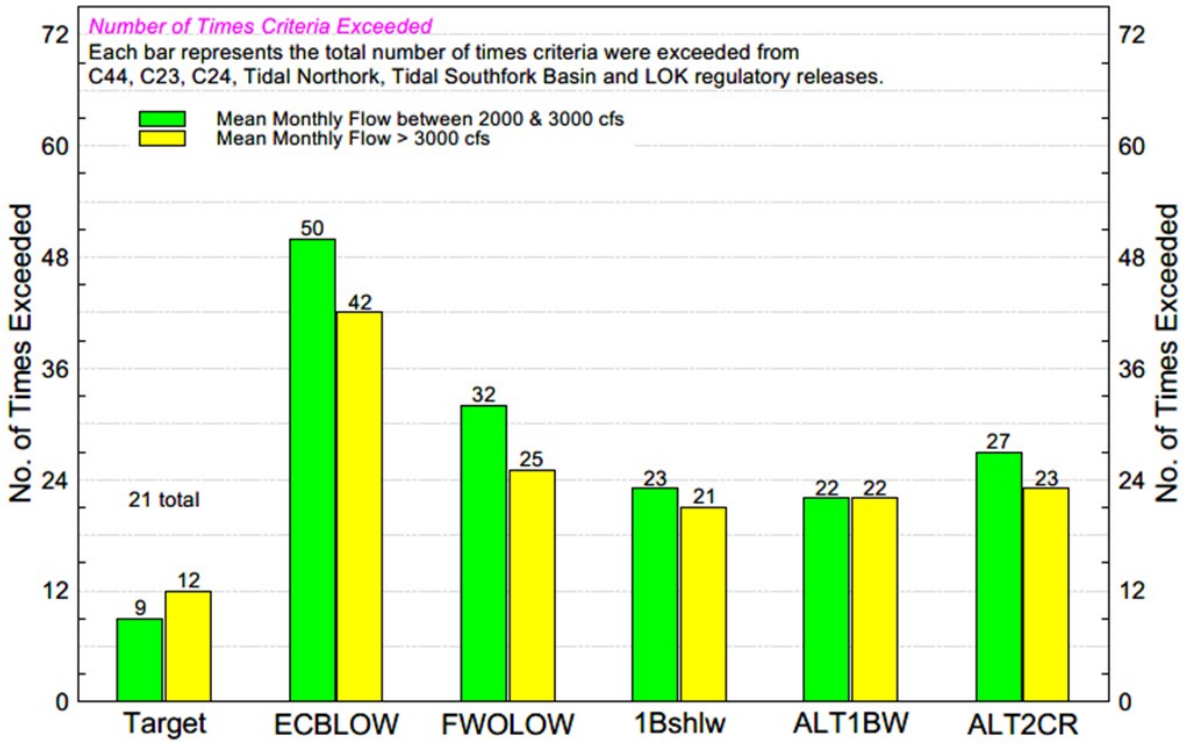


Figure E-7. Number of times the SLE High Discharge Criteria exceeded flows were >2000 & 3000 cfs and mean monthly flow was >3000 cfs.

E.3.3.2.6 Consecutive 14-day High Flow

The three LOWRP alternatives and FWO scored similarly for the number of times maximum discharge criteria (>2000 cfs) were not met for a given number of consecutive months (**Table E-12**), and it is unclear if there are any ecologically meaningful differences between FWO and the three project alternatives.

Table E-12. Number of times 1, 2, 3... consecutive months mean monthly flows exceed the High Flow Criteria (>2000 cfs) in the SLE over the entire POR (1965 - 2005).

No. of Consecutive Months	ECB	FWO	Alt1Bshlw	Alt1BW	Alt2Cr
17	1				
16					
15					
14					
13					
12	1				
11					
10	1				
9	1				
8	2	1			
7				1	1
6	2	1			
5	3	1	1	3	3
4	3	6	5	1	2
3	3	5	4	3	5
2	11	4	6	7	6
1	36	21	23	22	18

As in the CRE, fewer incidences of High Flow events, especially during the wet season, is beneficial for oysters in the SLE by preventing oligohaline-to-freshwater conditions in the Middle Estuary where oyster reefs are found. Even salinity below 10 ppt will stress some life history stages of oysters. As noted above, oysters can withstand extended low-salinity (e.g., 5 psu) conditions for a few weeks at a time, but salinity below 3 ppt is lethal (RECOVER 2007b). Flow/salinity relationships developed in the SLE indicate that flow above 2000 cfs results in salinity <3 ppt. It is difficult to ascertain whether the LOWRP alternatives have ecologically significant differences in the frequency and duration of harmful High Flow criteria (>2000 cfs) exceedances compared to FWO, but they do demonstrate a trend toward targets.

E.3.4 Summary and Conclusions

To promote understanding for stakeholders, managers, and LOWRP PDT members, the key findings from the Northern Estuaries evaluations of the LOWRP alternatives are provided below.

The CRE evaluation indicates slight numeric differences between LOWRP alternatives for most criteria, whose differences may or may not be ecologically significant, except for the improvement in the number of times mean monthly flows exceeded 2800 cfs for 7 consecutive months (from 1 to zero), and for 5 consecutive months (from 5 for FWO, to <2 months between the three alternatives). All SLE evaluation criteria indicate only slight numeric differences between LOWRP alternatives, but they demonstrate a trend toward targets.

Although Alt2Cr would have significantly more storage capacity than Alt1Bshlw and Alt1BW, it does not perform appreciably better. While existing authorized CERP projects provide the greatest benefit from ECB, LOWRP provides an additional increment of performance towards CERP goals beyond those projects.

The Lake Okeechobee Regulatory Releases criterion demonstrates an appreciable improvement from project alternatives compared to FWO, but again, there is little difference in performance between project alternatives. The project alternatives reduce the number of harmful releases from the lake by 35 – 45% compared to FWO. The LOWRP alternatives provide substantial improvement in reducing Lake Okeechobee regulatory releases compared to ECB and move the restoration needle closer to the full restoration target compared to ECB. However, Lake Okeechobee is not the only source of water for the Northern Estuaries, which also receive inputs from basin runoff. There is no guarantee these estuaries will not be affected by other sources of water, such as basin runoff, even with reductions in lake releases.

E.4 Lake Okeechobee

E.4.1 Introduction

The Lake Okeechobee regional report evaluates RSM-BN predictions of storage and treatment of water for two sections of the LOWRP: (1) the watershed and (2) Lake Okeechobee (**Figure E-8**). Simulations assume the current Lake Okeechobee Regulation Schedule (LORS 2008) with operational refinements as outlined by the LOWRP and CEPP. The optimized operations, related to CEPP, are described in the H&H appendix of the CEPP PIR/EIS.

To assess the effects of the LOWRP, output from five modeling scenarios were compared. Modeling scenarios included Alt1Bshlw, Alt1BW, and Alt2Cr, the ECB, and the FWO. The ECB represents the present configuration and operation of the water management system. The FWO scenario simulates a future configuration of the water management system without the LOWRP, but with other CERP projects that should benefit the overall system (**subsection 1.3.1**).

One LOWRP PM was developed to determine optimal sites for wetland restoration within the project area:

1. Lake Okeechobee Watershed Wetlands Restoration (LOWRP 2016)

Two RECOVER PMs for Lake Okeechobee were used in the LOWRP plan formulation and evaluation; one is based on hydrologic targets, including frequency of duration within an ecologically preferred lake stage envelope, as well as frequency of extreme high and low stages; and the other is based on predicted relationships of various flora and fauna to lake stages, which are scored and summed as an indicator of ecological conditions. These two PMs are:

1. Lake Stage (RECOVER 2007a)
2. Ecological Indicator Score - vascular SAV, non-vascular SAV (Chara spp.), panfish, cyanobacteria, epiphyton, and epipelon (RECOVER 2016)

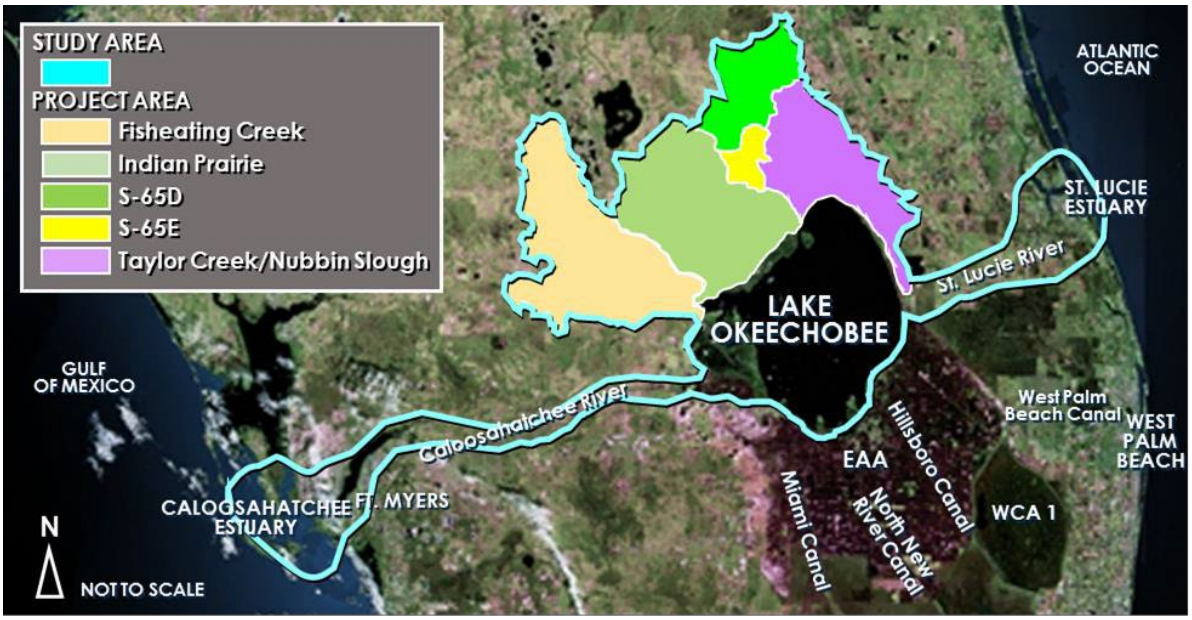


Figure E-8. The LOWRP Project Area. The watershed encompasses approximately 950,000 acres and includes the following sub-watersheds: Fisheating Creek, Indian Prairie, Lower Kissimmee (S-65D and S-65E) and Taylor Creek/Nubbin Slough.

E.4.2 Performance Measures and Evaluation Approach

E.4.2.1 The Watershed

No PMs were developed or used in plan formulation to evaluate the watershed. However, to meet project objectives, the project team pursued a complementary formulation strategy that considered wetland restoration at sites within the project area. Wetland restoration, in conjunction with water storage features in each alternative, is expected to increase overall efficiency and effectiveness of the restoration and storage elements. Information on the methodology regarding the selection of wetland restoration sites can be found in **Section 3** of the LOWRP PIR/EIS.

E.4.2.1.1 Lake Okeechobee Watershed Wetlands Restoration

The LOWRP PM aims to identify wetland sites considered optimal for restoration, and the analysis occurred separately from those used to determine the tentatively selected plan. This PM should be considered when evaluating the ECB and FWO scenarios. The selected wetlands sites, as determined by the PM, are intended to meet project objectives and supplement the benefits of the tentatively selected plan by increasing wetland acreage. The Restudy (also known as the Yellow Book) 'target' is 3,500 acres of wetland restoration within the Lake Okeechobee watershed basin (Lake Okeechobee watershed water quality treatment facilities). This target was adopted as a minimum threshold during the plan formulation process for LOWRP.

E.4.2.2 Lake Okeechobee

E.4.2.2.1 Lake Stage

The CERP goals for Lake Okeechobee are to have no frequent or prolonged departures of lake stage outside of the prescribed lake stage "envelope", other than an approximately once-per-decade dip to 11 ft. NGVD for

three months. Additionally, extreme high and low lake stage events would preferably be rare and of short duration.

E.4.2.2.1.1 Lake Stage Envelope

A wide body of published research (summarized in Havens 2002) documents the ecological benefits of seasonally variable water levels within the range of 12.0 feet (ft.) NGVD, in June and July, and 15.0 ft., from November to January. Falling water levels in late winter to spring benefit wading birds by concentrating prey resources in the littoral zone where those birds forage (Smith et al. 1995), water levels near 12.0 ft. benefit submerged plants and bulrush by providing optimal light levels for photosynthesis in the summer months (Havens et al. 2004), and variation in the prescribed range results in annual flooding and drying of upland areas of the littoral zone, which favors development of a diverse emergent plant community (Richardson et al. 1995, Keddy and Frazer 2000). However, periodic low stage events (11 ft. NGVD) occurred approximately once per decade at a duration of roughly three months in the 1950s to 1970s (prior to implementation of high stage regulation schedules), and are considered beneficial to the littoral zone because they allow for periodic exposure of seed banks, oxidation of accumulated organic material, and fires that are important to maintaining species diversity in the littoral zone.

E.4.2.2.1.2 Extreme High Lake Stage

Extensive research has documented the adverse impacts of extreme high and extreme low water levels on the littoral and nearshore areas of Lake Okeechobee (Havens 2002, Havens and Gawlik 2005). Extreme high stage, considered here as >17 ft. NGVD, allows wind-driven waves to uproot emergent and submergent plants in the littoral and nearshore regions. In addition, high lake stage permits the transport of suspended solids from the open water region, where unconsolidated sediments are thickest, to sand and peat-dominated nearshore and littoral regions. Transport of suspended solids to the nearshore and littoral regions reduces water clarity and light penetration, resulting in less submerged aquatic vegetation growth (James and Havens 2005). At extreme high lake stage, the transport of nutrient-rich water from the open water region to the littoral region may increase phytoplankton biomass and algal bloom frequency (RECOVER 2007c). It may also reduce periphyton biomass (through reduced light penetration), result in a less desirable phytoplankton community structure (e.g., increased cyanobacteria), and induce shifts in plant dominance to more undesirable taxa, such as cattail (*Typha* spp). Overall, high lake stages can result in reduced growth and germination of submerged plants, reduced reproduction of fish, and reduced diversity and increase of pollution-tolerant macroinvertebrates. Detailed research results regarding high stage impacts on the lake's plant and animal communities are in Maceina and Soballe (1990), Havens (1997), and Havens et al. (2001).

Table E-13. Illustration of how the valuation is performed for the lake stage envelope. The shaded central area is the desired stage envelope. Note that optimal scores include lake stages between 12.0 – 16.0 ft. NGVD.

Stage (ft. NGVD)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
19.0	3.5	4.0	4.5	5.0	6.0	6.5	6.5	6.0	5.0	4.0	3.5	3.5
18.5	3.0	3.5	4.0	4.5	5.5	6.0	6.0	5.5	4.5	3.5	3.0	3.0
18.0	2.5	3.0	3.5	4.0	5.0	5.5	5.5	5.0	4.0	3.0	2.5	2.5
17.5	2.0	2.5	3.0	3.5	4.5	5.0	5.0	4.5	3.5	2.5	2.0	2.0
17.0	1.5	2.0	2.5	3.0	4.0	4.5	4.5	4.0	3.0	2.0	1.5	1.5
16.5	1.0	1.5	2.0	2.5	3.5	4.0	4.0	3.5	2.5	1.5	1.0	1.0
16.0	0.5	1.0	1.5	2.0	3.0	3.5	3.5	3.0	2.0	1.0	0.5	0.5

Stage (ft. NGVD)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
15.5	0.0	0.5	1.0	1.5	2.5	3.0	3.0	2.5	1.5	0.5	0.0	0.0
15.0	0.0	0.0	0.5	1.0	2.0	2.5	2.5	2.0	1.0	0.0	0.0	0.0
14.5	0.0	0.0	0.0	0.5	1.5	2.0	2.0	1.5	0.5	0.0	0.0	0.0
14.0	0.5	0.0	0.0	0.0	1.0	1.5	1.5	1.0	0.0	0.0	0.5	0.5
13.5	1.0	0.5	0.0	0.0	0.5	1.0	1.0	0.5	0.0	0.5	1.0	1.0
13.0	1.5	1.0	0.5	0.0	0.0	0.5	0.5	0.0	0.0	1.0	1.5	1.5
12.5	2.0	1.5	1.0	0.5	0.0	0.0	0.0	0.0	0.5	1.5	2.0	2.0
12.0	2.5	2.0	1.5	1.0	0.0	0.0	0.0	0.0	1.0	2.0	2.5	2.5
11.5	3.0	2.5	2.0	1.5	0.5	0.5	0.5	0.5	1.5	2.5	3.0	3.0
11.0	3.5	3.0	2.5	2.0	1.0	1.0	1.0	1.0	2.0	3.0	3.5	3.5
10.5	4.0	3.5	3.0	2.5	1.5	1.5	1.5	1.5	2.5	3.5	4.0	4.0
10.0	4.5	4.0	3.5	3.0	2.0	2.0	2.0	2.0	3.0	4.0	4.5	4.5
9.5	5.0	4.5	4.0	3.5	2.5	2.5	2.5	2.5	3.5	4.5	5.0	5.0
9.0	5.5	5.0	4.5	4.0	3.0	3.0	3.0	3.0	4.0	5.0	5.5	5.5
8.5	6.0	5.5	5.0	4.5	3.5	3.5	3.5	3.5	4.5	5.5	6.0	6.0
8.0	6.5	6.0	5.5	5.0	4.0	4.0	4.0	4.0	5.0	6.0	6.5	6.5
7.5	7.0	6.5	6.0	5.5	4.5	4.5	4.5	4.5	5.5	6.5	7.0	7.0

E.4.2.2.1.3 Extreme Low Lake Stage

Conversely, extreme low stage, considered here as <10 ft. NGVD, results in desiccation of the entire marsh, including the deepest reaches of emergent plants, as well as a large portion of the nearshore region that supports submerged plants. Extreme low stage also encourages invasive exotic plants such as torpedograss and melaleuca to establish and spread in the upper reaches of the marsh, displacing native vegetation. Recovery from prolonged low stage events below 10 ft. NGVD is slow, requiring multiple years of appropriate stage regimes, as documented for submerged plants by Havens et al. (2004), for sport fish such as largemouth bass (Havens et al. 2005) and from field observations from 2007 to present.

Ecological Indicator Score

A number of key ecological communities occupy the nearshore and pelagic regions of Lake Okeechobee and can be used to assess the environmental health of the lake. Attributes considered in the ecological indicator score performance measure include several communities in the nearshore region; vascular SAV, non-vasular SAV (*Chara* spp.), panfish (bluegill and redear sunfish), cyanobacteria, and two types of periphyton; those growing on vegetation (epiphyton) and those on the sediment (epipelon).

Nearshore SAV and *Chara* provide important habitat for fish, wading birds, macroinvertebrates, other taxa and epiphytic algae (Havens et al. 2002). Similarly, the epipelic and epiphytic communities are important components of the lake's food web and compete with algal species for available nutrients (Zimba 1995; Carrick & Steinman 2001; Rodusky et al. 2001; 2010), while cyanobacteria can cause major health and safety issues if they are present in high abundance (US EPA 2016). Fish (panfish) are ecologically important because they represent a higher trophic level, which allows for the integration of other aspects of lake ecology. These components of the Lake Okeechobee ecosystem have been the subject of regular monitoring, allowing for the availability of long-term monitoring data sets. These data are needed to elucidate the relationships between lake stages and ecological responses.

The ecological indicator scores used in this combined performance measure are based on the average monthly lake stage that had the strongest, statistically significant correlation with the ecological indicator. The summer cyanobacteria abundance data were collected during July, (1994, 2000-2011) and June (1995). The panfish creel data were collected during January and February, 1997-2005. The epipelon abundance data were collected near the end of August 2002, March/April and September/October of 2003-2005 and 2008-2010. The epiphyte abundance data were collected during the same timeframe as the epipelon data during 2002-2005; the spring collection did not resume until 2009 due to lack of host vegetation and continued in 2010, fall 2011 and spring and fall 2012. The annual summer *Chara* and SAV coverage data were collected between 2000 and 2012 (SAV) and 2000 and 2013 (*Chara*). For all of the indicators, the lake stages in the correlation data sets were between approximately 3m and 5m, which defines the approximate range of lake stages over which this performance measure can be used.

E.4.3 Evaluation The Watershed

Lake Okeechobee Watershed Wetlands Restoration

One of the goals of the LOWRP is to achieve appropriate depth, duration and frequency targets in the Lake Okeechobee watershed wetlands. Wetland restoration is intended to increase habitat, water supply, and recreation in the watershed. The PM has five sub-metrics that establish the wetland targets. Scores from the wetland metrics were used to identify potential restoration sites.

- Wading bird support – the site is within 15km of a known wading bird colony.
- Percent connectivity – the site is connected to other lands that are in public ownership or have other environmental protections, such as conservation easements.
- Surface water connections – the site has a surface water connection to another water body (e.g. lake, creek, river, canal, wetlands) and would improve hydrological connectivity
- Restoration potential percent – the site is comprised of a high percentage of lands needing restoration
- Public Access - Site has high potential for public access and would support wildlife-related recreation thereby supporting a goal of the original C&SF Project as well as the CERP's Master Recreation Plan.

Each sub-metric uses the top-scoring and lowest-scoring wetland candidates as the determinants for the zero to 1.0 score. The LOWRP sub-team also agreed to target potential restoration lands that possessed at least 85 percent hydric soils (historic and current combined) in an effort to minimize acquisition of large areas of non-hydric soils that could undermine wetland restoration potential. Nine sites were evaluated (**Table E-14**; **Figure E-9**). Other constraints included:

1. No or minimal adverse impacts to threatened and endangered species as a result of restoration activities;
2. Site does not have potential for high chemical contaminant load based on historic land use that would interfere with restoration; and
3. Site does not have significant archaeological or cultural resources that would be adversely impacted by restoration activities.

Table E-14. Performance Measure Scores for Wetland Restoration Measures.

Site	Acreage	Wading Bird Colonies	Connectivity	Surface Water Connectivity	Restoration Potential	Colocation	Public Lands	Total
Lake O West	2,800	0.65	1	0.74	0.76	0.5	0	3.65
Paradise Run	3,847	0.47	0	1	0.49	1	0.5	3.46
Kissimmee River	2,595	0.47	0.16	0.75	0.33	0.5	1	3.21
IP-10	4,315	1	0.26	0.3	0.71	0.5	0	2.77
Bootheel Creek	3,432	0	0.79	0.52	0.39	0	0	1.7
Indian Prairie	5,370	0.47	0.39	0.1	0.53	0	0	1.49
Fish Slough	3,742	0	0.49	0.18	0.66	0	0	1.33
Lake O East	2,713	0.12	0	0	1	0	0	1.12

Based on the LOWRP sub-team's evaluation, six wetland sites were selected for the final round of evaluation: Lake Okeechobee West, IP-10, Paradise Run, and Kissimmee River (North, Center, and South) (**Figure E-9**). Scores for metrics at each site are reported in the LOWRP Wetland Restoration PM doc sheet (see LOWRP PIR/EIS Appendix G).

To determine wetland restoration benefits, habitat units (HUs) were calculated by measuring the acreage of different habitats in the wetland footprints. A "quality factor" (called Ecological Value; EV) was assigned for each habitat type within all of the potential restoration sites based on land use code (FLUCCS; from the 2015 SFWMD shapefile) using best professional judgment, supplemented by limited field evaluations. FLUCCS that are more ecologically degraded received lower EVs, while more native or natural habitats received higher EVs (on a scale of 0.0 to 1.0). FLUCCS that indicated permanent inundation (*e.g.,* 6440 Emergent Aquatic Vegetation, and 5600 Slough Waters) were assigned the highest EVs of 0.7. Other wetlands were assumed to show some level of adverse impact (due to a high percentage of non-native land uses around these wetlands); therefore, received a maximum EV of 0.5. Using ArcGIS, the size of each FLUCCS polygon within each potential restoration site was measured and multiplied by its EV to arrive at a HU for that polygon. All polygons inside the restoration site were then summed to calculate the total HUs.

Table E-15 provides a summary of existing condition, FWO, and alternative HUs. To calculate the benefits for each wetland site, the HUs for the FWO condition are subtracted from the HUs in the future with project condition. This results in the habitat unit lift for each wetland site.

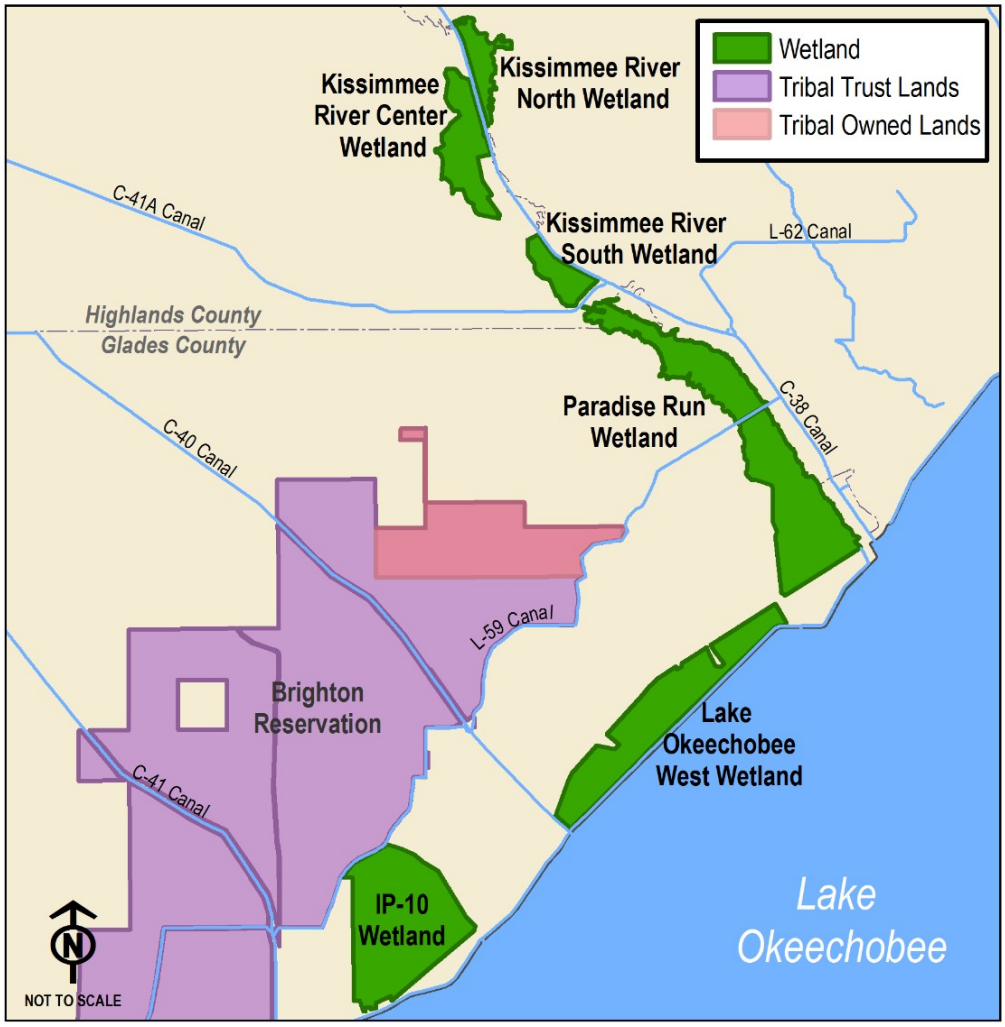


Figure E-9. Wetland Sites selected for final round of evaluation.

The Institute of Water Resources Planning Suite (IWR-Plan; certified version 2.0) Plan Generator and Cost Effectiveness/Incremental Cost Analysis modules were used to combine the potential wetland sites and identify cost-effective and 'best buy' combinations. This analysis is described in more detail in Section 3 of the LOWRP Project Implementation Report.

Table E-15. Habitat Unit Lift for Each Wetland Site

	Lake Okeechobee West	IP-10	Paradise Run	Kissimmee River-North	Kissimmee River-Center	Kissimmee River-South
Existing Condition HUs	620	850	1632	232	343	267
Future Without Project HUs	486	666	1278	182	269	209
Future With Project HUs	2,792	3,532	4084	537	1,196	553
HU Lift	**2,306**	**2,866**	**2806**	**355**	**927**	**344**

The best buy components were retained for further analysis. Kissimmee River Center and Paradise Run sites were selected as the wetland restoration component that met the 3,500 acre target for the least cost. By adding the proposed sites as restored wetlands (5,300 acres), the total wetland acreage in the LOWRP area will increase from 110,746 acres to 116,046 acres or an increase in wetland habitat from approximately 29% to 31% as compared to historical wetland acres.

It should be noted that the increase in wetland habitat benefits is expected under the assumption that the restored wetland sites will return an EV score of 1.0 under with-project conditions. Additionally, restoration measures to be implemented at each site have not yet been determined. It will be important for the project to consider the most effective restoration measures to ensure expected habitat benefits are realized.

Restoration of wetlands in the watershed can provide a crucial role in improving nutrient loading into Lake Okeechobee. The primary land uses in the watershed are beef cattle ranching and dairy farming for which there is a high net phosphorus (P) import (Flaig and Reddy 1995, Havens and Gawlik 2005).

Lake Okeechobee

Lake Stage

The Lake Stage PM includes evaluations of stage envelope (12.5 to 15.5 ft. NGVD), extreme high lake stage (>17.0 ft. NGVD), and extreme low lake stage (<10.0 ft. NGVD). In general, LOWRP followed the evaluation methods described in the Lake Stage - Lake Okeechobee PM document (RECOVER 2007a). The only difference is the LOWRP uses lake stages simulated by the RSM-BN model, rather than the SFWMM model.

Above Lake Stage Envelope

The above lake stage envelope performance measure evaluates the frequency and duration of stages above the optimal stage envelope (12.5 – 15.5 ft. NGVD). Optimal conditions are met when lake levels remain in the stage envelope, and this PM evaluates stages above that range, or stages above 13.0 – 16.0 ft., depending on time of year (**Figure E-8**). ALTs had relatively similar performance, scoring higher than the FWO by 2.3 – 3.3%. Alt2Cr performed the best by reducing time above the optimal range the most (**Figure E-10**).

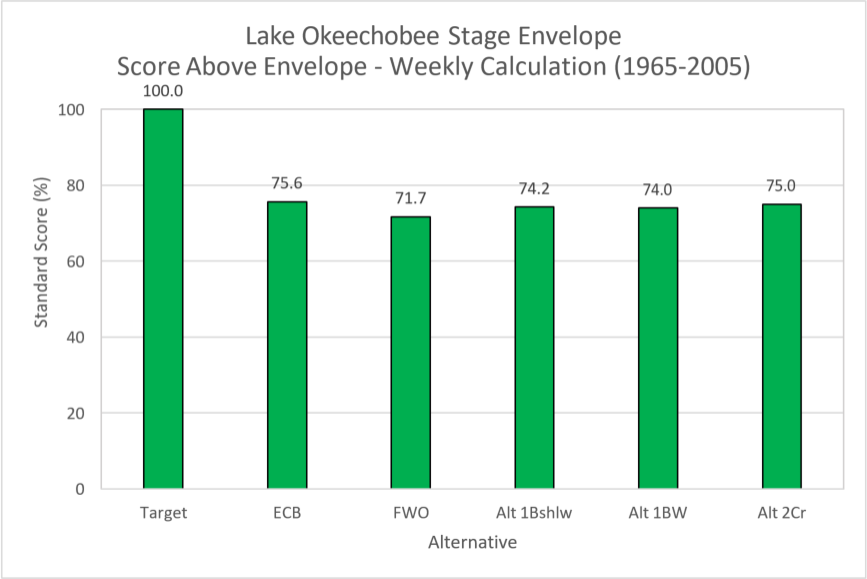


Figure E-10. Scores for Above Stage Envelope at Lake Okeechobee. A score of 0% is the worst score and indicates stage exceeds the envelope by 1 ft., or more, on average. A score of 100% is the best score and indicates the stage never exceeds the envelope.

Below Lake Stage Envelope

The below lake stage performance measure evaluates the frequency and duration of stages below the optimal stage envelope, penalizing stages below 12.0 – 14.5 ft. NGVD, depending on time of year. There was a noticeable difference between ALTs, ranging from 10.2% improvement from the FWO for Alt1BW to 14.2% improvement for Alt2Cr (**Figure E-11**).

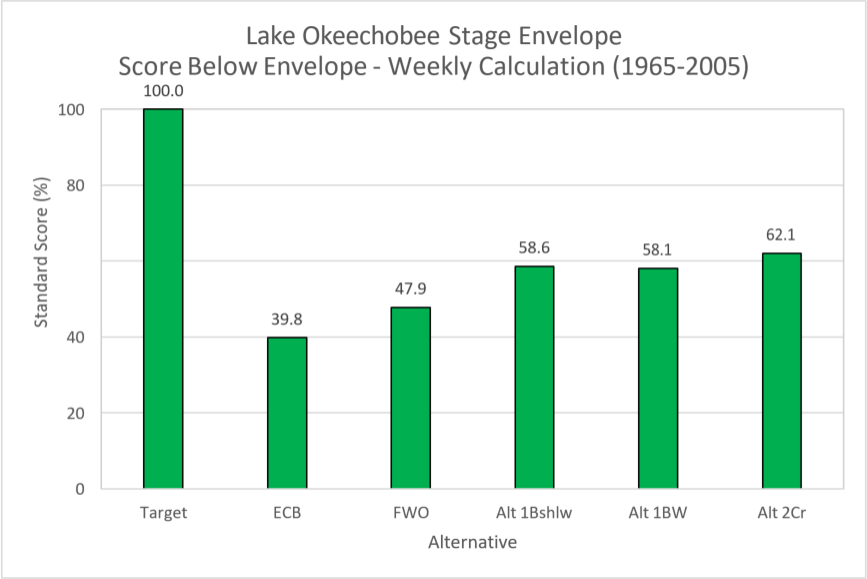


Figure E-11. Scores for Below Stage Envelope at Lake Okeechobee. A score of 0% is the worst score and indicates the stage falls below the envelope by 1 ft., or more, on average. A score of 100% is the best score and indicates the stage only falls below the envelope 10% of the time (<11 ft. NGVD for 3 months).

Above Extreme High Lake Stage

The above extreme high lake stage performance measure evaluates the duration of lake stages exceeding 17 ft. NGVD. All of the ALTs scored worse than the FWO, ranging from 5.1% worse for Alt1Bshlw to 2.7% worse for Alt2Cr (**Figure E-12**).

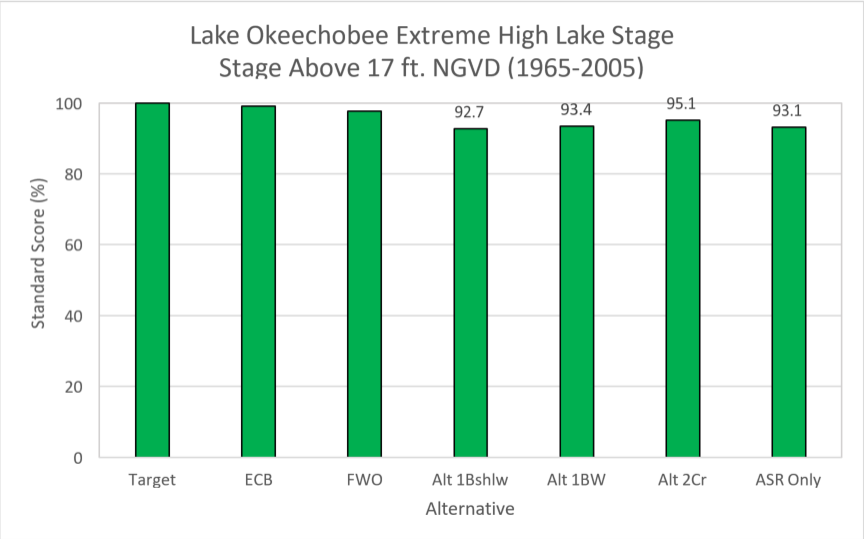


Figure E-12. Scores for Extreme High Lake Stage at Lake Okeechobee. A score of 0% is the worst score and indicates the stage exceeds 17 ft. NGVD for an average of 11 weeks, or more, per year. A score of 100% is the best score and indicates the stage never exceeds 17 ft.

Below Extreme Low Lake Stage

The below extreme low lake stage performance measure evaluates the duration of lake stages below 10 ft. NGVD. There was little difference between ALTs, with all scoring between 4.4% and 5.5% better than the FWO (**Figure E-13**). Among ALTs, Alt2Cr performed the best, while Alt1BW and Alt1Bshlw performed most similarly.

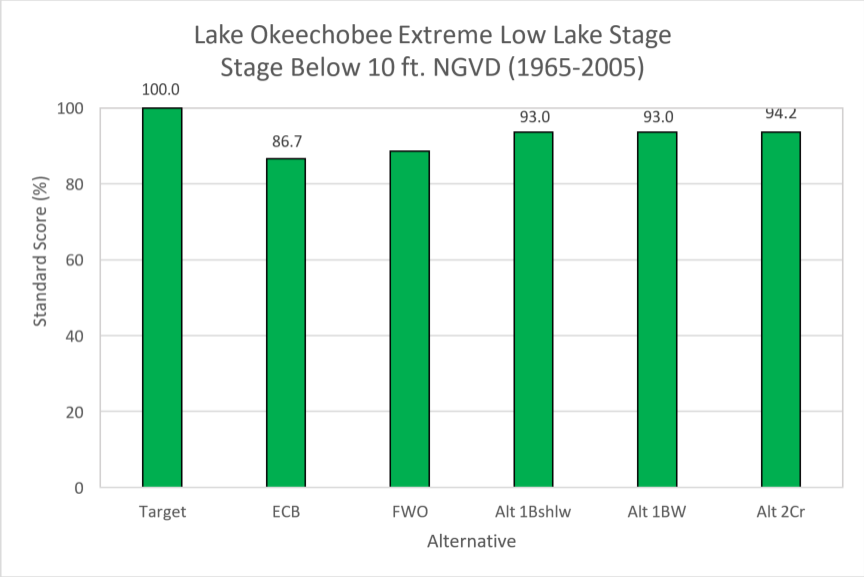


Figure E-13. Scores for Extreme Low Lake Stage at Lake Okeechobee. A score of 0% is the worst score, meaning the stage falls below 10 ft. NGVD for an average of 15 weeks, or more, per year. A score of 100% is the best score, meaning the stage never falls below 10 ft.

Stage Duration Curve

The stage duration curves for the ECB, FWO, Alt1Bshlw, Alt1BW, and Alt2CR show that all ALTs improve performance by reducing the duration of stages below 12 ft. NGVD, as well as duration and frequency of extreme low stages (<10 ft. NGVD). However, all ALTs slightly increase the frequency for extreme high lake stages (>17 ft. NGVD), while reducing the duration of stages in the lower end of the ecologically beneficial range (**Figure E-14**).

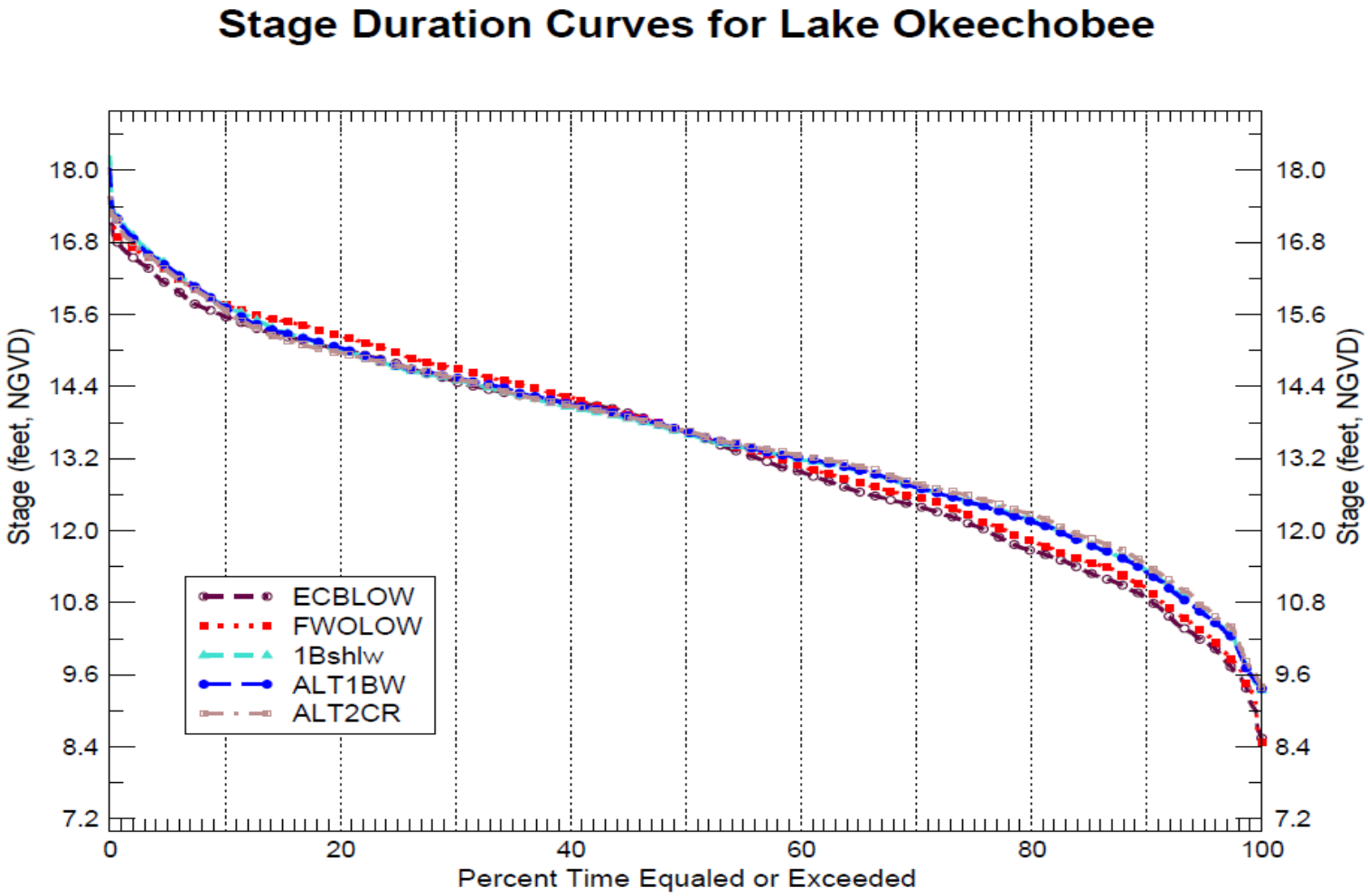


Figure E-14. Stage duration curves for the ECB, FWO, ALT1Bshlw, ALT1BW, and ALT2CR. The green line indicates the upper and lower thresholds of the stage envelope.

Ecological Indicator Score

The ecological indicator score performance measure includes evaluations of six nearshore ecological indicators (vascular SAV, *Chara*, panfish, cyanobacteria, epiphyton, and epipelon). In general, LOWRP followed the evaluation methods described in the Ecological Indicator Score – Lake Okeechobee Performance document (RECOVER 2016). The only difference is the LOWRP uses lake stages simulated by the RSM-BN model, rather than the SFWMM model.

The scores for each individual indicator and the combined annual ecological scores for each alternative were provided by the project team (**Figure E-15** and **Figure E-16**). The combined ecological scores for each alternative are calculated by summing the individual scores from each indicator.

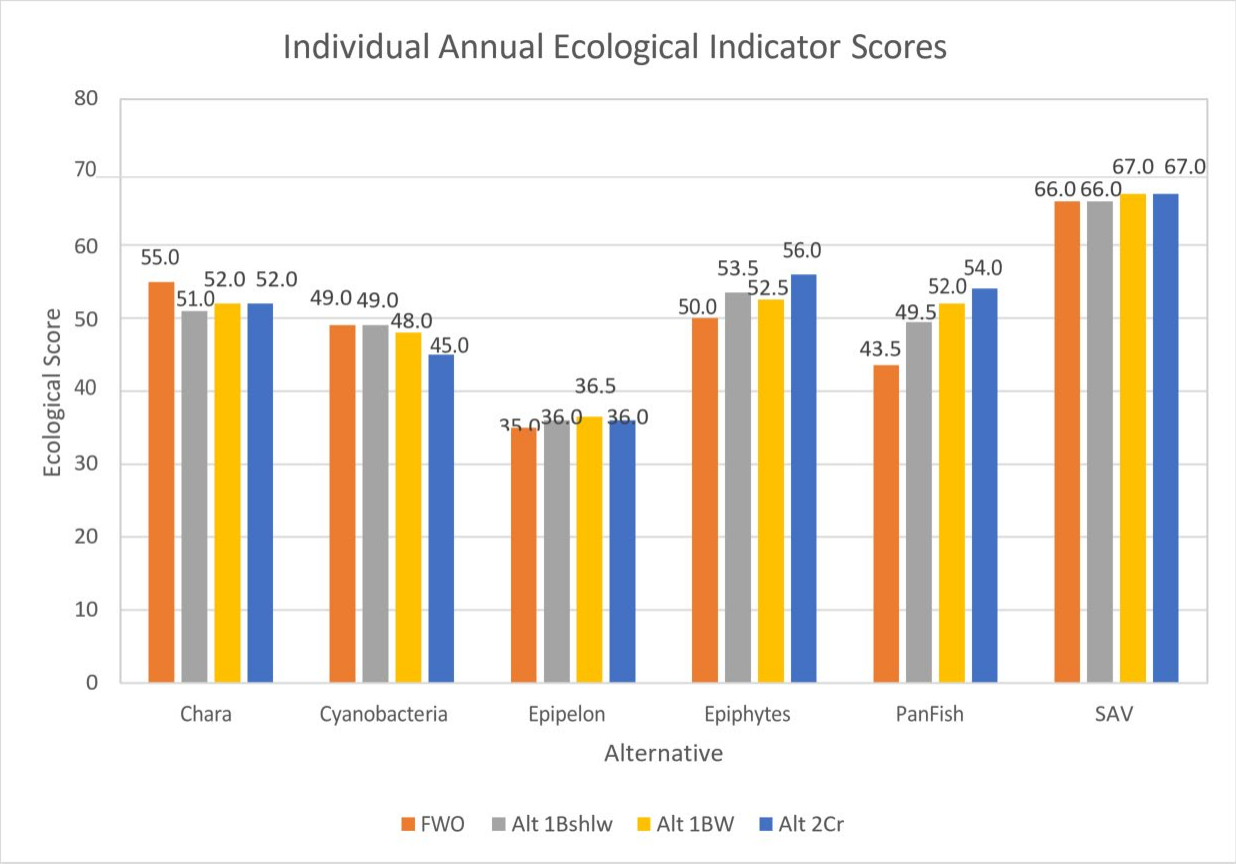


Figure E-15. Scores for ecological indicators in FWO, ALT1Bshlw, ALT1BW, and ALT2CR.

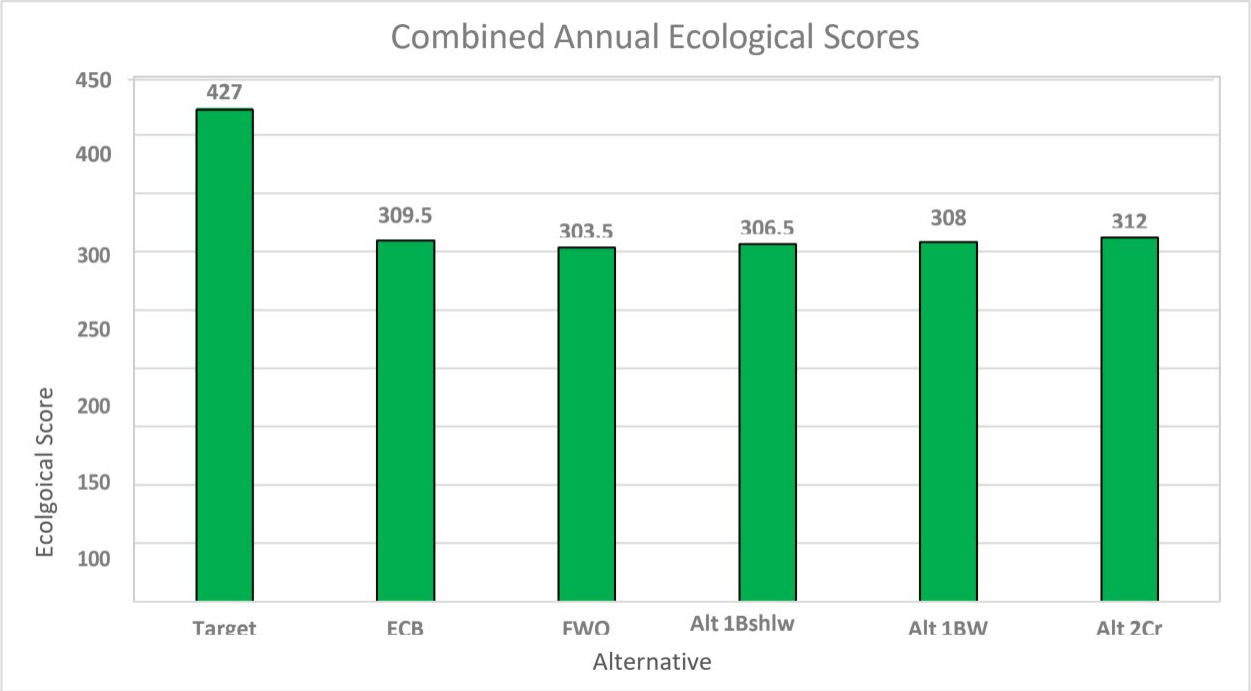


Figure E-16. Combined annual scores for ecological indicators in ECB, FWO, ALT1Bshlw, ALT1BW, and ALT2CR.

The combined scores provided by the project team did not equal the sum of the indicator scores provided, so the indicator scores were recalculated and the adjusted scores were used for the evaluation (**Figure E-17**). The re-calculation did not affect the ranking of scenarios; all ALTs achieved higher combined annual scores than the FWO.

In addition to re-calculating scores, some of the indicators were excluded from the combined indicator evaluation. The Ecological Indicator PM considers panfish and vascular SAV, which are identical to the indicators used to develop the Lake Stage Envelope PM. These indicators receive the highest scores when they fall within stages deemed optimal by the Stage Envelope PM (12 ft. – 15 ft.). By considering panfish and vascular SAV in the combined ecological score, it essentially duplicates the evaluation done by the Stage Envelope PM. To rectify this issue, the duplicated scores from these indicators were excluded, and the combined ecological score was re-calculated again (**Figure E-18**). The revised combined scores reduced the difference observed between scenarios, resulting in virtually identical scores for all ALTs and the FWO. Since each of the indicators considered in the combined score have slightly different hydrological requirements, the individual scores were evaluated separately. The individual score for *Chara* was the highest in the FWO (**Figure E-15**). All ALTs performed similarly and resulted in shorter durations of lake stages below 12 ft., depths that are amenable to Chara abundance. Lower water levels can increase irradiance, which supports Chara productivity (James and Havens 2005).

For epipelon, all ALTs performed better than the FWO, however there was very little difference between all scenarios. Scores ranged from 35 to 36.5, equating to differences of 1 or 2 monthly averages out of the POR.

For epiphytes, all ALTs performed better than the FWO. Alt2Cr performed best, while Alt 1BW performed the worst out of the ALTs. Optimal growth conditions for epiphytes occur when water depths are less than 14 ft. during the spring (March or April) and fall (September or October). Average lake stage in the fall

(September) appeared to influence ALTs scores the most. Average lake stage did not differ significantly between scenarios during the spring (March).

Scores for cyanobacteria were highest for Alt1Bshlw and the FWO, indicating the FWO and Alt1Bshlw would perform the best in preventing cyanobacterial blooms. Alt1BW performance was also comparable to the FWO and Alt1Bshlw, while Alt2Cr scored the lowest. Thus, according to the PM scoring methodology, Alt2Cr would have the highest probability in creating conditions that could potentially increase cyanobacteria abundance. However, though Alt2CR had the lowest score, it should be noted that it performed the best in the extreme high lake stage PM. For stages less than 14 ft. NGVD, Alt2Cr spends a longer duration at slightly higher stages compared to the other ALTs (**Figure E-14**). However, at stages greater than 14 ft. NGVD, Alt2CR spends a slightly shorter duration at higher stages compared to the other ALTs. This information is lost in the PM score since all stages greater than 14 ft. NGVD receive a score of 0. The increased performance of Alt2CR is likely attributed to its larger storage capacity, relative to the other LOWRP ALTs.

The cyanobacteria scores are determined by average May lake stage, which had the highest correlation with June and July cyanobacteria abundance. In the 10 wettest years over the 41-year POR, or those years where the average May lake stage was near 14.0 ft. NGVD (a 0 score for cyanobacteria PM), all LOWRP Alts varied between having better conditions (lower stages) or worse conditions (higher stages). All Alts performed worse than FWO in the top 4 wettest years (90th percentile), and better in the 5th – 9th wettest years (80th – 90th percentile), by similar amounts; between 0.7 ft. lower and 0.6 ft. higher (**Figure E-9**). In other words, in the very wettest of years, all LOWRP Alts had higher average May stages, but in more moderate wet years all LOWRP Alts had lower average May stages. Cyanobacteria abundance is likely dependent on other factors as well, like nutrient load, which would tend to be higher in wet years due to higher inflows and watershed runoff. However, assuming lake stage itself is a driving factor, all LOWRP Alts would potentially support higher cyanobacteria abundance relative to FWO in the very wettest of years (90th percentile). Despite these potential increases, these extreme high lake stages are expected to occur infrequently, which may avoid significant ecological effects.

Table E-16. Average May lake stage for FWO each LOWRP ALT during the ten highest years.

Year	FWO	Alt 2Cr	Alt1BShallow	Alt 1BW
1996	13.9	14.2	14.0	14.1
1979	14.4	13.9	13.8	14.0
1984	14.5	14.0	13.8	13.9
2003	14.6	13.9	14.0	13.9
1980	14.7	14.3	14.2	14.2
1993	14.8	14.3	14.4	14.4
1998	14.8	15.2	15.1	15.2
1995	14.9	15.5	15.2	15.3
1983	15.1	15.2	15.2	15.2
1970	15.2	15.1	15.7	15.5
Average	14.7	14.6	14.5	14.6

Table E-17. Difference between each LOWRP ALT and FWO for average May lake stage during 10 highest years.

Year	Alt 2Cr	Alt1Shallow	Alt 1BW
1996	+0.3	+0.1	+0.2
1979	-0.5	-0.6	-0.4
1984	-0.5	-0.7	-0.6
2003	-0.7	-0.6	-0.7
1980	-0.4	-0.5	-0.5
1993	-0.5	-0.4	-0.4
1998	+0.4	+0.3	+0.4
1995	+0.6	+0.3	+0.4
1983	+0.1	+0.1	+0.1
1970	+0.1	+0.6	+0.4
Average	-0.1	-0.2	-0.1

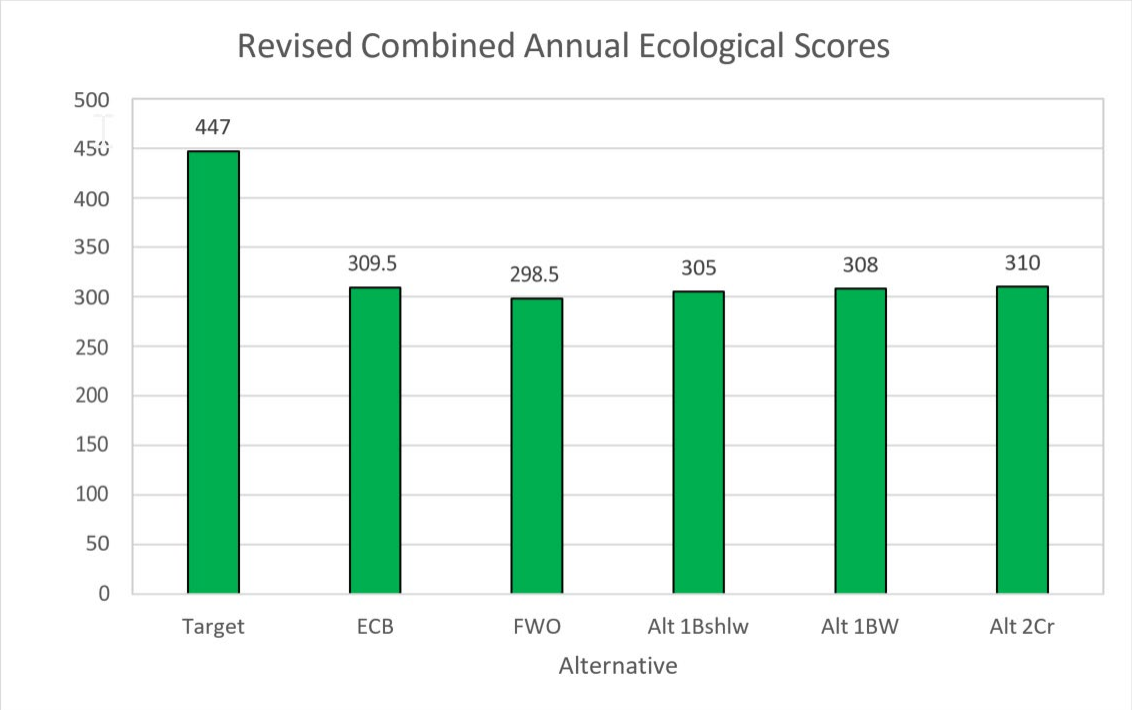


Figure E-17. Re-calculated combined annual scores for ecological indicators in FWO, ALT1Bshlw, ALT1BW, and ALT2CR.

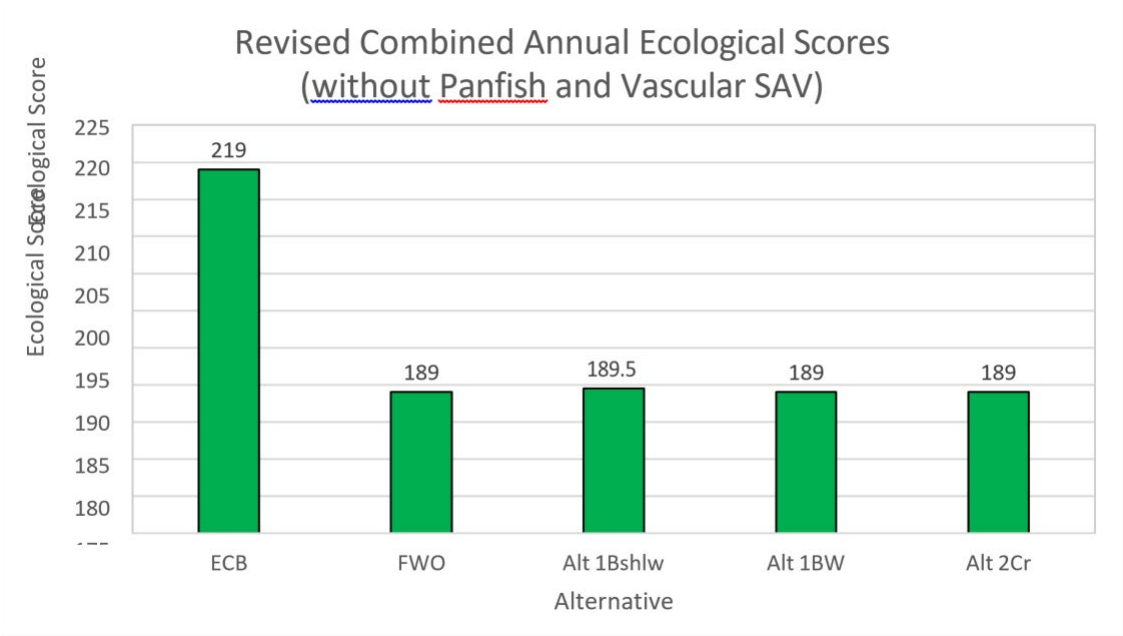


Figure E-18. Re-calculated combined annual scores for ecological indicators in FWO, ALT1Bshlw, ALT1BW, and ALT2CR - not including Panfish or Vascular SAV indicators.

E.4.4 Summary and Conclusions

Any increase in quality wetland acreage in the watershed should provide some benefit to lake ecology by improving hydrological conditions for wildlife and vegetation within and adjacent to the project area. Management strategies should include techniques to contain nutrients on site and improve capacity of soils to retain nutrients. Wetlands and streams can function as effective sinks because they offer long flow paths between upland sites and the receiving water body (Reddy et al. 1995). Restoration measures implemented for sites selected should be carefully considered in order to maximize the ecological value and meet expectations of predicted benefits.

The Lake Stage Envelope PM and stage duration curves for the FWO and the ALTs reveal that all ALTs improve performance by reducing frequency and duration of low lake stages. However, compared to the FWO, all ALTs slightly increase the frequency for extreme high lake stages (>17 ft. NGVD), while reducing the duration of stages in the lower end of the ecologically beneficial range. Because the duration of higher stages is longer in the ALTs compared to the FWO, this could potentially create conditions less optimal for *Chara* and more amenable to increasing cyanobacteria abundance (Maceina 1993, Havens et al. 1996, Havens 2002, Havens and Gawlik 2005). Conditions for panfish and SAV are expected to improve in the ALTs compared to the FWO, as indicated by the lake stage envelope PM. An evaluation of the performance of individual ecological indicators also revealed slight improvements of conditions for epipelon and epiphytes in the ALTs compared to the FWO.

In general, high lake stages (>15.5 ft.) and low lake stages (<12.0) are harmful for the ecology of the lake. However, infrequent low lake stages do have ecological benefits (Havens and Gawlik 2005). While reducing extreme lows should have beneficial effects to the ecology of the lake, particularly in the upper littoral marshes, reductions in frequency and duration of stages in the 11-13 ft. NGVD range may reduce opportunities for deeper-marsh vegetation to rebound from high stage or tropical events. For example, it is

unclear whether durations of roughly 20% for lake stages >15 ft. NGVD will be offset by durations of roughly 15% for lake stages <12 ft. NGVD. However, ALTs do show some improvement in stage durations between 15-15.5 ft. NGVD, which may help to offset reductions in duration of stages between 12-13 ft. NGVD. Additionally, modeling indicated that there are periods where the Lake's water level is held higher than FWO levels, though these events are expected to be rare enough to avoid significant ecological effects. The PDT should consider additional storage measures to allow for increased operational flexibility or optimize project operations to avoid extreme high lake levels.

Refinement of the Lake Okeechobee PMs is needed to ensure the best available information is being considered. For example, it is not clear why the lake stage envelope indicates a 12.5 ft. NGVD – 15.5 ft. NGVD threshold when earlier work suggests the ecologically preferred range is 12 – 15 ft. Additionally, explicit guidance on how to use the PMs in conjunction with others would be helpful for future evaluations so that PM scores are not duplicated or conflicting. The final score of combined ecological indicators, for example, would seem to depend on how many low- or moderate-lake stage dependent indicators were included in the analysis. Further, the current ecological indicators, other than panfish and epiphytes, were mostly insensitive to the differences between action alternatives or even between FWO and the alternatives, suggesting differences in lake stages for this project are expected to have little- to no-effect on these attributes, or it is not measurable given the current approach.

E.5 Lake Okeechobee Service Area

E.5.1 Introduction

Enhancement of economic values and social well-being is the second goal of CERP (**Table E-1**). To that end, water is a valuable commodity in south Florida playing a vital role in maintaining a thriving economy through increasing agricultural productivity, maintaining and increasing the health and productivity of fisheries, and improving economic and social benefits of ecotourism and recreational opportunities. Ecological restoration proposed by LOWRP has the following objectives:

- Improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often.
- Improve estuary discharges from Lake Okeechobee to improve the salinity regime and the quality of oyster, submerged aquatic vegetation (SAV), and other estuarine community habitats in the northern estuaries.
- Increase the spatial extent and functionality of aquatic and wildlife habitat within Lake Okeechobee and the surrounding watershed.
- Increase availability of the water supply to the existing legal water users of Lake Okeechobee.

An opportunity to improve water supply in the Lake Okeechobee Service Area (LOSA) was identified during plan formulation by reducing water supply cutbacks to existing legal users of Lake Okeechobee. The LOSA (**Figure E-19**) is made up of the Everglades Agricultural Area (EAA) and "other" LOSA areas, which are comprised of 298 districts; S-4, L-8, C-43 and C-44 basins; and North & Northeast Lakeshore and Lower Istokpoga.

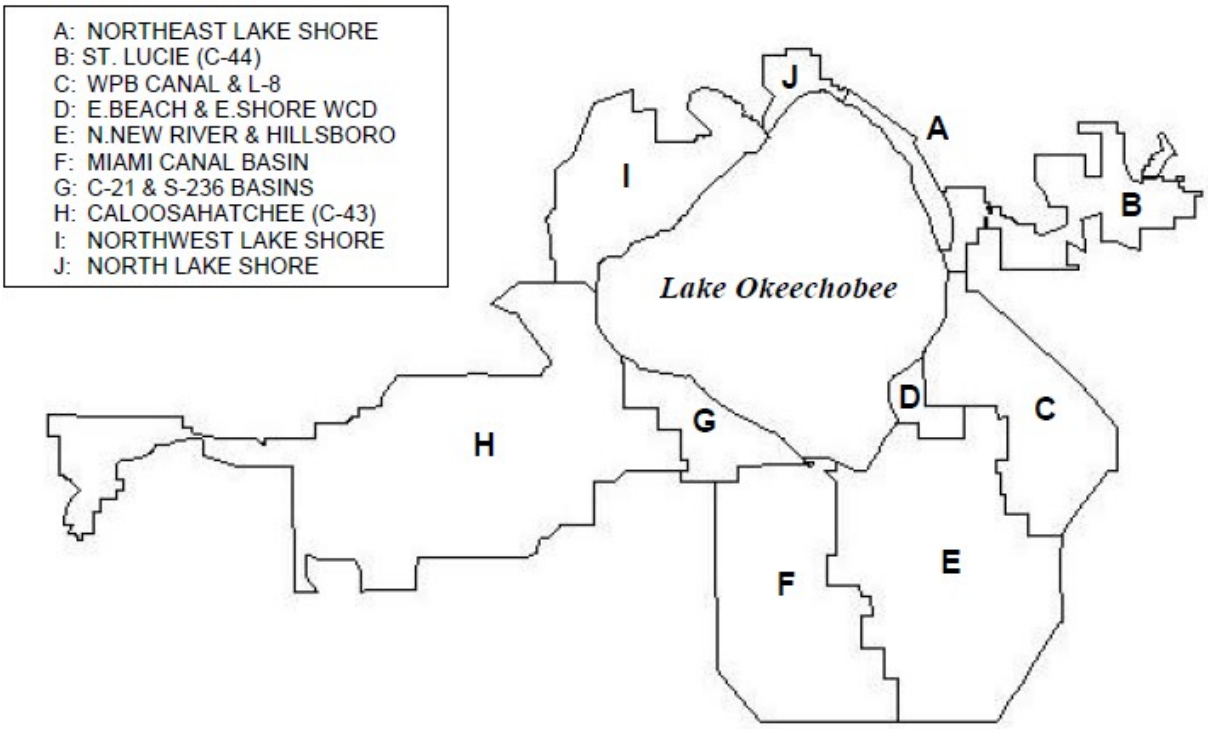


Figure E-19. Map of the Lake Okeechobee Service Area for Water Supply.

In the LOSA, water restrictions primarily affect agricultural water users (RECOVER 2005). Economic losses associated with water shortages depend not only on the number of water shortages, but also on the severity and duration of the water restrictions. The longer the restrictions are in place and the more severe the cutbacks, the more likely it is that crop yields will be reduced and the greater the expenses that are required by users to manage the water shortages (Apogee Research 1990 and 1991).

E.5.2 Performance Measures and Evaluation Approach

The CERP water supply goal for the Lake Okeechobee Service Area (LOSA) is to meet the water supply planning goal established in Florida law (Section 373.0361(2)(a)(1), Florida Statutes), which specifies that, for water supply plans, "the level-of-certainty planning goal associated with identifying the water supply needs of existing and future reasonable-beneficial uses shall be based upon meeting those needs for a 1-in-10 year drought event." A performance measure has been developed by RECOVER for the frequency and severity of water restrictions for Lake Okeechobee Service Area (RECOVER 2005). This measure is evaluated utilizing Regional Simulation Model Basins (RSM-BN) results. The South Florida Water Management Model (SFWMM) is no longer used.

The RECOVER Water Supply Performance Measure, "WS-1 Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area," assesses the frequency, duration, and severity of water shortages and restrictions throughout the period of record. The RSM-BN model utilizes a 41 year period of record, or time series, ranging from 1965 to 2005 in order to assess the frequency of water restrictions. More information regarding RECOVER's Water Supply PM for LOSA can be found in Appendix G of the LOWRP PIR/EIS.

E.5.3 Evaluation

Inconsistencies

During the evaluation of the LOSA water supply using the WS-1 Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area Performance Measure, some inconsistencies and discrepancies were observed and noted. While these inconsistencies/discrepancies do not appear to affect the final ranking of alternatives, the impacts to water supply of all alternatives are not as positive as projected by the calculations of the LOWRP PDT (**Table E-18** and **Table E-19**). The three (3) performance measure metrics used in the LOSA PM are:

1. Frequency of Water Restrictions
2. Duration of Water Restrictions discussed in further detail later in this section.
3. Severity of Water Restrictions

These metrics are discussed in more detail later in this section. These inconsistencies were documented by the RECOVER Regional System-wide Evaluation team:

1. The PDT used reports using calendar year (**Table E-18**) for their reporting where RECOVER and the LOSA PM use water year which is October through September (**Figure E-20** and **Figure E-21**).
2. The PDT did not calculate or address one of the three metrics (**Table E-18**). "Duration of Water Restrictions" was not calculated or discussed in regards to LOSA water supply.
3. The PDT used the Lake Okeechobee Water Shortage Management, or LOWSM, cutback volume to calculate their cutback totals.
4. RECOVER cannot determine how the PDT calculated the Severity Score. RECOVER assumed LOWSM cutback volume was utilized but RECOVER could not generate the same scores as the PDT using the LOWSM cutback volume data.
5. Severity Scores and Cutback Total should have been calculated using the Total Cutback data per the performance measure.
6. Each "Frequency of Water Restrictions for the 1965-2005 Simulation Period" graph is missing one data point at minimum (**Figure E-20** and **Figure E-21**).

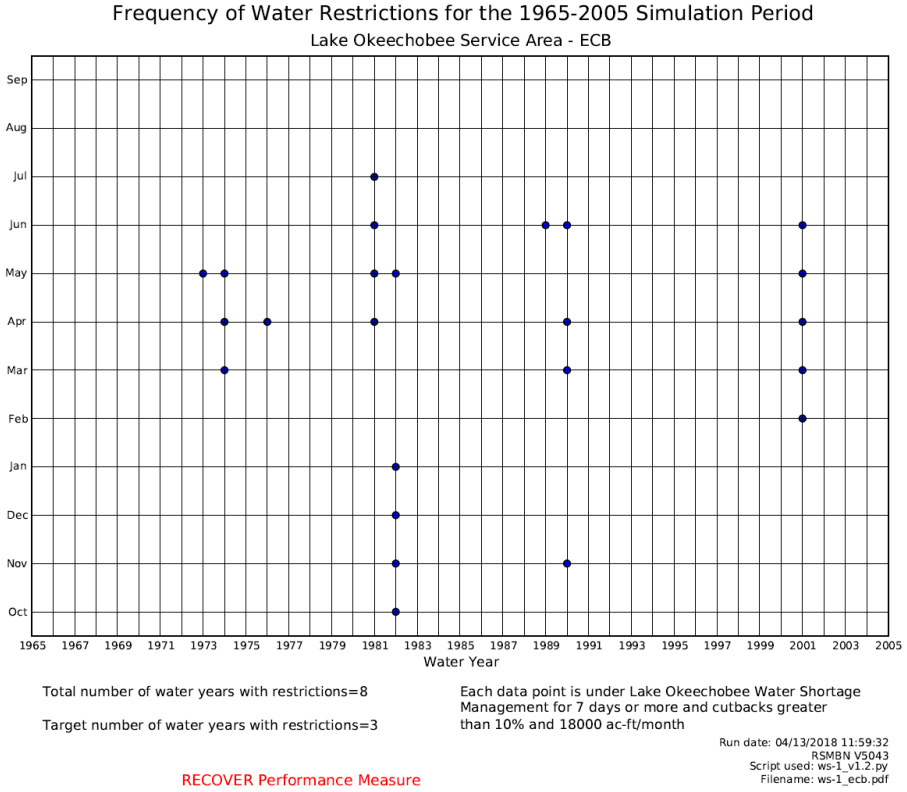
Water Restriction Criteria

LOSA water supply is evaluated based upon years where water shortages exist resulting in water restrictions (reduction in water released from Lake Okeechobee). There are three (3) criteria used in the performance measure to distinguish significant water restriction events throughout the period of record:

1. For a month to be counted as a significant water restriction, there must be supply-side restrictions for seven or more days.
2. The reductions in water deliveries must be 10% or greater.
3. The total reduction in water deliveries during the month must exceed 18,000 acre feet (18 kaf).

Frequency of Water Restrictions

Any water year (October to September) with a minimum of one month where the three (3) criteria are met is counted as a water year with significant supply-side restrictions. The target for the number of significant water restriction events is three (3) water years or less over the period of record (1965-2005) (**Figure E-20** and **Figure E-1**). "Frequency of Water Restrictions" charts (**Figure E-20** and **Figure E-21**) were generated using the WS-1 Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area Performance Measure. The ECB and FWO alternatives have eight (8) water years with significant supply-side restrictions (**Table E-18**). All of the alternatives (ALT1Bshlw, ALT1BW, and ALT2CR) in the final array have six (6) water years with significant supply-side restrictions (**Table E-19**), a 25% decrease in water restriction frequency from the FWO. All of the project alternative scenarios, including the base scenarios (ECB and FWO), were in performance deficiency. While there was no difference between the alternatives in the final array, all three (ALT1Bshlw, ALT1BW, and ALT2CR) reduced performance deficiency by two water years. However, the performance deficiency for all alternatives in the final array is twice the restoration target.



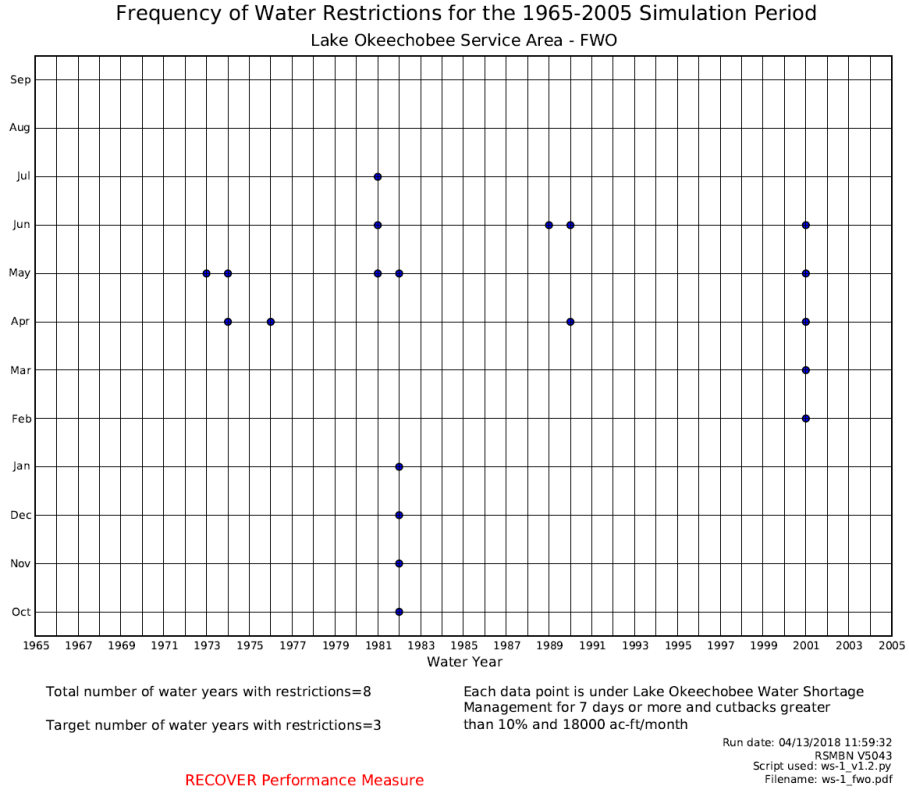
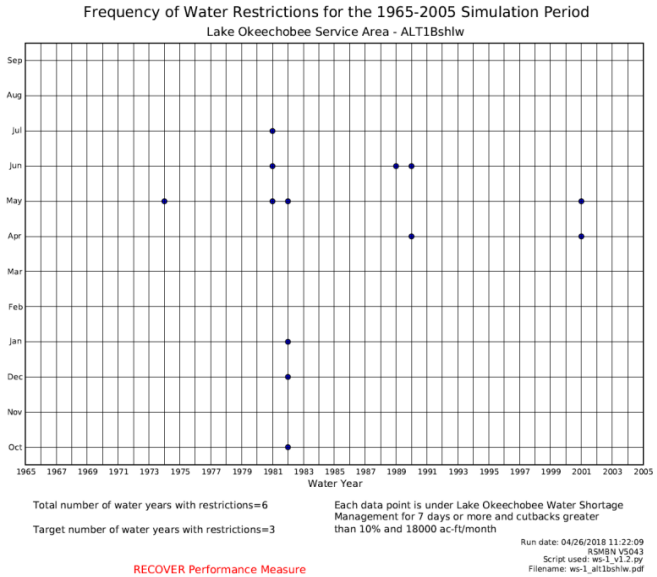
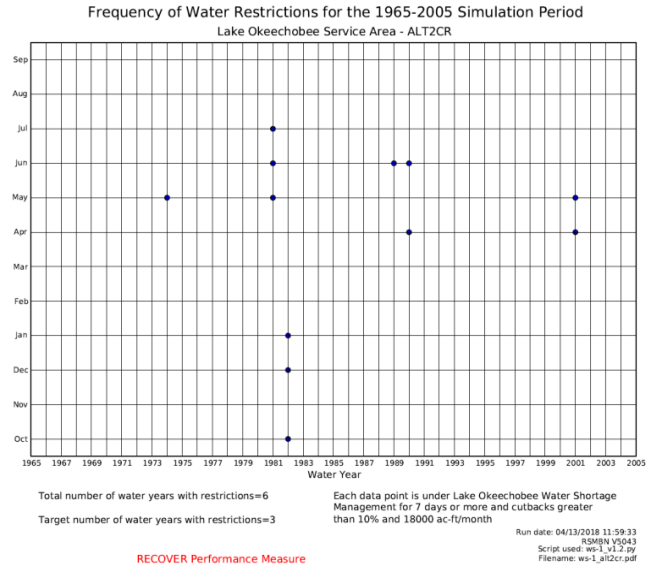
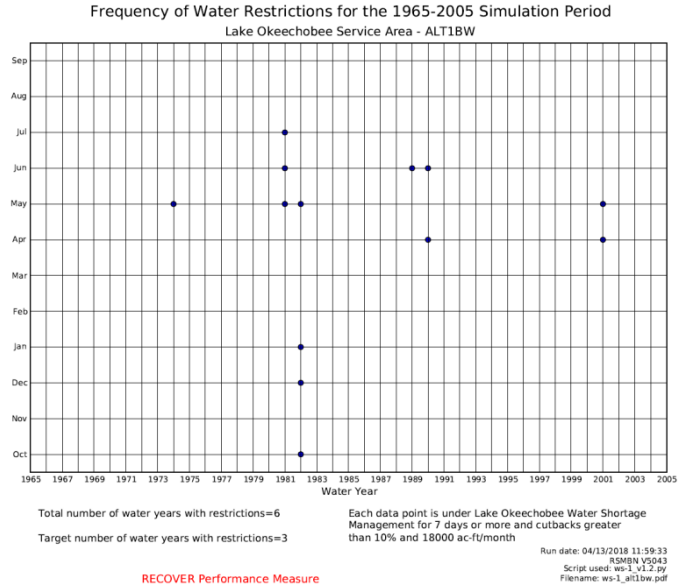


Figure E-20. Graphical representation of the "Frequency of Water Restrictions" for the ECB and FWO for comparison to the LOWRP project alternatives.







Frequency of Water Restrictions Tables: Missing Points

Alternative/Scenario	Water Year	Month
ECB	1988-89	May
ECB	1988-89	July
FWO	1988-89	July
ALT1Bshlw	2000-01	June
Alt1BW	1988-89	July
Alt1BW	2000-01	June
Alt2CR	2000-01	June

Figure E-21. Graphical Representation of "Frequency of Water Restrictions" for LOWRP project alternatives and list of missing data points in Figure E-20 and Figure E-21.

Duration of Water Restrictions

Any month during the POR where water restrictions met the three (3) water restriction criteria counts towards the "duration" score for each alternative scenario. The duration score is a count of the total number of months in the POR where significant water restrictions occurred. The target for the duration of significant water restriction events is eight (8) months with water restrictions or less over the period of record (1965-2005). If an alternative scenario scores over eight (8), the alternative is considered in performance deficiency. The duration performance deficiency (DPD) score is the duration score minus 8 (target).

All of the alternative scenarios are deficient with respect to duration performance (**Table E-19**). Every alternative scored better than the ECB and FWO, which had duration scores of 26 (18 DPD) and 21 (13 DPD) respectively. ALT2CR scored the best out of the final array of alternatives with a duration score of 13 (5 DPD), a 38% improvement from the FWO. However, ALT2CR did not meet the restoration target of 8. ALT 1Bshlw was the second best alternative with a duration score of 14 (6 DPD), a 33% improvement from the FWO. Alternative 1BW performed the worst of the alternatives with a duration score of 15 (7 DPD), an improvement of 28% from the FWO.

Table E-18. RECOVER WS-1 frequency and severity of water restrictions for Lake Okeechobee Service Area.

RECOVER WS-1 Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area

Simulation	POR	*Cutback Total (kaf)	Frequency	Severity Score	# of WY's w/ at least 1 cutback
ECB	1965-2005	857	8	13	8
FWO	1965-2005	688	8	12	8
ALT1Bshlw	1965-2005	446	6	6	6
ALT1BW	1965-2005	461	6	7	6
ALT2CR	1965-2005	384	6	4	6

*Computed using monthly cutbacks > 18k

**Cutback report tabulated by calendar year

Table E-19. RECOVER WS-1 frequency and severity of water restrictions for Lake Okeechobee Service Area (RECOVER recalculations).

RECOVER WS-1 Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area (RECOVER recalculations)

Simulation	POR	Cutback Total (kaf)*	Frequency Score^	Duration Score^^	Severity Score^^^
ECB	1965-2005	1,093.13	8	26	14
FWO	1965-2005	866.33	8	21	12
ALT1Bshlw	1965-2005	563.57	6	14	9
ALT1BW	1965-2005	628.65	6	15	10
ALT2CR	1965-2005	485.88	6	13	7

Data tabulated by Water Year (Oct-Sep)

*Computed using monthly cutbacks > 18k

^Frequency Target is 3 or less

^^Duration Target is 8 or less

^^^Severity Target is 7 or less

Severity of Water Restrictions

Severity of Water Restrictions uses the month with the highest monthly cutbacks within a water year (October to September) in order to represent how austere the water restriction was. The final severity score is a summation of the yearly severity evaluations over the POR. The severity restoration target is less than or equal to seven (7). Any severity score above 7 is considered deficient. A severity scale was established which assigns a score based on the size of the highest monthly cutback within a water year. The scale is as follows:

- A cutback less than 18 kaf receives a score of zero (0).
- A cutback greater than or equal to 18 kaf but less than 50 kaf receives a score of one (1).
- A cutback greater than or equal to 50 kaf but less than 100 kaf receives a score of two (2).
- A cutback greater than or equal to 100 kaf but less than 150 kaf receives a score of three (3).
- A cutback greater than or equal to 150 kaf receives a score of four (4).

The severity scores for ECB and FWO are 14 and 12 respectively. All of the project alternatives reduce the severity of water restrictions in the LOSA. Only one of the alternatives in the final array met the performance standards for restoration in regards to severity of water restrictions (**Table E-19**).

Alternative 2CR reduces the severity of water restrictions by 42% from the FWO, and meets the severity target with a severity score of seven (7). Although reducing the severity of water restrictions, there was not much separation between Alternative 1Bshlw (score: 9) and Alternative 1BW (score: 10).

ALT1Bshlw reduced the severity of water restrictions by 25%, whereas, ALT1BW only reduced severity by 17% from the FWO.

E.5.4 Summary and Conclusions

Water restrictions can have a profound effect on economic, social, and environmental aspects of life in south Florida. With water in limited supply, the frequency, duration, and severity of water restrictions are of vital importance to the health and well-being of society and environment of south Florida. Any plan for restoration involving the Lake Okeechobee Watershed needs to limit these three aspects. Assessment of the three alternatives in the final array show that meeting the water supply restoration targets for the Lake Okeechobee Service Area is a difficult challenge. All project alternatives improve water supply to LOSA compared to the FWO. Of the alternatives in the final array for the Lake Okeechobee Watershed Restoration Project, Alternative 2CR makes the most significant water supply improvements when compared to the FWO. Alternative 2CR reduces the impact of water restrictions by decreasing how often water restrictions occur (25% less often than FWO), decreasing the extent at which water restrictions occur (28% shorter duration than FWO), and reducing the severity when water restrictions do occur (42% less water restriction severity than FWO). Alternative 1Bshlw didn't perform as well as ALT2CR. ALT1Bshlw had water restrictions occur 25% less often than the FWO, had water shortages that were 33% more brief than the FWO, and reduced severity by 25% when compared to the FWO. Alternative 1BW performed the worst of the all project alternatives in regards to water supply. Improvements over the FWO, were 25% for frequency, 28% for duration, and 17% for severity.

E.6 Overall Rankings of LOWRP Alternatives

The RECOVER Regional Evaluation Team reviewed the performance of the final array of alternatives in regards to the effects on the St. Lucie Estuary and Caloosahatchee River and Estuary in the Northern Estuaries region, effects on littoral and near-shore zones of Lake Okeechobee, and the effects on the water supply of the Lake Okeechobee Service Area. Conclusions regarding these affects can be found at the end of each related section above. Overall, in regards to ecological and hydrological performance, the alternatives in the final array of alternatives for the Lake Okeechobee Watershed Restoration Project were ranked **(Table E-20**). Alt2CR was the best performing alternative for LOWRP from an ecological and hydrological perspective.

Table E-20. Overall Ranking of LOWRP Alternatives Based on Performance.

Region	ALT1Bshlw	ALT1BW	ALT2CR
Northern Estuaries	3	1	2
Lake Okeechobee	3	2	1
LOSA	2	3	1
Overall	3	2	1

***1 representing the best performing alternative and 3 representing the worst performing alternative**

E.7 RECOVER Regional Evaluation Team

There were 6 members on the regional evaluation team:

1. Michael Simmons, USACE
2. Jenna May, USACE
3. Patrick Pitts, USFWS
4. Phyllis Klarmann, SFWMD
5. Zach Welch, SFWMD
6. Agnes McLean, NPS

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E.9 RECOVER Consistency Review: Project Goals and Objectives and Performance Measures

Lake Okeechobee Watershed Restoration Project

RECOVER Consistency Review of Project Goals and Objectives and Performance Measures

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Coordinator: Michael Simmons (USACE)

Date: February 6, 2017

Status: Final

E.9.1 Introduction

The following document summarizes the consistency review of the Lake Okeechobee Watershed Project (LOWP) including the project's goals, objectives, and performance measures. This RECOVER consistency review fulfills the following requirements as prescribed by the Programmatic Regulations:

1. Ensure project is consistent with the CERP's goals and objectives.
2. Document consistency of the project performance measures with RECOVER's system-wide performance measures.
3. Suggest improvements to the project performance measures with the intent of improving target or evaluation methods to better evaluate project alternative plans that, if pursued, would contribute to selecting a tentative plan with the best performance by the project in achieving ecosystem restoration goals.

The RECOVER consistency review focused on the following general questions:

1. Are project-level goals and objectives consistent with CERP's system-wide goals and objectives?
2. Are project-level performance measures consistent with RECOVER's system-wide performance measures?
3. Are RECOVER system-wide performance measures included in the performance measure hierarchy? If not, are the reasons for exclusion documented?

In order to properly evaluate LOWP for consistency with CERP goals and objectives, as well as with RECOVER system-wide and regional performance measures, the following documents were reviewed:

1. Lake Okeechobee Watershed Project Alternative Milestone Report Summary
2. Lake Okeechobee Performance Measure: Lake Stage
3. Lake Okeechobee Performance Measure: Ecological Indicator Score
4. Northern Estuaries Performance Measure: Salinity Envelopes
5. Lake Okeechobee Performance Measure: Lake Okeechobee Watershed Wetlands Restoration

E.9.2 LOWRP Goals and Objectives

As stated above, one of the primary goals of a consistency review is to ascertain whether the LOWP goals and objects align with those of CERP. The Consistency Review Team (CRT) determined LOWP is consistent with the goals and objectives of CERP as provided in Table 1 of the LOWP Alternative Milestone Report Summary. This summary report follows by providing significant detail of how LOWP will, "enhance ecologic values and economic values and social well-being through improved water management flexibility of Lake Okeechobee, the Northern Estuaries (St. Lucie Estuary and Caloosahatchee Estuary), and the Greater Everglades." While LOWP incorporates the goals and objectives of CERP regarding the enhancement of ecological values, the CRT requires clarification on some of the information provided in the LOWP Alternative Milestone Report Summary.

These items are:

1. LOWP is consistent with the CERP goals and objectives to enhance ecological values. In reference to CERP goals and objectives related to economic values and social well-being, clarification is needed regarding protection/enhancement of recreational opportunities, effects on navigation, and protection and discussion of potential impacts to cultural/archaeological resources and values.
2. CERP LOWP storage components include benefits to regional water supply. Has the LOWP PDT adequately addressed water supply benefits? RESOPS (Reservoir Sizing and Operations Screening Model) has water supply performance measures to evaluate projects for the Eastern Agricultural Area and Western Basins (including Tribal Demands) which have not been used in this process. The findings are: 1) Lake Okeechobee Service Area (LOSA) supply and demand not delivered; 2) LOSA supply and demand not delivered for average of seven (7) largest drought years.
3. Under the "Study Purpose and Scope" section (pg. 2), the stated purpose of LOWP is "to assess Federal and non-federal interest in implementing components of CERP." The CRT believes the purpose of LOWP is ecological restoration with the aforementioned statement, perhaps, being a task to be completed pursuant to the goal of achieving of ecological restoration.
4. The Yellow Book focused quite heavily on water quality for the Lake Okeechobee Watershed region, yet this project will mostly serve as a means to regulate quantities (not quality) of water. It is mentioned on page 10 of the LOWP summary that other water storage measures were considered (e.g. STAs, FEBs), and were screened out because they would not provide cost-effective water storage capacity. Is cost-effectiveness the only reason why water quality is not in the planning effort? Were trade-offs between cost for storage capacity by different methods versus the added benefit of water treatment (in this case any method with treatment wetlands) considered? Or is the WQ already "acceptable" such that capacity/volume is indeed the main driver behind alternatives?
5. In regards to the "Deep Injection Well Formulation" section (pg. 13-14), there is confusion regarding Figure 3 as it compares to the information written throughout this section. According to the information provided, the reduction in "high discharge exceedance months" is substantially reduced with the combination of a 350,000 ac-ft reservoir, 80 ASR, and DIWs. However, this doesn't appear to be represented in Figure 3 scoring, especially when compared to scoring in Figure 2. The expectation of adding DIW's, based off the reduction stated, is an increase in scoring from Figure 2.
6. Additionally, all discussion on ASR's is for the amount of 80 wells in the "Deep Injection Well Formulation" section (pg. 13-14). Figure 3 shows the addition of DWIs to 40-60 wells. The CRT is unclear if this is an oversite or an error in Figure 3.

7. Table 10 (15 MGD DIW Capacity and Cost Estimates) and Table 11 (30 MGD DIW Capacity and Cost Estimates), both on pg. 17, refer to information provided in the "DIW Formulation" Section and Table 6. In Table 6, the DIW range provided for analysis to RESOPS was 450-1,300 MGD. The number of 15 MGD wells (30, 50, 70, 90) listed in Table 10 is consistent with the total MGD provided in Table 6 (450-1,300 MGD), with 90-15 MGD wells exceeding 1,300 MGD by 50 MDG. However, the only listed number of 30 MGD wells that falls within the analyzed DIW range is 30. The listed amounts of 50, 70, 90- 30 MGD DIW's exceeds the 1,300 MGD upper limit of analysis.
8. There is a typographical error in the "Phase 1 Alternatives" section (pg. 16) in the 3rd line of the paragraph. It should read, "…reservoir K05 Horizontal for a total storage of 154,554 acre-feet for a cost…."
9. In "Phase 1 Alternatives" section (pg. 16) in 5th line of the paragraph, please edit "ac-ft" to "acre-feet" for consistency.
10. In Table 8, please edit "AC-FT" to "ACRE-FEET" in the heading for column 2 for consistency.

There is a typographical error in the "Alternatives Considered but not Carried Forward" section (pg. 18) in the 4th line of the 3rd bullet. It should read, "…it has a high cost per acre-feet and would…"

E.9.3 Performance Measures for LOWRP

CRT is tasked with reviewing the performance measures for LOWP, in regards to the three (3) general questions stated in the introduction. LOWP incorporates four (4) performance measures for assessing project success of LOWP. Overall, with the inclusion the total system performance measures stated below, CRT agrees the performance measures used for LOWP are appropriate tools for achieving project success.

1. As part of any CERP project, there are a few total system performance measures that need to be considered. One of these total system performance measures is the Snail Kite Foraging Conditions Performance Measure (2005). The appearance of LOWP is that it would potentially add to snail kite foraging area. Given the listing status of the snail kite, CRT believes there should be analysis of effects to snail kite foraging conditions, specifically towards the apple snail. Restoration of wetland habitat may increase potential foraging area for the snail kite, especially along the littoral zones/ecotones of wetland/upland interfaces. Lake Okeechobee littoral zone alteration should address possible effects, both positive and/or negative, towards the snail kite and its prey source, the apple snail. It may also be beneficial to document predicted changes to exotic apple snail species populations due to predicted changes of exotic vegetation and native vegetation (not desired for project). Will the project affect the population of native apple snails positively, negatively, or no change?
2. LOWP does not address the total system performance measure "White Tail Deer Breeding Potential (2005)." Is it possible to utilize the predictive model utilized in this performance measure with potential LOWP inputs to assess any effect on the white tail deer breeding population?
3. Lastly, LOWP should reference the project's impacts on mercury bioaccumulation or acknowledge if no change (positive or negative) will occur within the system as a result of the project. As a total system performance measure, it bears mentioning how the project may or may not affect mercury bioaccumulation (2004).

For each performance measure involved with LOWP, CRT has provided a list of comments, concerns, or questions under each performance measure heading.

Lake Okeechobee Performance Measure – Lake Stage

This performance measure was last revised and accepted on March 7, 2007. Since its acceptance, this performance measure has been regularly used in RECOVER with success.

1. There is inconsistency with the stated upper and lower limits of the optimal water level envelope. In this performance measure, the desired stage envelope of 12.5 to 15.5 feet NVGD (pg. 4 of PM). However, the LOWP Alternative Milestone Report Summary the "ecologically beneficial envelope" is stated as 12 to 16 feet NVGD (pgs. 4,9 of LOWP Summary). The questions are: why are these different? Should these be different?
2. The Lake Okeechobee Lake Stage Performance Measure addressed the appropriate "frequency" and "duration" to produce the desirable healthy conditions; these factors are considered when developing protective water quality criteria. EPA agrees that these factors are important to consider in this case.

Lake Okeechobee Performance Measure – Ecological Indicator Score

This performance measure was last revised and accepted on October, 20, 2016. As this performance measure is new, this is one of the first uses of this performance measure.

1. See Lake Stage PM above. The Ecological Indicator Score PM also states the optimum lake stage range of 12.5 to 15.5 feet NVGD (pg. 1,4 of PM).
2. There is question as to whether this performance measure can provide the data required to properly assess for the LOWP goals and objectives which ultimately affects whether there is consistency between those and CERP/RECOVER system-wide goals and objectives. Recommendation is for the final version of this PM to be peer reviewed by the RECOVER Leadership Group (RLG). RLG did not review the final version after the changes were made following the public/agency comments period.
    a. High scoring PM alternatives will favor lake stages one (1) to two (2) feet lower than those of the Lake Stage PM. During the draft review, authors stated this PM is focused on the nearshore and pelagic zones and will be weighted with other PMs. However, considering the currently proposed Habitat Unit (HU) Scoring methodology which will be used to measure the environmental lift when comparing alternatives, the acres in the equation have 350,000 nearshore and pelagic acres versus 100,000 littoral zone acres. This creates a large scoring advantage for this PM. RECOVER needs to have a system-wide perspective to achieve balance in the development of PMs and their use in CERP.
    b. Other environmental factors and indicators play a significant role in the ecological health of LO. By selecting this indicator set dominated by strong correlations to low lake stage, it is essentially selecting for low rainfall, drought-like climatological conditions. Many other factors accompany these conditions including lower nutrient loading, and less tropical storm activity. Over reliance on this PM where a high score can be achieved with a lake level at 12 ft. NGVD for eight (8) months of the year seems contrary to a system-wide approach for the future that includes improvements in nutrient loading and additional storage.
    c. The ultimate target proposed for this PM is based on the best year of the SFWMM existing condition baseline (96% of the potential maximum) being achieved every year for 41 years with an interim score of the SFWMM existing condition baseline (72% of the potential maximum). The output of the 96% year in regard to other PMs could be informative as a system-wide reality check and indication of how best to balance this PM with other PMs.

Having a 96% maximum every year for 41 years target seems excessive. It would require 41 years of dry climatological conditions or very large storage and delivery volumes.

d. While all indicators chosen for the PM have a significant correlation to lake stage, the correlation for cyanobacteria is weak and is missing most of the factors related to cyanobacteria. Since most indicators get equal weight in points, this weak correlation is not addressed in the scoring.

e. Chara and Vascular SAV are both correlated to July lake stage resulting in both of them not receiving equal weight in the POR scoring due to the overlap. During the draft review, authors stated that the responses of Chara and Vascular SAV trend in the opposite direction resulting in a combined point maximum of 3 in July.

f. For some indicators, data influenced by the hurricane impact years of 2004, 2005, and 2006 are used depending on when the data was collected. During the draft review, authors stated that the hurricane impacts only affected a range of 7.6% to 31% of the data, depending on the length and specific temporal range of each data set. Are there any established criteria for the acceptance or rejection of such data in these circumstances? Thirty one percent (31%) sounds too high for a RECOVER system-wide PM.

g. There is no minimum lake level for five (5) of the six (6) indicators at which the score would be zero (0). During draft review, the authors indicated that there is no evidence from the data that the five (5) "no-minimum" indicators would be adversely impacted by lake stages under ten (10) feet. Given this circumstance, care must be taken that unintended negative system-wide outcomes do not result from the over-weighting of this PM if it is used to evaluate alternatives.

Northern Estuaries Performance Measure – Salinity Envelopes

This performance measure was last revised and accepted on April 5, 2007. Since its acceptance, this performance measure has been regularly used in RECOVER.

1. The full restoration target for flow in St. Lucie Estuary is stated as "31 months where mean flow is less than 350 cubic feet per second (cfs)" (pg.5 of PM). In Table 4 (pg. 11) of the LOWP Alternative Milestone Report Summary, the months exceeding existing conditions is stated at 30 (pg. 11, LOWP Summary). Is the information in the table based of the full restoration target for St. Lucie Estuary in the PM? How was this number (32 months) established for Caloosahatchee Estuary as full restoration target for flow is not stated in the PM?

2. Similar to above, how are the targets (months in exceedance) of 90, for St. Lucie, and 41, for Caloosahatchee, determined? How does this link to the PM?

3. The LOWP Summary cites a few details from the Northern Estuaries Salinity Envelopes Performance Measure for the Caloosahatchee Estuary (CRE) and St. Lucie Estuary (SLE) minimum flows required to support oysters or SAV salinity ranges in the "Problems and Opportunities" section (page 5). There is little detail or information regarding high discharge events. Is the assumption to measure desired reduction in high discharge events and improvement of salinity ranges built into the reservoir plan formulation RESOPS models (Tables 4 and 5, pages 11 and 12, respectively)?

4. This performance measure addresses appropriate biological endpoints such as SAV, oysters, and macroinvertebrates. EPA agrees that these are appropriate biological endpoints and notes that these are consistent with the development of protective criteria such as numeric nutrient values in Florida.

5. This performance measure, also, addresses the appropriate flows to ensure protection of the various estuaries, etc. EPA has recently identified the importance of appropriate flows in waterbodies to ensure that designated uses are protected. Consideration of flow is an important and appropriate factor to ensure protection of the subject waterbodies and estuaries.
6. The EPA report regarding "flow" can be found at https://www.epa.gov/sites/production/files/2016-12/documents/final-aquatic-life-hydrologic-alteration-report.pdf. It may also be beneficial to have the EPA National Flow Expert, Lisa Gordon, involved in additional review or as a participant in future meetings as a resource to answer any questions regarding flow, water quality standards, protection of designated uses of waters including downstream waters (estuaries in this case).
7. The RECOVER Northern Estuaries Regional Coordinators will be working to update the Northern Estuaries Salinity Envelope Performance Measure in the next year. Considering there will also be "more detailed regional models" for reservoir formulation alternatives forthcoming per the LOWP Summary, to what degree should the team revisit this PM for consistency once it is updated? The CRT acknowledges that, for now, this is the PM we have to work with.

LORWP PM – Lake Okeechobee Watershed Wetlands Restoration

This performance measure is specific to LOWP and has not been approved as of the date of this review.

1. Following a different format then most other performance measures, the CRT recommends the inclusion of the following sections: Desired Condition and Notes. Typically these two sections include information on the purpose and overall design of the performance measure including the ultimate preferred outcome or goal.
2. Associated with #1, was the sole purpose of this performance measure to "screen" down the nine
3. (9) wetland restoration sites to five (5) for further analysis?
4. Associated with #2, what role does this performance measure have in the determination or "screening" of the top five (5) to the tentatively selected plan (TSP)?
5. Inconsistency between review document and this performance measure. The review document lists a screen down of 12 sites where as the performance measure states a screen down of 9 sites.
6. The only statement relating to where the 12 or 9 sites originated from is in the review document, stating the current effort started with the top 12 previously recommended watershed wetland sites. Perhaps a short description (in a Notes section of the PM; or something similar) on where the site choices originated from; or a short timeline or description of how these sites were selected; or a statement/description of initial criteria leading to site selection could be included for clarity.
7. Table 6 interrupts the breakdown of the evaluation process and disrupts the flow of the document. It is located a couple of pages after its first reference and several pages before its next reference. Being such a long table (3 ½ pages), perhaps placing it near the end of the document or revising the table would benefit the readability of the performance measure and provide clarity as well.

E.10 RECOVER Consistency Review: Lake Okeechobee Watershed Restoration Project (LOWRP) Adaptive Management and Monitoring Plans

Lake Okeechobee Watershed Restoration Project

Draft RECOVER Consistency Review of Adaptive Management and Ecological Plan and associated Monitoring Plans

June 15, 2018

E.10.1 Introduction and Purpose of the Evaluation

In accordance with CERP Guidance Memorandum 40.02 and other relevant guidance (e.g., CERP Guidance Letter 12/06), RECOVER must review the Lake Okeechobee Watershed Restoration Project (LOWRP) project level monitoring plan(s) in regards to consistency with the existing Monitoring and Assessment Plan (MAP 2009) to prevent duplication of monitoring activities. Additionally, in this review, RECOVER evaluates the need for project-level monitoring to fill temporal or spatial gaps for parameters monitored in the MAP 2009 in order to evaluate project-level effects. As projects are typically not at the construction stage when this Review is prepared, and that a variety of changes may occur between now and operational readiness of the Project, this Review should be considered an interim document. Future developments may require modification of monitoring plans and/or revision of this Review. This document provides RECOVER's comments and recommendations to the Project PDT regarding incorporation of proposed monitoring into the project.

Adequate monitoring is needed to effectively implement RECOVER's adaptive management (AM) principals per Federal Principals and Requirements for Federal Investments in Water Resources (Mar 2013) and USACE implementation guidance of Section 2039 of the Water Resources Development Act of 2007 – Monitoring Ecosystem Restoration, and to be in coordination with the CERP RECOVER AM strategy (http://141.232.10.32/pm/program_docs/adaptive_mgmt.aspx). MAP related monitoring generally has as its goal the generation of long-term datasets of sufficient temporal and spatial scope to permit valid interpretation(s) and consequently facilitate effective adaptive management of system-wide restoration over the long-term. Proposed monitoring, as envisioned by CERP project teams, must address the reality that finite resources and rising costs are additional considerations that must be included when prioritizing monitoring needs. The objectives of the review are to identify monitoring elements appropriate and necessary to be incorporated into the Project and coordinated with the MAP to verify restoration performance of the project and rive adaptive management for the project, as needed.

Project-level monitoring typically involves monitoring that is: (1) required by permit, (2) directly related to project operations (e.g., stage and flow), (3) to be used for assessing overall project performance, and to adaptively manage the individual components and its interaction with the larger group of project components into the future.

E.10.2 Background

The ecosystem of Lake Okeechobee and its surrounding watershed have undergone significant changes over the past 120 years. Historically, freshwater flowed from Lake Okeechobee south through the Everglades to Biscayne Bay, Florida Bay and lower southwest coast of Florida. In the last 120 years, the source of historic typical flow has been retained in the Lake (proper) and discharged to the Northern Estuaries by means of regulatory releases through the C-43 and -44 canals. The results have been prolonged high volume discharges of water from the Lake to the Northern Estuaries and input of excessive nutrient concentrations in the Lake and Northern Estuaries. These sustained effects have brought about the degradation of floral and faunal species found in these areas. During the same time period, significant amount of wetland acreage was drained and converted to agricultural lands for farming and ranching. In order to incrementally start the restoration of the Lake Okeechobee Watershed, the purposes of LOWRP are:

1. Increase water storage capacity in the watershed to better manage Lake Okeechobee water levels for lake ecosystem health and water supply improvements.
2. Improve the quantity and timing of fresh water discharges to the St. Lucie and Caloosahatchee River and Estuary that adversely affect salinity and estuarine biota.
3. Restore degraded hydrologic habitat for fish and wildlife throughout the study area.
4. Increase the spatial extent and functionality of the internationally recognized Everglades wetlands of South Florida.

E.10.3 LOWRP Adaptive Management and Monitoring Plans

Ecological Monitoring and Adaptive Management Plan

The ecological monitoring plan focuses on LOWRP's success at meeting project objectives whereas the adaptive management plan specifically focuses on addressing project uncertainties. Most of LOWRP's ecological monitoring supports the resolution of project uncertainties, the ecological monitoring plan was incorporated in the Adaptive Management Plan for LOWRP. The primary objective of the LOWRP Adaptive Management and Monitoring Plan (AMMP) is to identify the monitoring necessary to inform decision-makers, LOWRP partner agencies, and the public on achieving restoration success, as well as address uncertainties that can be addressed with efficiently structured approaches. To achieve this objective, the AMMP is a collection of strategies which identify future management options that can be used to address project deficiencies towards meeting project objectives as determined by monitoring associated with the project uncertainties. Each strategy follows a scientific approach that uses performance measures, monitoring, triggers, and thresholds to inform restoration progress and support decisions regarding the need to adjust LOWRP to improve restoration performance. The organization of strategies and management options included in the AMMP is based on the uncertainties associated with each LOWRP project objective:

1. Improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often.
2. Improve estuary discharges from Lake Okeechobee to improve the salinity regime and the quality of oyster, SAV, and other estuarine community habitats in the northern estuaries.
3. Increase the spatial extent and functionality of aquatic and wildlife habitat within Lake Okeechobee and the surrounding watershed.
4. Increase availability of the water supply to the existing legal water users of Lake Okeechobee.

The AMMP is a collection of all known and/or anticipated monitoring activities conducted at the project level, through RECOVER, or via outside sources such as scholastic research in order to reduce costs and effort while increasing knowledge to make the most informed decisions possible.

Water Quality Monitoring Plan

The Water Quality Plan as of June 2018, is still in a draft version. Upon completion, the Water Quality Plan will contain the necessary monitoring to ensure LOWRP implementation complies with all Federal and State water quality standards and statutes.

Hydrometeorological Monitoring Plan

The Hydrometeorological Monitoring Plan as of June 2018, is still in a "draft" version. Upon completion, the Hydrometeorological Monitoring Plan will identify the necessary hydrological and metorological

monitoring needed to operate new LOWRP project structures along with the existing Central and Southern Florida (C&SF) structures.

E.10.4 RECOVER Recommendations General Comments

1. Monitoring Plans for LOWRP are in draft form at the time of this "draft" RECOVER Review. Revision to this Review of the final LOWRP Monitoring Plans will be required prior to the finalization and approval of this Review.

General Adaptive Management Plan Comments

1. If RECOVER performance measure targets are based on a 36-year period of record, do restoration targets that are not an absolute value of 0 or 100 need adjusted now that the period of record has been extended to 41 years? (Is there a need to adjust targets based on an extended POR?)
2. Are the 2005 interim goals and targets still accurate "measuring sticks" to assess project success tracking?
3. In Table D-8, is the "decision criteria" for infestations of 5% a trigger for each plant species or for all plant species combined?
4. Reference (Tables D-8 & D-9); was there any discussion on management action options regarding the seedbank in regards to wetland restoration?
5. Reference (Table D-9); what is the number of season cycles needed to observe a shift in vegetation towards wetland species? Can other wetland indicators be used?

Lake Okeechobee Comments

1. In Section D.4.1.1., first paragraph, it describes uncertainty regarding effects of "stabilized" water levels as predicted to occur with LOWRP. RECOVER suggests saying "reducing occurrence of extremes", rather than "stabilized".
2. Is there a hierarchy or prioritization of ecological indicators for Lake Okeechobee in regards to ecological importance or significance?
3. RECOVER suggests separating ecological indicators instead of assessing combined scores since environmental requirements (i.e. lake stage and duration) differ. It appears there is already separation among indicators since some have indicator-specific thresholds identified for triggers of management action. (Uncertainty #25)
4. Nesting success for wading birds is not covered under the current RECOVER LO wading bird contract, only colony locations, timing, and size (number of nests). The PI has reported success in the past, but it is not a requirement of their contract. If this is something the project will need, the contract will need to be revised to include this monitoring component. (Uncertainty #26)
5. Management options have been described for invasive vegetation, but it is not clear if invasive fauna have been considered. Are there management options for invasive species like apple snails, cichlids, feral pigs? These were addressed in the wetland restoration areas, but not in-lake.
6. While Objective 3 describes increases in extent and functionality of wildlife habitat that will occur within Lake Okeechobee and the watershed, the project-level monitoring section for assessing restoration seems limited to only the restored wetlands and WAF.
7. Will changes in lake stages impact ability for habitat management actions (i.e. prescribed fire operations and herbicide use)?

8. With Aquifer Storage and Recovery (ASRs) being a newer technology, is there an implementation strategy to only construct a few ASRs in order to test and assess ecological and hydrological impacts and effects of the ASR structure and operations?

9. Uncertainty regarding "water supply in the LOWRP footprint" (D.4.4.1) is an uncertainty that best fits under D.4.1 Lake Okeechobee Strategies and Management Options. This uncertainty pertains to the effects on ecological indicators as result of water supply in the lake. Given this, the use of the Ecological Indicator PM is warranted. Water supply is general related to the amount of water available for sources outside of the lake, such as farming operations which relies on the Frequency and Severity of Water Restrictions for LOSA.

Northern Estuaries Comments

1. LOWRP has one project objective pertinent to oysters in the Northern Estuaries Module: improve estuary discharges from Lake Okeechobee to improve the salinity regime and the quality of oyster, submerged aquatic vegetation (SAV), and other estuarine community habitats in the northern estuaries. While LOWRP focuses on improving habitat conditions, i.e. salinity envelope, for oysters, the LOWRP adaptive management plan focuses on increasing populations of oyster throughout the estuaries. IF LOWRP improves habitat conditions for oysters like it is planned to, is it the responsibility of LOWRP to focus on other aspects outside of the objective, such as substrate or flows, to increase oyster populations, or is it a RECOVER Northern Estuaries concern?

2. Will improvement in an established, more stable salinity envelope result in the creation of substrate (habitat) for oyster recruitment? How will Lake Okeechobee discharge influence oyster recruitment in regards to oyster spat movement upstream?

3. As discussed in the AMMP, there are currently no empirically-based thresholds ("triggers") established for any of the ecological indicators for the Northern Estuaries region, which includes oysters and submerged aquatic vegetation. Without a good reference or historical condition and interannual variability driven by rain and stochastic storm events, it is not possible to discern what level of loss in extent, biomass, or health of these indicators would trigger and necessitate additional management action for restoration purposes. While RECOVER Interim Goals provide some guidelines for expected targets for associated VECs as CERP Projects come online, it must be possible to detect project-specific outcomes. Several appropriate AM strategies have been identified for the Northern Estuaries, but the chosen AM strategy will depend on the observed outcome, e.g., if an estuary is substrate-limited or spat-limited, with some AM strategies which might include substrate deployment and seeding of spat-on-shell, respectively.

General Water Quality Monitoring Plan Comments

1. Consider including a map of all locations where monitoring will be conducted.

2. RECOVER understands that the ASR locations are conceptual at this point, RECOVER recommends the identification/determination of locations for the ASR test wells (initial set(s) of ASR wells) in order to better understand ASR effects, requirements, and associated water quality structures/design.

3. RECOVER recommends that all existing water quality stations which LOWRP will rely on be added to the Water Quality Monitoring Plan.

General Hydrometeorological Monitoring Plan Comments

1. RECOVER recommends that a map of all existing hydrometeorological stations which LOWRP will rely on be added to the Water Quality Monitoring Plan.

E.10.5 Summary

RECOVER supports the LOWRP draft AM Plan. These plans utilize the best available science and monitoring currently available. RECOVER acknowledges that items included in the AM Plan are "not guaranteed to be funded as-is, but will be considered again when LOWRP is closer to being implemented." The LOWRP AM is reliant on all existing MAP (2009) monitoring continuing and that any future MAP updates will be incorporated into this AM. LOWRP will fund any monitoring directly related to the AM Plan but is not designed to replace RECOVER's system-wide monitoring and science efforts. However if any LOWRP monitoring (not funded by LOWRP) is eliminated or reduced, LOWRP will need to incorporate that monitoring into the project in order to meet project goals and objectives. All monitoring incorporated in the LOWRP AMMP will need to be reevaluated over time in order to assess the status and results of on-going monitoring and to address any deficiencies or excesses in monitoring levels or effort.

E.11 RECOVER Review of the Lake Okeechobee Watershed Restoration Project (LOWRP) Draft Project Operating Manual (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LOWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess most current system-wide scientific knowledge.

RECOVER will continue coordination with the USACE and the SFWMD during future LOWRP project operations manual updates as requested.