APPENDIX G
BENEFIT MODEL

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APPENDIX G BENEFIT MODEL

G.1 MODEL DOCUMENTATION

The Department of the Army Engineering Regulation (ER) 1105-2-100 requires that ecosystem restoration planning contribute to national ecosystem restoration (NER), which is measured in terms of increases in the net quantity and/or quality of desired ecosystem resources. The United States Army Corps of Engineers (USACE) uses NER benefits as the basis to compare alternatives and select plans for ecosystem restoration projects. The following documents the methodology that was used to quantify ecological benefits and support plan evaluation, comparison, and selection for the Central Everglades Planning Project (CEPP). The CEPP Planning Model underwent peer review per Engineering Circular (EC) 1105-2412, 31 May 2011 (Assuring Quality of Planning Models) and was recommended for single-use on CEPP by the National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) on July 24, 2013. The USACE Headquarters (HQUSACE) Model Certification Panel approved the CEPP Planning Model on August 13, 2013. The CEPP Planning Model was applied in this study to quantify habitat units consistent with its application in CEPP.

G.1.1 Description of the CEPP Planning Model

The hydrologic modeling results for the alternatives considered in the CEPP PACR were input to the CEPP Planning Model applied during CEPP to quantify ecological benefits. The CEPP Planning Model was specifically developed to evaluate project alternatives within the CEPP project domain (ecoregion and/or watershed in south Florida). The primary areas to be evaluated included the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), the Water Conservation Areas (WCA 3A and 3B), Everglades National Park (ENP), and Florida Bay.

The CEPP Planning Model was developed by the Jacksonville District with support from multiple federal and state agencies. Members of the CEPP project delivery team included subject matter experts on Everglades' flora and fauna, with extensive experience working in south Florida and Everglades' wetlands ecosystems. Members of the project delivery team also included ecologists, hydrologists, and planners from the USACE, United States Fish and Wildlife Service (USFWS), National Park Service (NPS), South Florida Water Management District (SFWMD), and Florida Department of Environmental Protection (FDEP). **Section G.2** of this appendix describes the CEPP Planning Model applied to quantify habitat units for the CEPP PACR alternatives.

Performance measures were used to make the correlation between hydrologic output and ecosystem functions and evaluate the degree to which proposed alternative plans met restoration objectives. Each of the project performance measures for the CEPP planning effort were derived from those performance measures approved for use in CERP by Restoration, Coordination and Verification (RECOVER). RECOVER is an interagency and interdisciplinary scientific and technical team that provides system-wide scientific and technical support to the CERP. Performance measure scores were generated from hydrologic models. Each performance measure had a predictive metric and a desired target representative of historical conditions or pre-drainage hydropatterns within the study area. The desired targets were based on hydrologic requirements necessary to meet empirical or model-derived ecological conditions.

Performance measure scores were displayed as a function of restoration potential or achievement of the target with the minimum value of 0 representing a fully degraded ecosystem and a maximum value of 100 representing the restoration target. Habitat unit (HU) scores were produced from Habitat Suitability Indices (HSI), which converted the (0 to 100) scale of each performance measure to an (0 to 1) index value. These HSI were then applied to an acreage of potential benefit within the project area.

G.1.2 Description of Project Performance Measures

The CEPP project delivery team utilized performance measures developed from the Northern Estuaries, Greater Everglades Ridge and Slough, and Florida Bay Conceptual Ecological Models (CEMs) to make the correlation between hydrologic output and ecosystem functions (Barnes 2005, Sime 2005, Ogden 2005, Rudnick et al. 2005). Conceptual ecological models, as used in the Everglades restoration program, are non-quantitative planning tools that identify the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the best biological attributes or indicators of these ecological responses (Ogden et al. 2005). These CEMs have been extensively peer reviewed and provide the framework for the planning and assessment of the CERP. Performance measures used to evaluate project alternatives are listed below. Each performance measure has one or more sub-metrics. RECOVER documented each of the performance measures.[1] The documentation sheets provide the scientific basis and justification for the use of the performance measures by referencing peer reviewed literature as well as referencing the relationship of the performance measure to the CEMs.

Greater Everglades Performance Measure - Inundation Duration in the Ridge and Slough Landscape

- PM 1.1 Percent Period of Record (PPOR) of Inundation

Greater Everglades Performance Measure - Sheetflow in the Ridge and Slough Landscape

- PM 2.1 Timing of Sheetflow
- PM 2.2 Continuity of Sheetflow
- PM 2.3 Distribution of Sheetflow

Greater Everglades Performance Measure - Hydrologic Surrogate for Soil Oxidation

- PM 3.1 Drought Intensity Index

Greater Everglades Performance Measure – Dry Events in Shark River Slough

- PM 4.1 Number of Dry Events
- PM 4.2 Duration of Dry Events
- PM 4.3 Percent Period of Record (PPOR) of Dry Events

Greater Everglades Performance Measure - Slough Vegetation Suitability

- PM 5.1 Hydroperiod
- PM 5.2 Dry down
- PM 5.3 Dry Season Depth

[1] The documentation sheets located at the RECOVER website address note that the performance measures are hydrologic metrics based on output from the South Florida Water Management Model (SFWMM). The SFWMM was not used to produce output for the performance measures. Hydrologic models used for this study are described in **Section G.1.3** (**Hydrologic Models Used**).

- PM 5.4 Wet Season Depth

Northern Estuaries Performance Measure

Caloosahatchee Estuary

- PM 6.1 Low Flow Targets
- PM 6.2 High Flow Targets

St. Lucie Estuary

- PM 7.1 Low Flow Targets
- PM 7.2 High flow Targets

Southern Coastal Systems Performance Measure

- PM 8.1 Dry Season Regime Overlap
- PM 8.2 Wet Season Regime Overlap
- PM 8.3 Dry Season High Salinity
- PM 8.4 Wet Season High Salinity

G.1.3 Hydrologic Models Used

Each of the performance measures has defined metrics and targets. The performance measures are hydrologic metrics based on output from regional hydrologic models. These models provided daily, detailed estimates of hydrology across the 41-year period of record (January 1965 – December 2005) and were used to evaluate system responses to project alternatives. The regional models proposed as the primary tools for the CEPP assessment included the Regional Simulation Model for Basins (RSM-BN) (version 2.3.2) for the Northern Estuaries and Everglades Agricultural Area (EAA) and the Regional Simulation Model for the Glades and Lower East Coast Service Areas (RSM-GL) (version 2.3.2) for the WCAs, ENP, and the Lower East Coast (LEC). These models were 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. The model domain covers Lake Okeechobee and four major watersheds related to the northern portion of the project area; Kissimmee, Lake Okeechobee, St. Lucie River, Caloosahatchee River and the EAA.

The RSM-GL is a sub-regional model which includes Palm Beach, Broward, and Miami-Dade Counties, the WCAs, ENP, and Big Cypress National Preserve (BCNP). The model uses historical and modeled boundary condition data for the purpose of defining flows at water control structures, tidal stages, etc. RSM-GL simulates hydrology on a daily basis using climatic data for the January 1965 – December 2005 period of record, which includes both drought and wet periods. The RSM-GL simulates major components of south Florida's hydrology including evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and incorporates current or proposed water management control structures and operational rules.

Output from the regional models was maintained in a data access, storage, and retrieval system (DASR) managed by the SFWMD and USACE under the CERP Information and Data Management Program. Output

for each performance measure sub-metric was readily available and was typically provided in a comma-separated-value (csv) format. Output from the csv files were then imported into the CEPP Planning Model. Output data was also provided in chart and graphic format to aid in the assessment of restoration benefits.

Performance measure targets were primarily based on output from the SFWMD's Natural System Model version 4.6.2 (NSM), which simulates the hydrologic response of a pre-drained Everglades. The NSM has been used as a planning tool in several Everglades restoration projects. Additional documentation of the above mentioned models can be found at the SFWMD's webpage. The hydrologic models referenced have been validated through the USACE Engineering Model Certification process established under the Engineering and Construction (E&C) Science and Engineering Technology (SET) initiative.

G.1.4 Spatial Extent of Performance Measures

The primary areas evaluated in CEPP included the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), the Greater Everglades (WCA 3A) and Francis S. Taylor (WCA 3B) Wildlife Management Areas (WMAs), ENP, and Florida Bay. The following documents the spatial extent of the project or the locations used to evaluate the performance of each alternative.

Northern Estuaries Performance Measures

Performance measures within the Northern Estuaries were used to evaluate habitat suitability for oyster and submerged aquatic vegetation based on target flows over water control structures. Within the Caloosahatchee Estuary, targets were based on freshwater discharges at the S-79 structure (**Figure G-1**). Within the St. Lucie Estuary, targets were based on freshwater discharges at the S-80, S-48, S-49 and Gordy road structures (**Figure G-1 and Figure G-3**). The goal of this study, and of CEPP, is/was to improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries. Decreasing undesirable discharges has the potential to provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations. The salinity envelope target for the Caloosahatchee River and Estuary is a salinity range of 16 to 28 practical salinity units (psu). The salinity envelop target for the St. Lucie is a salinity range of 12 to 20 psu. Extensive monitoring and modeling of the Caloosahatchee and St. Lucie estuaries, as well as flows and loads from the associated basins and Lake Okeechobee, have been performed to determine representative median salinities associated with flow events at these structures. Salinity levels at stations throughout each of the estuaries have been recorded. Calculation of habitat benefits achieved by each of the project alternatives was restricted to portions of the estuary where changes in salinity in relation to freshwater flows across water control structures (i.e. S-79, S-80, S-48, S-49 and Gordy road structures) could be reasonably predicted. For analytical purposes, consistent with CEPP, the area within the Caloosahatchee and St. Lucie estuary systems to be potentially affected by proposed alternatives was assumed to encompass 85,973 acres (70,979 acres for the Caloosahatchee Estuary (Zone CE-1) (**Figure G-2**) and 14,994 acres for the St. Lucie Estuary (SE-1) (**Figure G-3**)). Performance measure scores within the Northern Estuaries were generated from the RSM-BN.

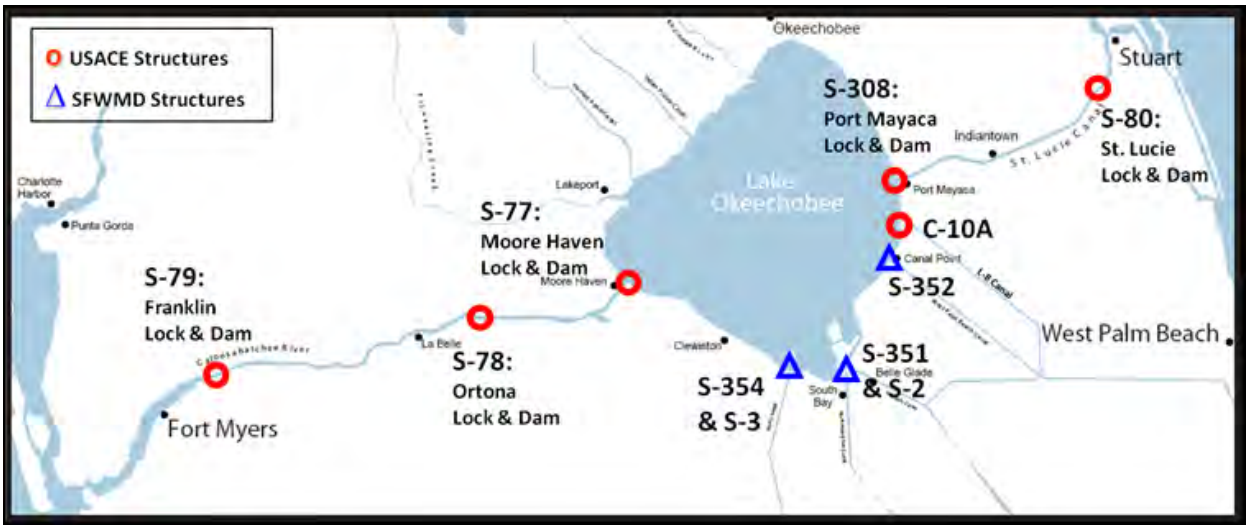


Figure G-1. Key Structures of Lake Okeechobee and the Northern Estuaries

Figure G-2. Estimate of the Maximum Area of Potential Ecological Benefit for the Caloosahatchee Estuary (Zone CE-1)

Figure G-3. Estimate of the Maximum Area of Potential Ecological Benefit for the St. Lucie Estuary (Zone SE-1)

Greater Everglades Performance Measures

Performance measure scores within the Greater Everglades were generated from hydrologic output from the RSM-GL using indicator regions (IRs) and/ or flow transects.

IRs were used for performance measures that measured the depth, distribution, duration of surface flooding and dry event severity (i.e., Inundation Duration in the Ridge and Slough Landscape, Hydrologic Surrogate for Soil Oxidation, Slough Vegetation Suitability, and Dry Events in Shark River Slough). IRs are groups of adjacent cells within the model grid that together represent a particular region of the Greater Everglades common to both present and pre-drainage systems. The cells within an IR are intended to be homogeneous in soil type, vegetative structure and topography and were therefore expected to show similar responses to hydrologic changes. Because IRs have ground elevations and community structure that are similar to much more extensive areas of the natural system, hydrologic patterns in each indicator region was used to evaluate how well alternative plans achieved hydrological restoration targets at sub-regional and regional scales. IRs were adapted from the South Florida Water Management Model (SFWMM), representing those previously defined by RECOVER to represent ridge and slough habitat, and additions to capture the immediate hydrologic effects of the Miami Canal.

Transects are groups of adjacent cells within the model grid that span sections of the study area, with an orientation roughly perpendicular to the direction of flow. Transects were used for performance measures

which measured the timing and distribution of flows. Transects were adapted from the SFWMM, and represent those previously defined by RECOVER and additional transects to capture the immediate hydrologic effects of the Miami Canal.

Performance measure output for individual zones was also evaluated to describe the effects within WCA 3 and ENP. The extent of CEPP required the region be divided into nine zones. However, given the extent of the project area considered in this CEPP PACR, extrapolation from the IRs and/or transects was limited. **Figure G-4** to **Figure G-7** illustrate the location of IRs and transects within the RSM-GL model mesh applied in this study. IRs added to capture the immediate hydrologic effects of the Miami Canal are shown only in **Figure G-5**.

Zones were delineated to capture the spatial extent of the structural components of the alternatives considered in CEPP. Zones were also delineated based on differences in existing conditions within the CEPP study area. Zones evaluated in this CEPP PACR included 3A-NE, 3A-NW, 3A-MC, 3A-C, 3A-S, 3B, ENP-N, ENP-S, and ENP-SE. A description of the justification for each zone included in CEPP is provided below.

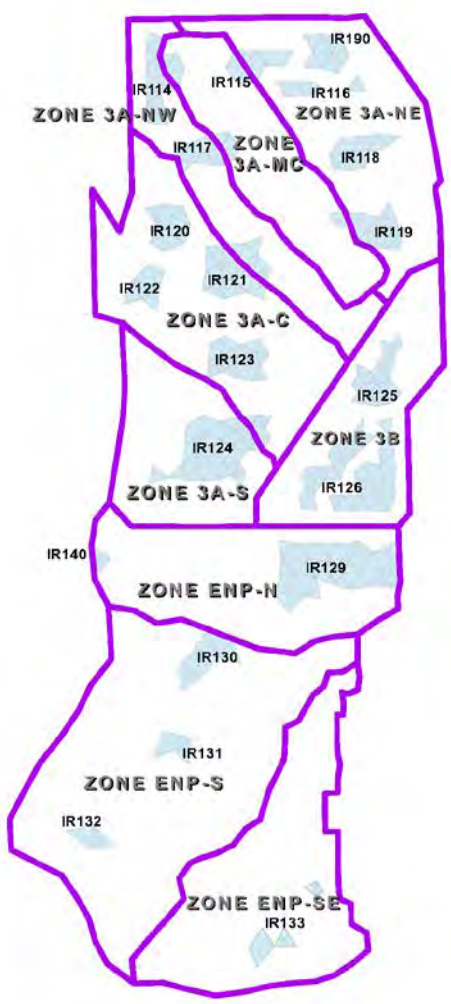


Figure G-4. Indicator Regions within the RSM-GL Model Mesh

Zone 3A-MC was sized to capture the immediate hydrologic effects of the Miami Canal. Zone 3A-MC was also delineated to completely contain the IRs adjacent to the Miami Canal.

Zone 3A-NE is one of the most over drained areas within northern WCA 3A and is severely degraded. Zone 3A-NE was sized to capture the hydrologic effects of a potential conveyance and distribution feature planned along the northeastern boundary of WCA 3A.

Zone 3A-NW is also over drained and severely degraded. Zone 3A-NW was sized to capture the hydrologic effects of a potential conveyance and distribution feature planned along the northwestern boundary of WCA 3A.

Zone 3A-C was delineated to represent an area of WCA 3A with a relatively well conserved ridge and slough landscape.

Zone 3A-S was delineated to represent an area of WCA 3A that has been impacted by impoundment structures. The southern portion of WCA 3A is primarily affected by high water and prolonged periods of inundation. The line delineating Zone 3A-C from Zone 3A-S was selected to be parallel to the Miami Canal in order to maintain a boundary roughly equidistant from the Miami Canal and be roughly mid-way between the Zone 3A-NW boundary and Tamiami Trail.

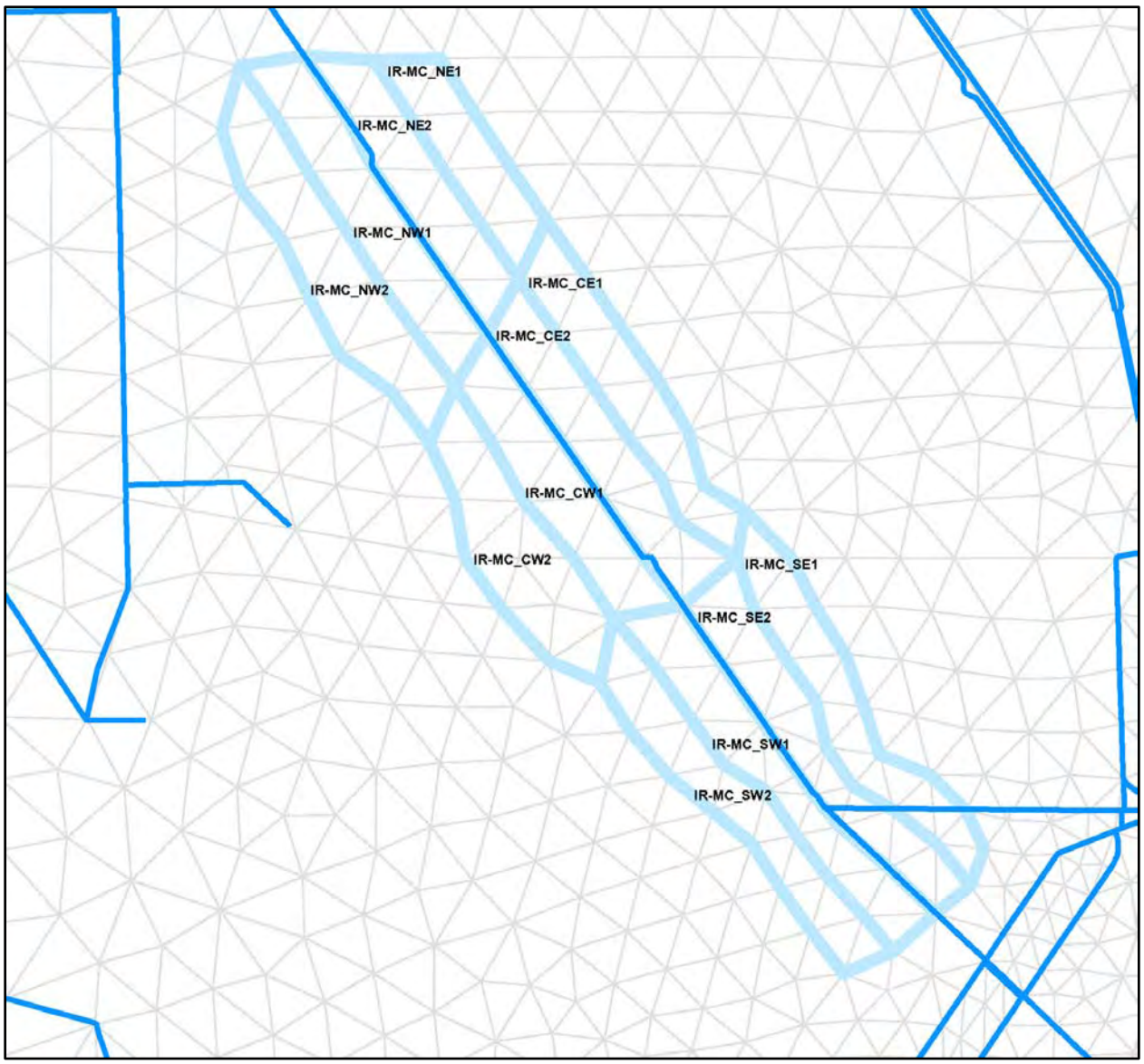


Figure G-5. Miami Canal Indicator Regions within RSM-GL Model Mesh

Zone 3B was delineated to represent an area hydrologically isolated from the project by levees. Zone 3B was delineated to determine hydrologic benefits of the project to WCA 3B.

Zone ENP-N was delineated to completely contain IRs 129 (Northeast Shark River Slough) and 140 (Lostman's Slough) located south of WCA 3A. The boundary of Zone ENP-N was also delineated to reach the southern extent of the L-67 Extension located in Everglades National Park.

Zone ENP-S was delineated to capture mid, southwest and south Shark River Slough in Everglades National Park.

Zone ENP-SE was delineated to capture Taylor Slough in ENP and reach the southern extent of Everglades National Park.

Where multiple IRs or transects occurred in a zone (**Figure G-7**), the performance measure results were averaged. If an individual IR or transect crossed more than one zone, the performance measure results for the IR or transect were applied to each of the zones the IR or transect crossed. For analytical purposes, the area within WCA 3A, WCA 3B, and ENP to be potentially affected by the project was assumed to encompass 1,076,248 acres (i.e., summation of acreages within each of the nine zones).

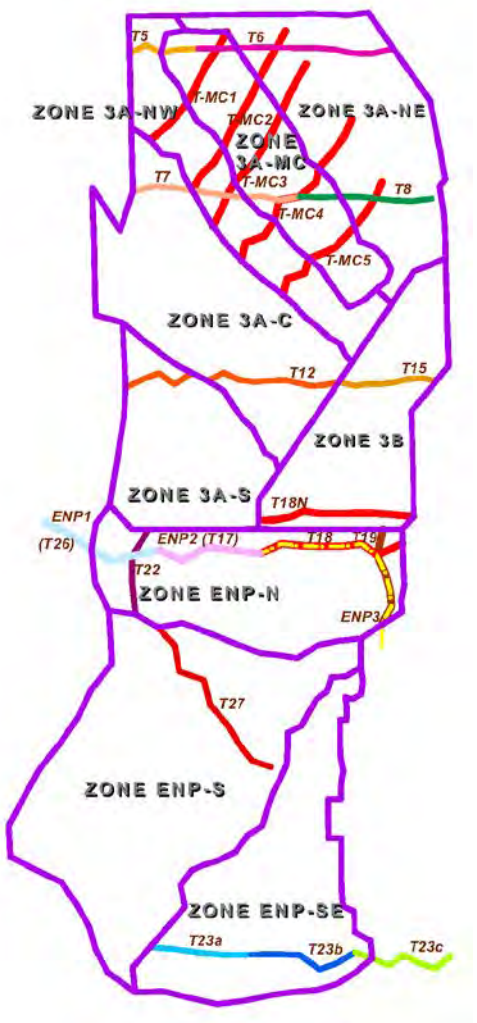


Figure G-6. Transects within the RSM-GL Model Mesh

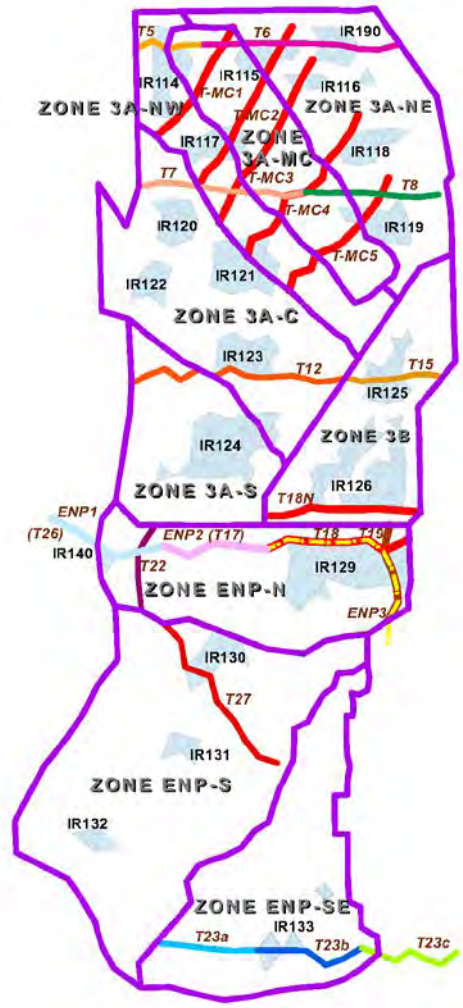


Figure G-7. Indicator Regions, Transects and Zones Within RSM-GL Model Mesh

Southern Coastal Systems Performance Measures

Performance measures for Florida Bay were used in CEPP to measure predicted salinity values within the Bay. Simulated hydrology produced by RSM-GL for each CEPP alternative was post-processed using multiple linear regression (MLR) statistical models to estimate salinity conditions at 17 Marine Monitoring Network (MMN) stations in Florida Bay. To further evaluate the spatial extent of the effects from CEPP, Florida Bay was divided into six zones of similarity based on water quality characteristics (**Figure G-8**). Zones evaluated in CEPP included North Bay (FB-NB), East Bay (FB-EB), East-Central Bay (FB-EC), Central Bay (FB-C), South Bay (FB-S), and West Bay (FB-W). Where multiple MMN stations occurred in a zone (**Figure G-8),** the performance measure results were averaged for CEPP. For analytical purposes, the area within Florida Bay to be potentially affected by the CEPP authorized project was assumed to encompass 476,096 acres (i.e., summation of acreages within each of the six zones).

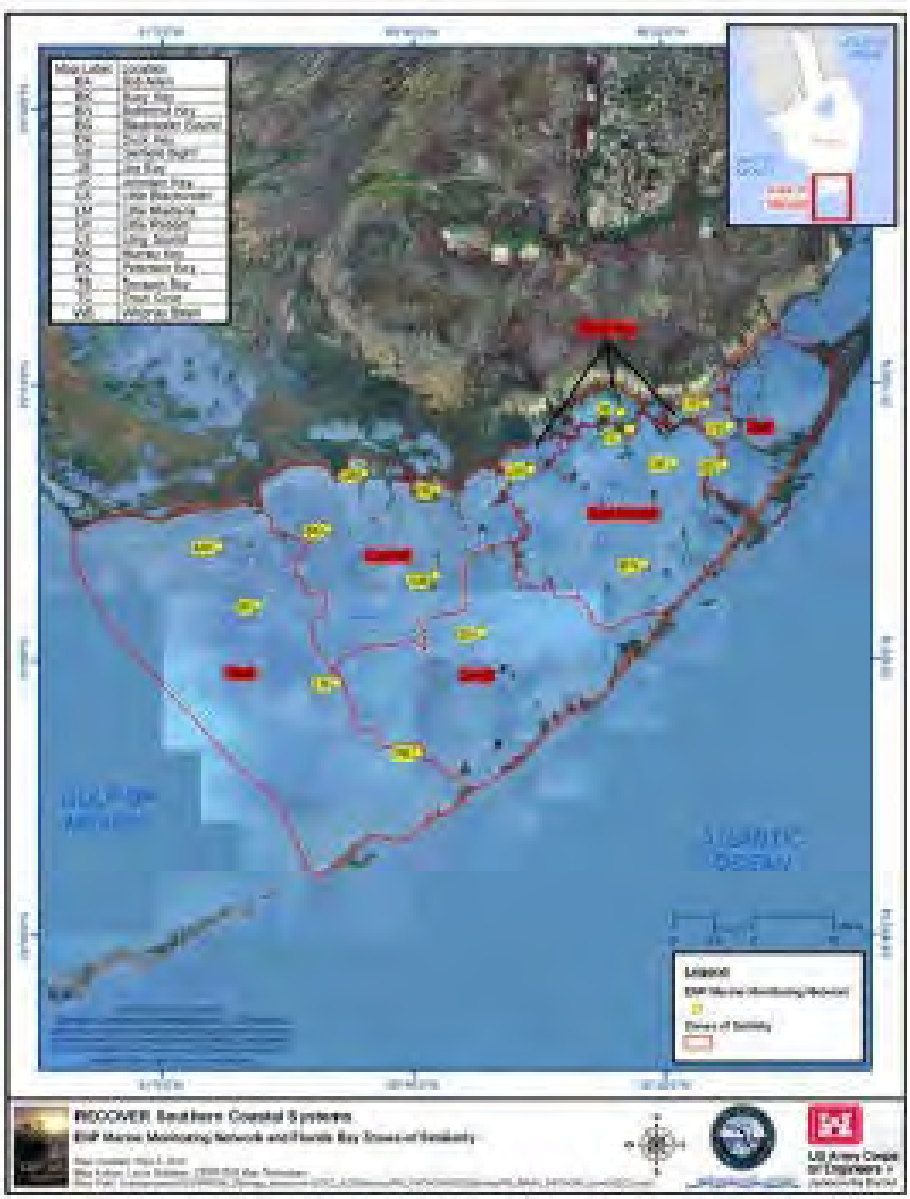


Figure G-8. Florida Bay Marine Monitoring Network and Florida Bay Zones of Similarity

G.1.5 Performance Measure Metrics

The following provides a brief description of the above performance measures including the performance measure target(s) for each, and the applicable metrics for the target(s). Further information for these performance measures can be found at the RECOVER webpage.

G.1.5.1 Northern Estuaries Performance Measures

G.1.5.1.1 Caloosahatchee Estuary

G.1.5.1.1.1 PM 6.1 Low Flow Targets and PM 6.2 High Flow Targets

Overall restoration goals include re-establishment of a salinity range favorable to juvenile marine fish, shellfish, oysters and submerged aquatic vegetation (SAV), re-establishment of seasonally appropriate freshwater flows of favorable quality that maintain low salinities in the upper estuary and reestablishment of more stable salinities and ranges in the lower estuary.

Targets are based on freshwater discharges from the C-43 canal at the S-79 structure where the mean monthly inflow should be maintained between 450 and 2,800 cubic feet per second (cfs). Targets were developed to reduce minimum discharge and mediate high flow events to the estuary to improve estuarine water quality and protect and enhance estuarine habitat and biota.

Ultimately, the low flow target is zero months that the mean monthly inflow from the Caloosahatchee watershed, as measured at S-79, falls below a low-flow limit of 450 cfs (C-43 basin runoff and Lake Okeechobee regulatory releases).

Ultimately, the high flow target is no months with mean monthly flows greater than 2,800 cfs, as measured at the S-79, from Lake Okeechobee regulatory releases in combination with flows from the Caloosahatchee River (C-43) basin.

G.1.5.1.2 St. Lucie Estuary

G.1.5.1.2.1 PM 7.1 Low Flow Targets and PM 7.2 High Flow Targets

Overall restoration goals include maintaining a salinity range favorable to fish, benthic invertebrates, oysters and SAV. This requires addressing high volume, long duration discharge events from Lake Okeechobee, the C-44, C-23, and C-24 watersheds. The flow targets are designed to result in a favorable salinity envelope in the mid estuary of 8 to 25 psu salinity. For the CEPP, the flow targets for the St. Lucie Estuary focus on flows from Lake Okeechobee only. This is due to the fact that the watershed flow targets are being addressed in the Indian River Lagoon South (IRLS) Project which is included in the 2050 base conditions. Full restoration targets are estimated to be:

- 31 months where mean flow is less than 350 cfs.
- 0 Lake Okeechobee regulatory discharge events (14-day moving averages > 2,000 cfs)

For each of the estuaries, scores will be reported for project alternatives indicating the number of times discharge criteria (i.e., flow targets) and/or corresponding salinity envelope criteria are not met. Alternatives are scored based on achievement of targets.

G.1.5.2 Greater Everglades Performance Measures

G.1.5.2.1 Inundation Duration in the Ridge and Slough Landscape

G.1.5.2.1.1 PM 1.1 Percent Period of Record (PPOR) Inundated

The ecological target is a percent period of record (PPOR) of inundation representative of pre-drainage conditions as modeled by the NSM version 4.6.2 in the ridge and slough landscape. The PPOR is the simulation period (January 1965 – December 2005). PPOR of inundation is the total time inundated (days) divided by the full period of record.

This performance measure is applied to IRs within the RSM-GL model mesh. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the nine zones, by averaging scores from each IR within each zone (**Table G-1**). PPOR of inundation are reported for each of the project alternatives and target (NSM version 4.6.2). Alternatives are scored based on achievement of target.

Table G-1. Indicator Regions Aggregated by Zone

Zone	Indicator Regions
3A-NE	IR-115, IR-116, IR-118, IR-119, IR-190
3A-MC	IR-MC-NE1, IR-MC-NE2, IR-MC-NW1, IR-MC-NW2, IR-MC-CE1, IR-MC-CE2, IR-MC-CW1, IR-MC-CW2, IR-MC-SE1, IR-MC-SE2, IR-MC-SW1, IR-MC-SW2
3A-NW	IR-114, IR-117, IR-121
3A-C	IR- 120, IR-121, IR-122, IR-123
3A-S	IR-124
3B	IR- 125, IR 126, IR 128
ENP-N	IR-140
ENP-S	IR-130, IR-131, IR-132
ENP-SE	IR-133

Further information for this performance measure can be found at the RECOVER website.

G.1.5.2.2 Sheetflow in the Everglades Ridge and Slough Landscape

G.1.5.2.2.1 PM 2.1 Timing of Sheetflow

This performance measure consists of two components; the timing of sheet flow and the spatial distribution and continuity of sheet flow. The timing scores provide information about how the timing of discharges across transects (and each transect's sub-transect) are altered by alternative project configurations. The target is restoration of pre-drainage timing of flows within the area of impact of the project as simulated by the NSM version 4.6.2. For each year in the simulation period of record (January 1965 – December 2005), monthly flow volumes are calculated for each specified RSM-GL transect (and sub-transect), and then expressed as a percentage of total annual flow volume along the transect. The absolute value of the difference between the flow volumes for the project alternative condition and target condition (NSM version 4.6.2) is then calculated to yield a monthly deviation from target. The monthly distances between the target values and those yielded by the project alternatives are then summed to yield an annual deviation from target. A timing index score is then calculated by subtracting the annual deviation from target from the value of one. These calculations are conducted for each year in the period of record. The magnitudes of the index scores are proportional to the similarity between the timing of

flows in the pre-drained system. An index score of 1.0 indicates that the timing of flows yielded by the project alternative perfectly matches the timing of flows yielded by the target condition.

This performance measure is applied to transects within the RSM-GL model mesh. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the nine zones by averaging scores from each transect within each zone.

G.1.5.2.2.2 PM 2.2 Continuity of Sheetflow and PM 2.3 Distribution of Sheetflow

The continuity and distribution scores provide information about how flow distribution within individual transects are altered by alternative project designs/operations. The continuity target is to have uniform flow across paired transects which cross barriers or canals at each time step (monthly) and the distribution target is to have uniformity of flow along the length of each transect at each time step (monthly). The best performing alternatives will have the most uniform flow along the length of transects, and between paired transects.

Uniformity of sheet flow is measured by the Coefficient of Variation (Cv) statistic. The Cv is defined as the ratio of the standard deviation (σ) to the mean (μ). The Cv is calculated at each time step (monthly) for each transect or transect pair using flow per mile. The score at each location is the standard deviation (σ) of flow divided by the mean (μ) from all sub-transects in an individual transect or transect pair. The objective is to minimize the Cv at each time step; a low Cv score (Cv=0) is an indicator of pre-drainage sheet flow.

This performance measure is applied to transects within the RSM-GL model mesh. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the nine zones by averaging scores from each transect within each zone. **Table G-2** indicates which transects are averaged within each of the nine zones for this performance measure.

Table G-2. Transects Aggregated by Zone

Performance Measure Transects Aggregated			
Zone	2.1 Sheetflow in the Ridge and Slough Landscape – Timing	2.2 Sheetflow in the Ridge and Slough Landscape –Continuity	2.3 Sheetflow in the Ridge and Slough Landscape – Distribution
3A-NE	T-6, T-8,	T-MC2_& T-MC3, T-MC3_& T-MC4, T-MC4 & T-MC5	T-6, T-8, T-MC2, T-MC3, T-MC4, T-MC5,
3A-MC	T-5, T-6, T-7, T-8	T-MC1 & T-MC2, T-MC2 & T-MC3, T-MC3 & T-MC4, T-MC4_ T-MC5	T-5, T-6, T-7, T-8, T-MC1, T-MC2, T-MC3, T-MC4, T-MC5,
3A-NW	T -5, T-7	T-MC1 & T-MC2, T-MC2 & T-MC3, T-MC3 & TMC4, T-MC4 & T-MC5	T-5, T-7, T-MC1, T-MC2, T-MC3, T-MC4, T-MC5,
3A-C	T-7, T-12	NA	T-7, T-12
3A-S	T-12	NA	T-12
3B	T-15	T18N & T18S	T-15, T18N
ENP-N	ENP-1 (T-26), ENP-2 (T- 17), ENP-3 (T-18S +T 19)	T18N & T-18S	ENP-1 (T-26), ENP-2 (T-17), T18S
ENP-S	T-27	NA	NA
ENP-SE	T-23 (T-23A+ T-23B +T 23C)	NA	T-23A, T-23B, T-23C

T-27 is only used to score the timing metric (sub-metric 2.1) of this performance measure in zone ENP-S. Ground surface elevations vary along T-27 such that uniform flow is not expected, and therefore the flow distribution metric does not apply. Also, water management has the potential to create unnaturally uniform flow by delivering water to higher elevation areas, creating a situation where the performance measure scores are difficult to interpret. As with T-27, ground surface elevations vary along T-23 in zone ENP-SE such that uniform flow is not expected. To score T-23 with the distribution metric (sub-metric 2.3), T-23 has been subdivided into sub-transects T-23A, T-23B, and T-23C. Each sub-transect can be evaluated separately for uniformity of flow (there are separate scores for T-23A, T-23B, and T-23C). As the timing of flow (sub-metric 2.1) at each T-23 sub-transect is nearly the same, however, it is not necessary to evaluate timing at each sub-transect separately. A single timing score for T-23 will be reported by computing the average of the timing scores from each of the T-23 sub-transects (T-23A, T-23B, and T-23C).

G.1.5.2.3 Hydrologic Surrogate for Soil Oxidation

G.1.5.2.3.1 PM 3.1 Drought Intensity Index

This performance measure represents peat exposure to oxidation by using the NSM version 4.6.2 Drought Intensity as a target. Drought intensity is calculated by multiplying depth to water table from ground surface (in feet [ft]) by duration (days) of belowground water levels to yield a ft-days below land surface summary for each specified RSM-GL cell in the simulation model. For each day of the period of record (January 1965 – December 2005) each specified RSM-GL cell is queried for water depth relative to land surface elevation. If water levels are below ground, the depth below ground is determined and scored in ft below ground units. If water levels are at ground level or above ground, the specified RSM-GL cell is scored as zero. Daily values of drought intensity for each cell are summed to compute an annual drought intensity score for each year in the simulation. Annual drought intensity scores are then summed across the period of record to produce cumulative drought intensity scores.

This performance measure is applied to indicator regions within the RSM-GL model mesh. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the nine zones by averaging scores from each indicator region within each zone (**Table G-1**). Cumulative drought intensity scores are reported for each of the project alternatives and target (NSM version 4.6.2) for each zone. Alternatives are scored based on achievement of target.

This performance measure is similar to the Greater Everglades Performance Measure Dry Events in Shark River Slough. However, this performance measure is applied over a broader area, and also provides the relative severity of drought events. This is important in evaluating the potential occurrence of unnatural peat destroying fires which affect microtopography, and the structure and distribution of plant communities.[2]

G.1.5.2.4 Dry Events in Shark River Slough

G.1.5.2.4.1 PM 4.1 Number of Dry Events, PM 4.2 Duration of Dry Events, PM 4.3 PPOR of Dry Events

The ecological target is the recovery of the pre-drainage patterns of multiyear hydroperiods as modeled by the NSM version 4.6.2 in Shark River Slough within ENP. This performance measure reflects how many

[2] This performance measure was derived from the Greater Everglades Performance Measure - Extreme High and Low Water Levels in Greater Everglades Wetlands.

times, and for what duration, water levels fall below ground in Shark River Slough in the period of record. This measure is important in extrapolating the hydrologic behavior of alternative plans to ecological effects on floral (e.g., white water lily, sawgrass) and faunal (e.g., fishes, wading birds) assemblages in Shark River Slough.

The number and duration of dry events are used to calculate the PPOR of dry events. The PPOR with dry conditions is calculated as the average duration of dry events (days) multiplied by the number of dry events divided by the total period of record (POR). The period of record is the number of days in the simulation period (January 1965 – December 2005). A dry event is calculated as a discrete segment of time from the point at which water levels fall below ground surface until the time they rise above ground. Minor events where water rises above ground slightly less than 0.2 feet, do not determine the end of a dry event at that moment until it continues to rise above 0.2 feet. PPOR of dry events are reported for each of the project alternatives and target (NSM version 4.6.2).

This performance measure is applied to IRs 129 – 132 within the RSM-GL model mesh (**Figure G-4**). Therefore, this performance measure is only scored at Zones ENP-N and ENP-S. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the two zones, by averaging scores from each IR within each zone. PPOR of dry events are reported for each of the project alternatives and target (NSM version 4.6.2). Alternatives are scored based on achievement of target.

G.1.5.2.5 Slough Vegetation Suitability

G.1.5.2.5.1 PM 5.1 Hydroperiod, PM 5.2 Dry down, PM 5.3, Dry Season Depth, PM 5.4 Wet Season Depth

A three-step process was followed in the development of this performance measure to arrive at the targets and tools to predict performance. During Phase I, scientific evidence defining characteristic pre-drainage native Everglades slough indicator species, their historical and current distribution, and defining hydrologic conditions was gathered. The analysis of plant associations across the Everglades identified that slough communities were historically dominated by white water lily (*Nymphaea odorata)* as well as slim spikerush (*Eleocharis elongata*) prior to the construction of the Central & South Florida Project (C&SF Project) and therefore were selected as indicator species.

During Phase II, the empirical evidence gathered during Phase I was evaluated to define performance measure targets. Based on the scientific evidence, the optimal hydrologic conditions for the two-indicator species are;

1. to maximize continuous hydroperiods (days with depth ≥ 0.0 ft) (Hydroperiod)
2. to minimize dry down events below 0.7 ft (20 cm) (Dry down)
3. to maintain dry season average depths of 1.5 to 2 ft (~46 to 60 cm) (Dry Season Depth)
4. maintain a wet season average depths of 2 to 3 ft (~60 to 90 cm) (Wet Season Depth)

During Phase III, the targets gathered and defined during Phases I and II were matched to NSM version 4.6.2 frequency curves that best fit the hydroperiod optima for the two-indicator species. The performance measure target is the empirical frequency curve from NSM version 4.6.2 that most closely matches the slough vegetation hydrologic optima. For example, return periods (years) of annual maximum continuous hydroperiods are plotted for the period of record (1965-2005) for each alternative at each IR. The percent of target achieved (%) for each year plotted on the frequency curve is computed relative to

base conditions. The alternative's score for this metric at each IR is computed by averaging the percent of target achieved for all years. This is calculated for each of the above performance measure metrics.

This performance measure is applied to indicator regions within the RSM-GL model mesh. This performance measure is not scored at IR 140 or IR 190. To facilitate evaluation of each alternative's performance, separate scores are reported for each of the nine zones by averaging scores from each indicator region within each zone (**Table G-1**).

Note, IRs 140 and 190 have been defined by RECOVER to be representative of sawgrass and marl marsh. However, some ridge and slough habitat has been found within these regions historically. These IRs were therefore included in our analysis but not scored with the slough vegetation performance measure.

G.1.5.3 Southern Coastal Systems Performance Measure

Salinity targets (here called "paleo-adjusted NSM salinity targets") are derived using simulated pre-drainage hydrologic conditions from the NSM version 4.6.2 and MLR statistical models (NSM-MLR) to estimate salinity conditions at 17 MMN stations in Florida Bay. Paleo-ecological information provided by the United States Geological Survey (USGS) studies in Florida Bay are used to adjust the NSM-MLR salinity time series values at each MMN station to more closely represent historical salinity conditions.

Simulated hydrology produced by RSM-GL version 2.3.2 is post-processed using the MLR statistical models to predict salinities at the MMN stations. The alternative salinity time series are then compared to the paleo-adjusted NSM salinity targets using the metrics described below. Each metric is appraised on a monthly and seasonal basis (for this performance measure, wet season = June through November; dry season = December through May).

G.1.5.3.1 Regime Overlap

G.1.5.3.1.1 PM 8.1 Dry Season Regime Overlap and PM 8.2 Wet Season Regime Overlap

For each MMN site, the distribution of salinities in the paleo-adjusted NSM record (target) is compared to the predicted distribution (CEPP alternative) of results between the 25th and 75th percentiles (hereafter referred to as the "mid-range"). The mid-range distribution of paleo-adjusted NSM salinities in the period of record is evaluated on a cumulative monthly and seasonal basis to determine the target for this metric.

The mid-range distribution is determined for monthly and seasonal CEPP alternative model output at each MMN site and compared to the target distribution. The overlap between the mid-range distributions is determined on a monthly and seasonal basis and is reported as a proportion of the midrange values of each CEPP alternative model output that fall within the mid-range of the target. This provides a "regime overlap score" for each month on a 0 to 1 scale.

G.1.5.3.2 High Salinity

G.1.5.3.2.1 PM 8.3 Dry Season High Salinity and PM 8.4 Wet Season High Salinity

This metric focuses on the exceedances (in days) of the predicted data (CEPP alternative) above a high-salinity threshold. The high-salinity threshold is calculated using the period of record for the paleo-adjusted NSM. The 90th percentile value is determined separately for each MMN station and used as the high-salinity threshold. The high salinity target is for high salinity threshold exceedances in the CEPP alternative model output to be no more frequent than occurs in a comparable paleo-adjusted NSM time

period (here called "target exceedances"). Target exceedances are calculated on a monthly and seasonal basis. The desired metric score is 1.0.

G.1.6 Method: Calculation of Ecosystem Benefits

The calculation of ecosystem benefits (quantitative scoring) consisted of four general steps, as illustrated in **Figure G-9**. These are: (1) rescaling of performance measures to common units; (2) combining performance measures into an aggregate score for each of the zones in the project area (i.e., two zones in the Northern Estuaries, nine zones in WCA 3 and ENP, and six zones in Florida Bay*)*; (3) and converting the zone scores into HUs that were then used to (4) compare alternatives.

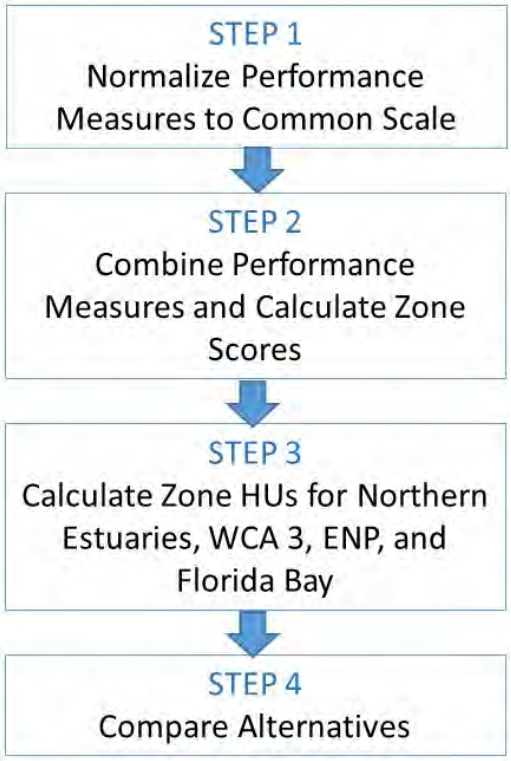


Figure G-9. Overview of Steps in Calculating Ecosystem Benefits and Numerical Outputs

G.1.6.1 Step 1: Normalize Performance Measures Scores to Common Scale

Summary: Raw performance measure outputs were linearly rescaled to have a common range of values between 0 and 100. These values were extrapolated to provide a set of performance measure scores for each zone. The product of this step was a set of performance measure scores on a common measurement scale within each region of the project area (i.e. Northern Estuaries, WCA 3, ENP, and Florida Bay).

G.1.6.1.1 Northern Estuaries Performance Measures

Survey information from the 2007 System Status Report (RECOVER 2007b) was used to determine the zero score on the zero to 100 scale for current conditions (i.e., Existing Conditions Baseline [ECB]). Oyster surveys performed in 2003 and 2004 indicate that as of those dates there were 18 acres of live oyster bars in the Caloosahatchee Estuary and 117 acres in the St. Lucie Estuary. Target acreages for these locations

are 500 acres and 834 acres respectively. These targets were determined to be the maximum acres achievable after all CERP components affecting these areas are built and operational (RECOVER 2005). This target assumes all reservoir, Stormwater Treatment Area (STA), and wetland rehydration features which are needed to obtain favorable salinities are in place. Also to reach these targets, substrate improvements which includes muck removal and the addition of suitable substrate such as oyster cultch will be needed. To calculate the score on the zero to 100 scale for current conditions, a percentage of the target was used (i.e., 14% St. Lucie Estuary and 4% for the Caloosahatchee Estuary) based on the acres of oysters from the 2003 and 2004 surveys. Original scores for each performance measure for the ECB were then rescaled to these values. The minimum value for each performance measure for the original scale was then extrapolated using the known score determined for the ECB (14 for the St. Lucie Estuary and 4 for the Caloosahatchee Estuary) and the target score of 100.

Acreages of oysters were determined to be a suitable measure for purposes of determining the zero to 100 score for current conditions. Oysters, which naturally dwell in the middle (mesohaline) portion of the estuaries, are affected by both high- and low-flow violations of the salinity performance measure. Oysters provide many benefits to the estuaries because they improve water quality by filtering particles from the water, serve as prey and habitat for numerous other organisms, and play an important role in the estuarine food chain. Oysters serve as excellent indicator species because salinity conditions suitable for oysters also produce favorable conditions for a suite of other desirable estuarine organisms that dwell both directly on the reef as well as in other areas of the estuary. As a keystone species and valued ecosystem component, oysters are indicative of the ecosystem health.

G.1.6.1.2 Greater Everglades Performance Measures

Within WCA 3 and ENP, each of the project performance measures were developed using measurement units and a scale suitable to the hydrologic parameters the performance measure was designed to evaluate. In order to combine these different performance measures into a single overall score, it was necessary to transform all the performance measures to a common scale that represented a comparable range of ecosystem performance, regardless of differences in the original metrics. The scale chosen for this purpose was one that ranged from zero to 100, with the minimum of zero representing a fully degraded ecosystem and a maximum of 100 representing the restoration target.

Rescaling from the original performance measure scale to this common, zero to 100 scale was done by simple linear projection. The maximum score of 100 was assigned to performance measure values that, on their original scale, were defined as the ecosystem restoration target. These targets were established at the time the performance measures were originally developed. The minimum of zero was assigned to performance measure values that, on their original scale, represented hydrologic conditions in a fully degraded ridge and slough ecosystem.

In order to establish what constitutes this minimum value on the original scale within WCA 3 and ENP, reference areas within the existing system were chosen, and output from the ECB from the RSM-GL was used to set the minimum, “fully degraded” score for each performance measure. The ECB was used for this purpose because it is a description of assumed hydrologic conditions in December 2010-2011 as modeled by using a multi-year period of record based on assumptions such as land use, population, water demand and assumed operations of the C&SF Project. As such, the ECB provided the best available RSM-GL representation of current habitat quality within the project area.

Some Greater Everglades performance measures were scored using indicator regions within the RSM-GL domain while others used flow transects. ECB scores from indicator regions and flow transects in northwestern WCA 3A were selected as reference sites. The reference sites, which at one time were part of the ridge and slough landscape, are now fully degraded as a result of the existing hydrologic conditions.

The environmental condition of northern WCA 3A is an accurate measure of the current degraded ecologic condition of WCA 3A. Northwestern WCA 3A has been over drained and its natural hydroperiod shortened. Over drainage of northern WCA 3A has resulted in the invasion of a number of plant species (e.g., cattail and willow) associated with drier conditions and has increased the frequency of severe peat fires. Peat fires have resulted in the loss of the ridge and slough landscape that was once characteristic of the area as well as causing the release of soil phosphorous leading to conditions more favorable for cattail colonization and expansion. Today northern WCA 3A is largely dominated by a sawgrass/cattail community and scattered shrubs and lacks the natural structural diversity of plant communities seen in central and western WCA 3A.

These reference sites were intended to represent degraded conditions for all Greater Everglades performance measures. For indicator region based performance measure scores, the ECB score from IR 114 was used to establish the minimum score for the project performance measure. For project performance measures scored at flow transects, the ECB score from T-5, T-MC1, and/or transect pair T-MC1 and T-MC2 were used. These indicator regions and transects are all located in northwestern WCA 3A. Alternative plan performance measures scores were then rescaled relative to the minimum ECB score. **Table G-3** depicts the Greater Everglades performance measures, a description of the metric, and lists the reference degraded site used for each performance measure.

Table G-3. Rescaling of Project Performance Measures and Location of Degraded Reference Site for Greater Everglades Performance Measures

Metric #	Performance Measure Metric	Untransformed Values	Degraded Reference Site
1.1	Inundation Duration in the Ridge and Slough Landscape – PPOR Inundated	% PPOR with water depth >0.0 ft	IR 114
2.1	Sheetflow in the Ridge and Slough Landscape – Timing of Sheetflow	flow /mile	Transect T-5
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity of Sheetflow	flow /mile	Transect T-MC1 Transect Pair T-MC1&T-MC2
2.3	Sheetflow in the Ridge and Slough Landscape – Distribution of Sheetflow	flow /mile	Transect T-MC1
3.1	Hydrologic Surrogate for Soil Oxidation – Drought Intensity Index	water depth relative to land surface elevation (ft- days below ground)	IR 114
4.1	Dry Events in Shark River Slough – Number of Dry Events	number of dry events with water depth < 0.2 ft	IR 114
4.2	Dry Events in Shark River Slough – Duration of Dry Events	duration of dry events with water depth < 0.2 ft	IR 114
4.3	Dry Events in Shark River Slough – PPOR of Dry Events	% PPOR with water depth <0.2 ft	IR 114

Table G-3. Rescaling of Project Performance Measures and Location of Degraded Reference Site for Greater Everglades Performance Measures (continued)

Metric #	Performance Measure Metric	Untransformed Values	Degraded Reference Site
5.1	Slough Vegetation Suitability – Hydroperiod	maximize continuous hydroperiod (depth ≥ 0.0 ft	IR 114
5.2	Slough Vegetation Suitability – Dry down	minimize continuous dry down events (depth ≤ 0.7 ft (20 cm)	IR 114
5.3	Slough Vegetation Suitability – Dry Season Depth	attain dry season average depths of 1.5 - 2.0 ft	IR 114
5.4	Slough Vegetation Suitability – Wet Season Depth	attain average wet season depths of 2.0 - 3.0 ft	IR 114

G.1.6.1.3 Southern Coastal Systems Performance Measures

Within Florida Bay, a method to rescale performance measure scores to a common scale was already developed per the documentation sheet. Performance measures were rescaled on a zero to one scale as described in **Section G.1.5.3** above.

G.1.6.2 Step 2: Combine Performance Measures and Calculate Zone Scores

Summary: Within each zone, performance measure scores were combined for each project alternative to produce a net zone benefits score between 0 and 1.

In Step 2, performance measure scores were combined to yield a score for each project alternative. This was repeated for the two zones within the Northern Estuaries, each of the nine zones within WCA 3 and ENP, and for the six zones within the Florida Bay. This value, which would be between 0 and 1, was then used in Step 3 to calculate the zone's contribution to the total HUs for the alternative.

For performance measures that included more than one IR or flow transect within a zone, performance measure sub-metrics for individual IR and transects were aggregated to produce a single score for each performance measure sub-metric per zone.

The CEPP Planning Model implemented an assumption that performance measure results used as inputs to the planning model were of equal credibility and reliability. The CEPP Planning Model included an option to weight performance measures within each zone of the study area and/or weight specific IRs specifically within the WCA 3 and ENP zones. This was included to provide the capacity to investigate the sensitivity of HU computations to the emphasizing or de-emphasizing of individual performance measures (at specific locations) deemed to be disproportionately influenced by errors/biases in the underlying hydrologic model used to produce the performance measure sub-metric scores.

It must be noted, that three of the Greater Everglades performance measures (*Sheetflow in the Ridge and Slough Landscape, Dry Events in Shark River Slough, and Slough Vegetation Suitability)* included two or more sub-metrics, for example, for PM 5 there were PM sub-metrics 5.1, 5.2, 5.3 and 5.4. Performance measures for the Northern Estuaries and Florida Bay also contained multiple sub-metrics. If a performance measure score had more than one sub-metric, sub-metric scores were averaged to prevent a performance measure with multiple sub-metrics from contributing disproportionately in comparison to a performance

measure having only a single metric. Once this step was complete, a single score (0 to 1 scale) was produced for each zone.

G.1.6.3 Step 3: Calculate Zone Habitat Units for Northern Estuaries, WCA 3, ENP, and Florida Bay

Summary: The 0 to1 benefits score for each zone was then multiplied by the acreage of the zone to generate a HU value for the zone.

For each zone, the zone benefits score from Step 2 was then multiplied by the zone's acreage to produce a HU value for acres of restored Everglades' wetland or acres of restored estuary. This was repeated for each of the zones within the project area. Each zone could have a maximum of 1 HU per acre. This is because a score of 1 represents 100% suitable habitat for that acre, for that specific performance measure. This enables evaluators and decision-makers to consider how differences between alternatives are distributed spatially, including potential trade-offs in benefits between sub-regions of the project area.

The HU values for all zones within WCA 3 and ENP (Zones 3A-NE, 3A-MC, 3A-NW, 3A-C, 3A-S, 3B, ENP-N, ENP-S, and ENP-SE) were summed to produce a total HU value for each alternative, as well as for the future without (FWO) project condition within this portion of the project area. HU values for all zones in Florida Bay (Zones FB-W, FB-C, FB-S, FB-EC, FB-NB, and FB-E) and the Northern Estuaries (Zones CE-1 and SE-1) were also summed.

G.1.6.4 Step 4: Compare Alternatives

Summary: The total HUs and the difference in HUs between each alternative and the FWO project condition were displayed in tables that also report the partition of HUs into contributions from each zone within the Northern Estuaries, WCA 3, ENP, and Florida Bay.

The HU values for the FWO project condition were subtracted from each alternative to produce HU lift.

G.2 SUMMARY OF ALTERNATIVE PERFORMANCE

An extensive discussion of performance measure scores for each project alternative is documented below. Performance measure results are summarized by planning region (i.e., Northern Estuaries, WCA 3, and ENP, and Florida Bay). Comprehensive summary tables of the individual performance of each project alternative are presented throughout this section for each zone within a given region. Comparisons are made between the ECB and the FWO. Each project alternative is then compared to the FWO. Consistency with the authorized CEPP plan was established by ensuring the FWO performance measures in this effort are similar to the Alternative 4R2 from CEPP. In many cases these values were consistent but some variations do exist. Similarities and differences are described in the following sections.

Performance measure scores are shown on a common measurement scale that ranges from zero to 100, with the minimum of zero representing a fully degraded ecosystem and a maximum of 100 representing the restoration target. Color coding has been used to facilitate interpretation of results and identify ranges of performance measure scores with values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue. These comprehensive summary tables are used to illustrate the relative influence of each performance measure to a given zone. Performance measure graphics are included for select locations throughout each region to depict general trends in performance. The percent of target HUs achieved by a given alternative for each zone is also noted within the summary

tables. A summary of the HU results is also presented in **Section 4** (**Evaluation and Comparison of Alternative Plans**) of the main report for the CEPP PACR alternatives (i.e., Alternative R240, Alternative R360, and Alternative C360). Alternatives R240 and R360 included two different design configurations and are presented as Alternatives R240A and R240B and Alternatives R360C and R360D or C360C, respectively, when costs are presented; costs for Alternative C360D were thought to be too costly for the benefits produced and therefore Alternative C360D was not evaluated. The design configurations had no effect on habitat conditions and therefore it was assumed that Alternatives R240A and R240B yielded the same habitat units and Alternatives R360C and R360D yielded the same habitat units. Alternative C360C assumed the same design configuration as Alternative R360C but also offered water for multiple purposes (water supply). The distribution of water was effected and the habitat units for Alternative C360C are presented in this appendix. A summary of performance for each alternative is given in **Sections G.2.1** through **G.2.4**.

Results of the cost effectiveness incremental cost analysis (CE/ICA) identified Alternative R240A as providing the greatest overall benefits with the least cost per habitat unit. The incremental annual average cost versus annual average habitat units illustrated that Alternative R240A ($2,564) is also incrementally more cost effective than the Alternative C360C ($3,029). Learning from the operational benefits gained from Alternative C360C, similar operations were applied to the Alternative R240A design configuration. Operations were also refined to provide additional opportunities for other water related needs (i.e., water supply) in the EAA. Modeling scenarios were subsequently conducted to identify project effects resulting from operational changes. A summary of performance for Alternative C240A is described in **Sections G.3**.

G.2.1 Northern Estuaries

The Caloosahatchee and St. Lucie estuaries both receive excessive discharges from Lake Okeechobee as well as their local basins during wet years, and suffer from too little discharge on excessively dry years. Alternative performance in the Northern Estuaries was measured by evaluating the frequency and magnitude of freshwater inflows from Lake Okeechobee and the estuary watersheds. Flow targets are outlined under the RECOVER salinity performance measure. These targets were developed to achieve desired salinity ranges in the estuaries to meet the needs of key indicator species such as oysters and submerged aquatic vegetation. Within the Caloosahatchee Estuary, targets were based on freshwater discharges from the C-43 canal at the S-79 structure where the mean monthly inflow should be maintained between 450 and 2,800 cfs. Flows less than 450 cfs are considered harmful since these flow levels allow salt water to intrude, raising salinity above the tolerance limits for communities of submerged aquatic vegetation in the upper estuary. Flows greater than 2,800 cfs cause mortality of marine seagrasses and oysters in the lower and mid estuary and, at flows greater than 4,500 cfs, seagrasses begin to decline in San Carlos Bay (See **Section G.1.5.1.1**). Within the St. Lucie Estuary, targets were based on freshwater discharges at the S-80, S-48, S-49 and Gordy road structures where the target frequency of mean biweekly flows should be maintained between 350 and 2,000 cfs. Based on the salinity tolerances of oysters, flows less than 350 cfs result in higher salinities at which oysters are susceptible to increased predation and disease. Flows in the 350-2,000 cfs range produce tolerable salinities. Flows greater than 2,000 cfs result in low, intolerable salinity within the estuary. Flows greater than 3,000 cfs damage seagrasses in the Indian River Lagoon (See **Section G.1.5.1.2**). Targets were developed to reduce minimum discharges and mediate high flow events to the estuaries to improve estuarine water quality and protect and enhance estuarine habitat and biota.

Table G-4 and **Table G-5** show performance measure scores on a zero to 100 scale for the Caloosahatchee and St. Lucie Estuaries. The percent of target HUs achieved by a given alternative for each zone is also noted.

Table G-4. Rescaled Performance Measure Scores (Zero to 100 Scale) for Caloosahatchee Estuary (Zone CE-1) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALT C360
6.1	Low Flow (< 450 cfs)	4	81	78	80	79
6.2	High Flow (>2800 cfs)	4	29	35	36	38
	Percentage of Target HU (HSI x 100)	**4**	**55**	**57**	**58**	**59**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Table G-5. Rescaled Performance Measure Scores (Zero to 100 Scale) for St. Lucie Estuary (Zone SE-1) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
7.1	Low Flow (< 350 cfs)	0	53	48	49	51
7.2	High Flow (>2000 cfs)	17	57	71	76	75
	Percentage of Target HU (HSI x 100)	**9**	**55**	**60**	**63**	**63**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

In the Caloosahatchee Estuary, the FWO scores are consistent with the results of the CEPP Alternative 4R2, the authorized plan (**Table G-4**). The number of times mean monthly flows greater than 2,800 cfs were not met for the FWO occurred 70 times. The number of times mean monthly flows less than 450 cfs were not met occurred 23 times for the FWO (**Figure G-10**).

In the St. Lucie Estuary, the number of times flows greater than 2,000 cfs from Lake Okeechobee regulatory releases were not met occurred 36 times for the FWO (**Figure G-11**). The number of times flows less than 350 cfs were not met occurred 65 times for the FWO (**Figure G-11**).

Consistent with CEPP, the FWO assumes the implementation of the C-43 Western Basin Storage Reservoir in the Caloosahatchee Estuary and the IRLS Project within the St. Lucie Estuary.

Modeling results of the alternatives indicate a reduction in the number of high discharge events from Lake Okeechobee to the Northern Estuaries. Within the Caloosahatchee Estuary, the number of times mean monthly flows greater than 2,800 cfs were not met decreased from 70 in the FWO to 64 for Alternative R240, 63 for Alternative R360, and to 61 for Alternative C360. Within the St. Lucie Estuary, the number of times biweekly flows greater than 2,000 cfs from Lake Okeechobee regulatory releases were not met decreased from 36 in the FWO to 24, 20, and 21 for Alternatives 240, 360, and C360 respectively (**Figure G-11**). The number of low discharge events to the Caloosahatchee Estuary increased slightly in comparison to the FWO moving from 23 in the FWO to 27, 24, and 25 for Alternatives 240, 360, and C360. The number of low discharge events to the St. Lucie Estuary increased to 68, 67, and 66 respectively for Alternatives R240, R360, and C360 in comparison to the FWO which was roughly 65. The increase in these events is not expected to have a significant effect on vegetation and/or fish and wildlife resources (See **Section 5 and Appendix C.2.1**).

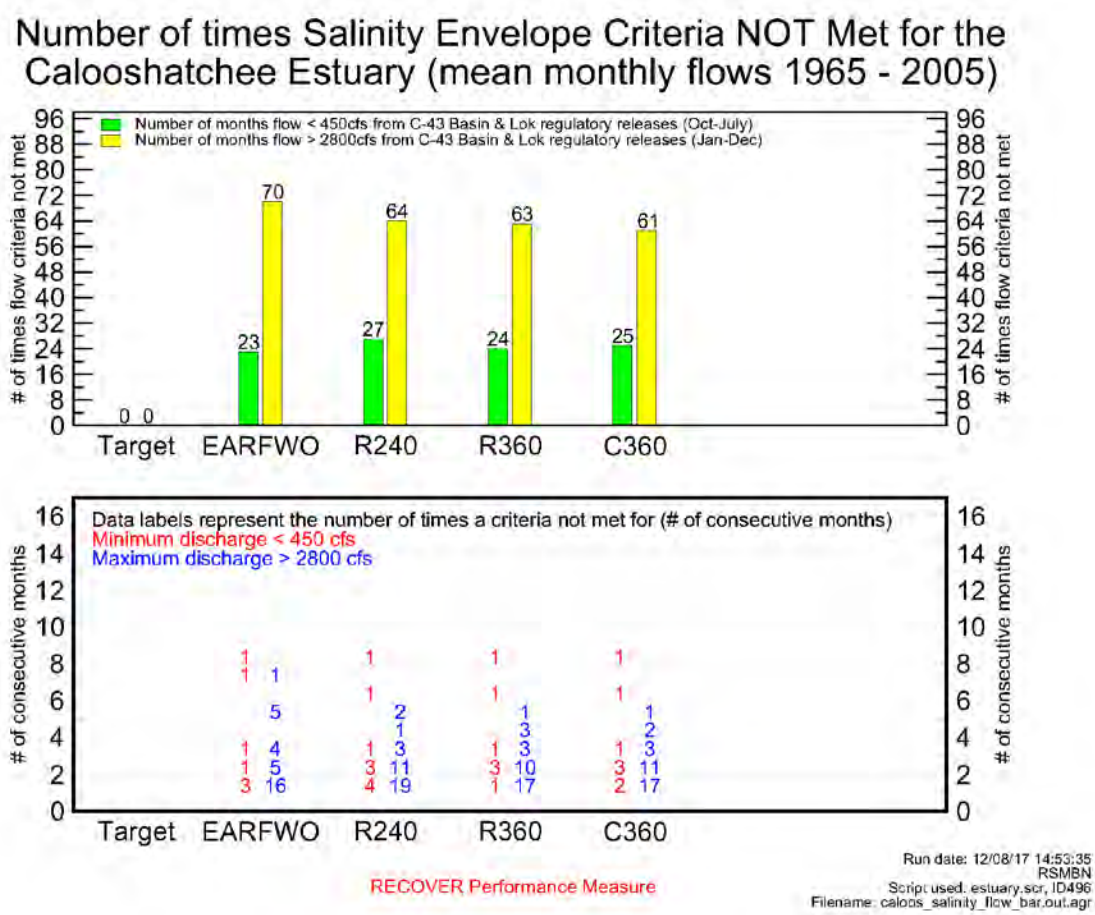


Figure G-10. Number of Times Salinity Criteria Not Met for the Caloosahatchee Estuary for Each Alternative

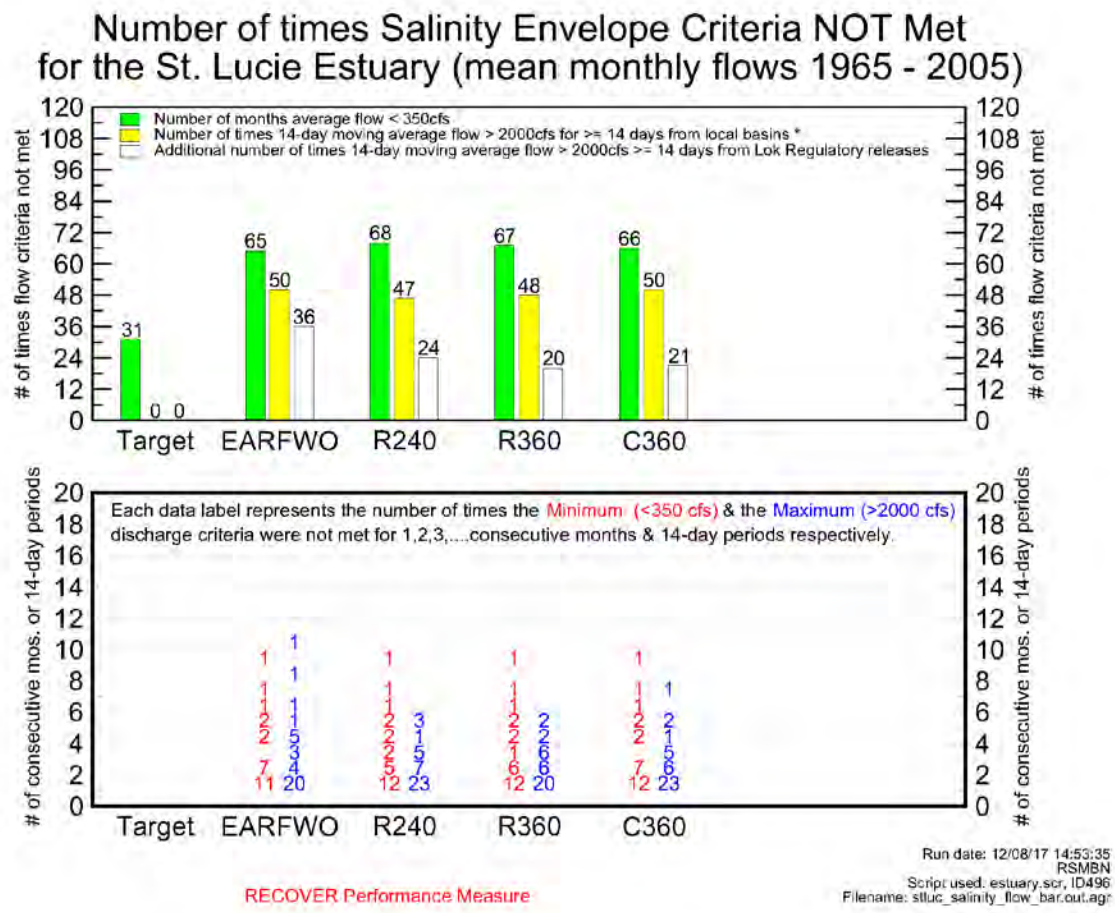


Figure G-11. Number of Times Salinity Criteria Not Met for the St. Lucie Estuary for Each Alternative

Increases in low flow violations during the dry season were indicated by the modeling effort; however, due to the infrequency of the increases in these events is not expected to have a significant effect on SAV and oysters within the estuaries. Although these extreme dry spells are rare in the St. Lucie Estuary, unlike the Caloosahatchee Estuary they can occur and therefore supplemental flows during dry times may be warranted and have been accounted for in the IRLS water reservation process. If additional low flow canal releases become needed, the preferred delivery path would be through the North Fork of the St. Lucie River as was modeled during the IRLS CERP project and not from the S-80 on the C-44 canal.

Flows that are altered beyond historic conditions have negatively impacted healthy floral and faunal communities. Historically, natural freshwater discharges into the Caloosahatchee and St. Lucie Estuaries sustained an ecologically appropriate range of salinity conditions to facilitate the presence of juvenile marine fish, shellfish, oysters and submerged aquatic vegetation. Current water management practices have resulted in rapid salinity changes and a shift in the ecological components that historically defined the estuaries to communities that have been deemed less desirable.

The area within the Caloosahatchee and St. Lucie Estuaries that has the potential to be beneficially affected by the project is 70,979 acres for the Caloosahatchee Estuary and 14,994 acres for the St. Lucie Estuary. Implementation of alternatives would achieve 57-59% and 60-63% of the target HUs for the

Caloosahatchee and St. Lucie Estuaries, respectively (**Table G-4** and **Table G-5**). The FWO would achieve 55% of the target HUs for the Caloosahatchee Estuary and St. Lucie Estuary (**Table G-4** and **Table G-5**). The improvements in flows to the Northern Estuaries from CEPP were major (FWO). The alternatives considered in the CEPP PACR are moderate but move conditions closer to the overall goal of CERP for the Northern Estuaries. Implementation of the A-2 Reservoir and A-2 STA would help to maintain the target frequency and duration of water releases to the Northern Estuaries and would help curtail continued habitat loss and allow the recovery of more desirable communities.

G.2.2 WCA 3 and ENP

In the pre-drainage system, the inundation pattern supported an expansive system of freshwater marshes including longer hydroperiod sawgrass "ridges" interspersed with open-water "sloughs," higher elevation marl prairies on either side of Shark River Slough, and forested wetlands in the Big Cypress marsh. Flood control and water supply projects have compartmentalized and fragmented the Everglades landscape, reduced flows through the sloughs, and altered hydroperiod and depths. The result has been substantially altered plant community structures, reduced abundance and diversity of animals, and spread of exotic vegetation. The desired restoration condition is to restore pre-drainage patterns of multiyear hydroperiods and pre-drainage patterns of sheetflow.

G.2.2.1 Northern WCA 3A

The Miami Canal functions as a major, unnatural drainage for WCA 3A. In combination with the northern levees of WCA 3A (L-4 and L-5), the Miami Canal has substantially impacted historical sheetflow and natural wetland hydroperiods. As a result, the natural capability of northern WCA 3A to store water is lost and the Miami Canal effectively over-drains the area. These hydrologic changes have increased the frequency of severe peat fires and have also resulted in the loss of ridge and slough topography that was once characteristic of the area. Most of WCA 3A north of Interstate 75 has experienced some form of fire and in more recent years those fires have moved farther south into the western portion of WCA 3A. Today, northern WCA 3A is largely dominated by sawgrass, cattail, and scattered shrubs and lacks the structural diversity of plant communities seen in central and western WCA 3A. Alternatives for the CEPP consist of variations of the length and placement of a hydropattern restoration feature along the northern levees of WCA 3A and the length of backfill of the Miami Canal. Implementation of the CEPP is expected to rehydrate much of northern WCA 3A by providing a means for redistributing treated STA discharges from the L-4 and L-5 in a manner that promotes sheetflow and by removing the drainage effects associated with the Miami Canal. Resumption of sheetflow and related patterns of hydroperiod and water depth will significantly help to restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape.

Alternatives improved hydrologic conditions in northern WCA 3A in comparison to the FWO (**Table G-6, Table G-7, and Table G-8**). Scores improved in terms of meeting the desired targets for measures of inundation duration, sheetflow timing and continuity, and slough vegetation suitability for dry and wet season depths. The authorized CEPP plan achieved major performance with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events. The FWO scores for these performance measures ranged from 30 to 98. As such, the alternatives considered in this study provide moderate improvements to move conditions closer to the CERP Goals. Alternatives did not have

a major effect on hydroperiod targets when compared with the FWO. Overall, performance measures did improve.

Table G-6. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northwestern WCA 3A (Zone 3A NW) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	63	95	96	97	97
2.1	Sheetflow in the Ridge and Slough Landscape – Timing	20	34	38	37	36
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity	4	61	62	62	62
2.3	Sheetflow in the Ridge and Slough Landscape-- Distribution	24	68	68	68	69
3.1	Hydrologic Surrogate for Soil Oxidation -–- Drought Intensity Index	63	97	100	100	100
5.1	Slough Vegetation Suitability – Hydroperiod	46	80	78	79	79
5.2	Slough Vegetation Suitability –- Dry down	51	85	86	86	85
5.3	Slough Vegetation Suitability – Dry Season Depth	22	38	40	40	40
5.4	Slough Vegetation Suitability – Wet Season Depth	22	46	49	50	50
	Percentage of Target HU (HSI x 100)	**44**	**77**	**79**	**79**	**79**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Table G-7. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3A Miami Canal (Zone 3A MC) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALT R240	ALT R360	ALT C360
1.1	Inundation Duration in the Ridge and Slough Landscape	55	88	91	91	91
2.1	Sheetflow in the Ridge and Slough Landscape – Timing	18	32	36	35	35
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity	4	61	62	62	62
2.3	Sheetflow in the Ridge and Slough Landscape-- Distribution	28	62	61	62	62
3.1	Hydrologic Surrogate for Soil Oxidation –- Drought Intensity Index	52	75	78	79	79
5.1	Slough Vegetation Suitability – Hydroperiod	42	73	73	74	74
5.2	Slough Vegetation Suitability –- Dry down	63	85	86	87	86
5.3	Slough Vegetation Suitability – Dry Season Depth	37	49	52	52	52
5.4	Slough Vegetation Suitability – Wet Season Depth	40	50	53	54	54
	Percentage of Target HU (HSI x 100)	**42**	**70**	**72**	**72**	**72**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Table G-8. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northeastern WCA 3A (Zone 3A NE) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	40	94	95	95	95
2.1	Sheetflow in the Ridge and Slough Landscape – Timing	16	30	34	33	33
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity	6	59	60	60	60
2.3	Sheetflow in the Ridge and Slough Landscape — Distribution	18	57	57	56	55
3.1	Hydrologic Surrogate for Soil Oxidation –- Drought Intensity Index	50	93	93	93	93
5.1	Slough Vegetation Suitability – Hydroperiod	38	66	67	68	67
5.2	Slough Vegetation Suitability –- Dry down	58	82	84	85	85
5.3	Slough Vegetation Suitability – Dry Season Depth	35	45	47	48	48
5.4	Slough Vegetation Suitability – Wet Season Depth	30	41	43	44	44
	Percentage of Target HU (HSI x 100)	**36**	**74**	**75**	**75**	**75**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

CEPP produced improved inundation patterns in northwestern WCA 3A. Indicator region 114 was inundated for 91% of the period of record for the FWO. The alternatives only slightly increased inundation to 93%. The depths within northwestern WCA 3A as depicted by the normalized weekly stage duration curve for IR 114 are depicted in **Figure G-12**, an example IR for Zone 3A-NW. Changes in depths were minor relative to the FWO in the mid-range of ponding depths. A discussion of how these changes may affect environmental resources can be found in **Appendix C.2**.

Improved inundation patterns in northwestern WCA 3A resulted in better suitability for slough vegetation for all alternatives in dry and wet season depth (**Table G-6**). Alternatives R360 and C360 provided slightly improved conditions for slough vegetation relative to the FWO and Alternative R240, as shown for IR 114 in **Figure G-13**. None of alternatives met the desired dry and wet season water depth targets for slough vegetation in northwestern WCA 3A; however, the alternatives do slightly improve conditions for slough vegetation relative to the FWO by increasing water depths in both the wet and dry season at this location.

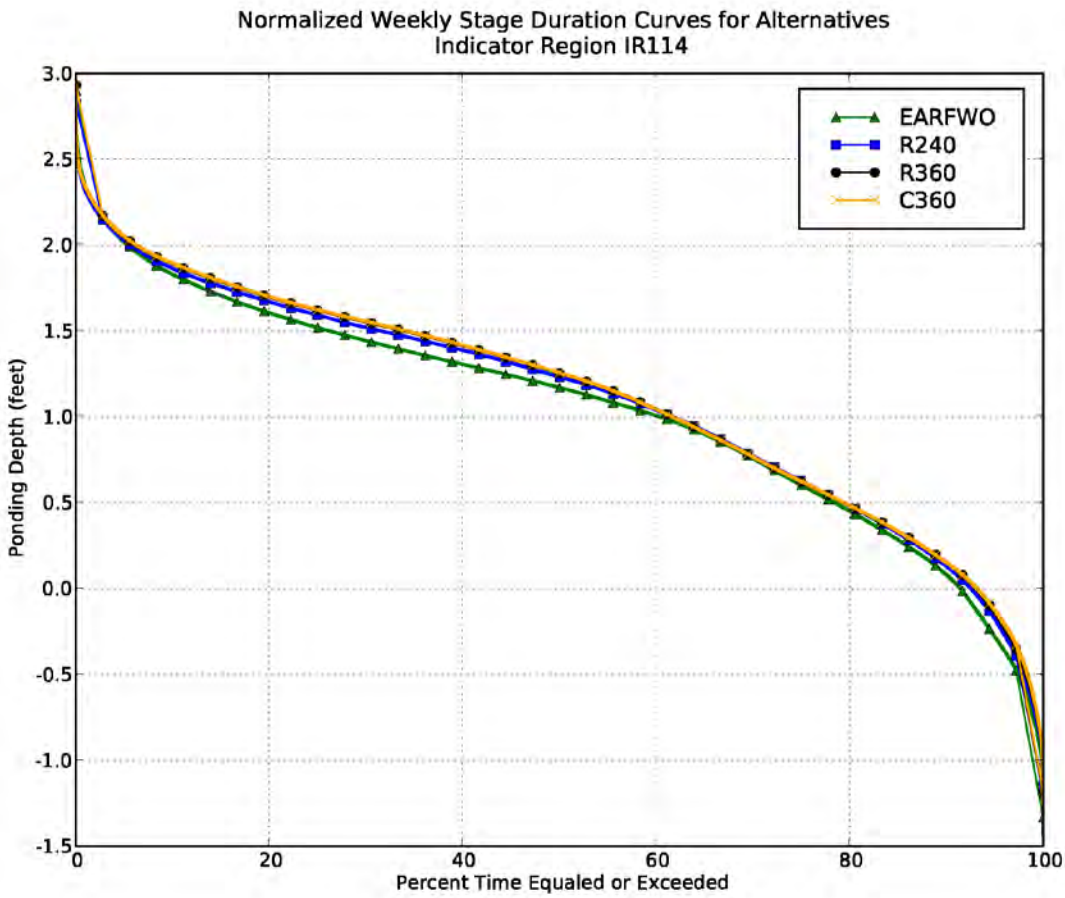


Figure G-12. Normalized Weekly Stage Duration Curve for Indicator Region 114 for Each Alternative

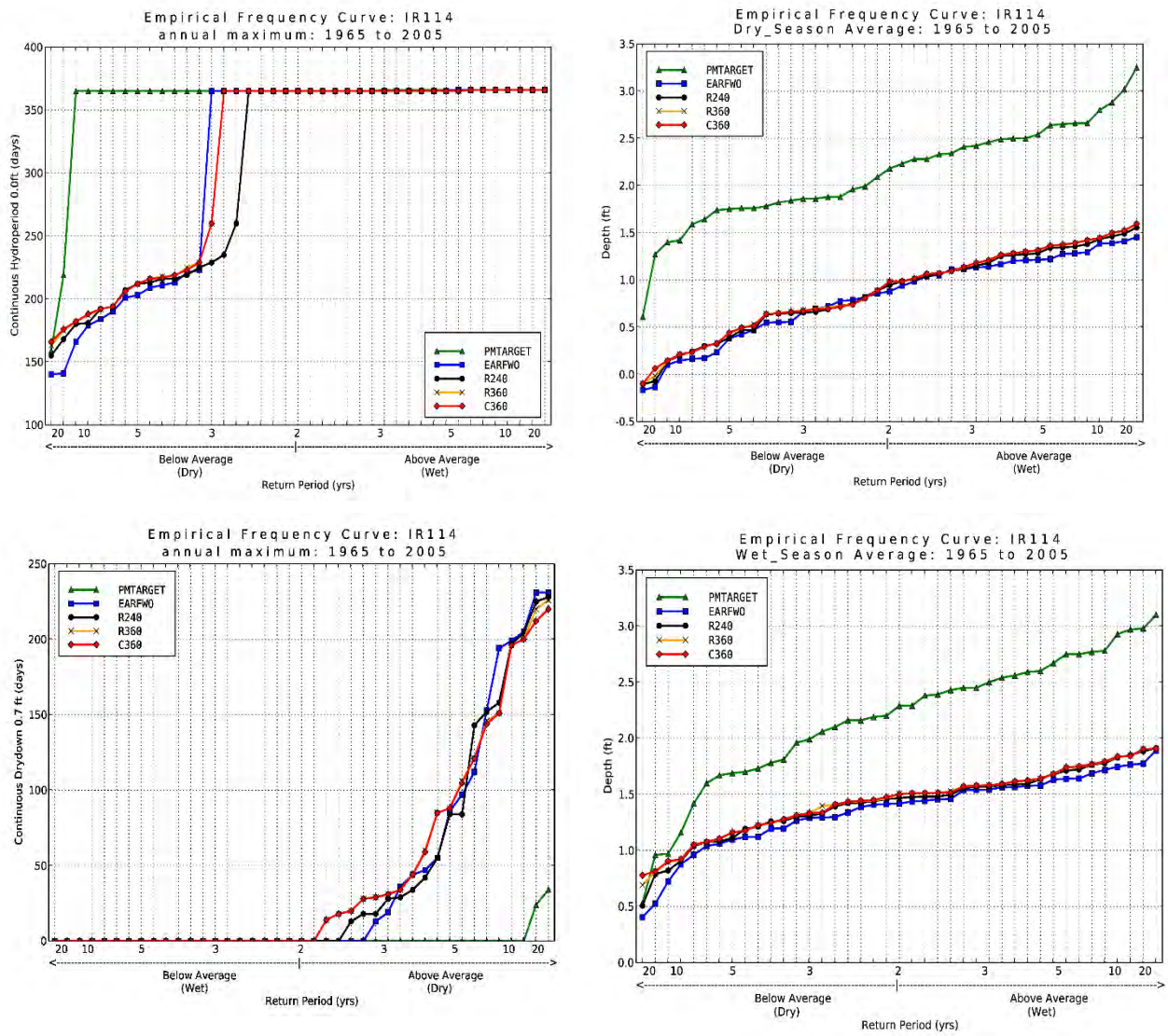


Figure G-13. Slough Vegetation Empirical Frequency Curves Indicator Region 114 for Each Alternative

Minor improvements in alternative scores compared with the FWO condition also occurred in northeastern WCA 3A (Zone 3A-NE) (**Table G-8**). Alternatives had minor increases in inundation patterns in IRs in northeastern WCA 3A located directly south of the easternmost spreader that is approximately 1.5 miles east of the G-206 structure. Differences between alternatives were so slight in the normalized weekly stage duration curve they are hard to distinguish (**Figure G-14**); the IR 116 is an example or Zone 3A-NE. The sheetflow distribution decreased slightly but improved the timing and continuity. The drought intensity index remained consistent with the FWO for each alternative. All alternatives slightly increased the slough vegetation suitability compared with the FWO (**Table G-8**). A discussion of how these changes may affect environmental resources can be found in **Appendix C.2**.

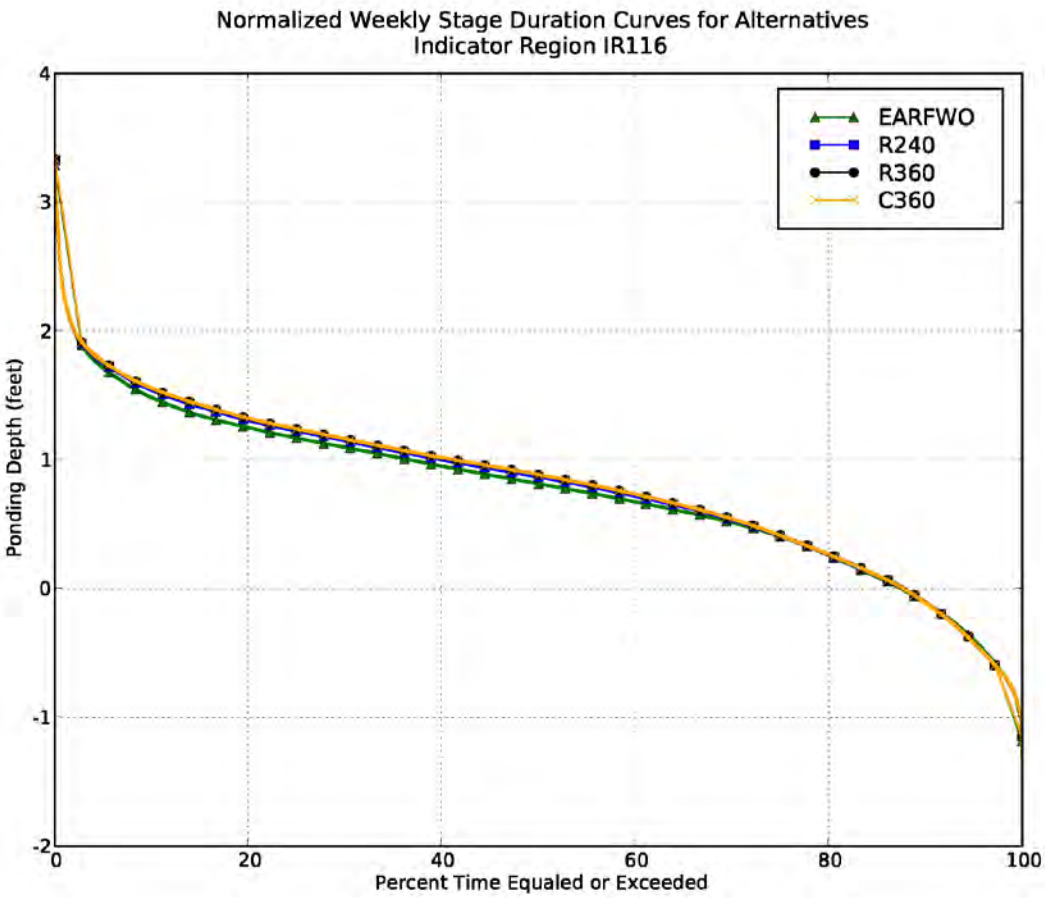


Figure G-14. Normalized Weekly Stage Duration Curve for Indicator Region 116 for each Alternative

CEPP assumed that implementation of the authorized plan would significantly affect hydrology in northern WCA 3A. Alternative performance in WCA 3 and ENP was measured by evaluating the depth, distribution, and duration of surface flooding, and the timing and distribution of flows. Because of the significant improvements made in CEPP, smaller scales of benefits resulted from the alternatives considered in this CEPP PACR when compared with the FWO, CEPP. Of the performance measures used, scores for each alternative for measures of inundation duration ranged from 87% of the period of record to 97% of the period of record across northern WCA 3A (**Table G-9**). Inundation duration for the FWO ranged from 87% of the period of record to 96% of the period of record (**Table G-9**). Reductions in drought intensity in northern WCA 3A relative to the FWO ranged from 1 to 178 ft-days over the period of record (**Table G-10**).

Table G-9. Percent Period of Record of Inundation for each Alternative (Raw Performance Measure Scores)

Zone	Indicator Region	FWO	ALTR240	ALTR360	ALTC360
Zone 3A-NW	IR 114	91	93	93	93
	IR 117	95	95	95	95
	IR 121	96	96	96	96
Zone 3A-MC	MC NE 1	93	94	94	95
	MC NE 2	95	96	97	97
	MC NW 1	93	94	95	95
	MC NW 2	90	91	91	91
	MC CE 1	92	92	92	92
	MC CE 2	87	88	88	88
	MC CW 1	91	91	91	91
	MC CW 2	94	94	94	94
	MC SE 1	91	92	92	92
	MC SE 2	88	89	89	89
	MC SW 1	91	91	92	92
	MC SW 2	93	93	93	93
Zone 3A-NE	IR 115	92	93	93	93
	IR 116	88	88	88	88
	IR118	87	87	87	87
	IR 119	92	92	93	93
	IR 190	89	89	89	89

Table G-10. Hydrologic Surrogate for Soil Oxidation (Water Depth Relative to Land Surface Elevation Ft-Days below Ground) for each Alternative (Raw Performance Measure Scores)

Zone	Indicator Region	FWO	ALTR240	ALTR360	ALTC360
Zone 3A-NW	IR 114	-438	-335	-281	-260
	IR 117	-247	-250	-247	-246
	IR 121	-145	-163	-161	-164
Zone 3A-MC	MC NE 1	-360	-264	-225	-194
	MC NE 2	-227	-157	-130	-110
	MC NW 1	-380	-275	-237	-216
	MC NW 2	-624	-528	-491	-472
	MC CE 1	-443	-441	-435	-439
	MC CE 2	-1525	-1465	-1442	-1445
	MC CW 1	-578	-581	-574	-582
	MC CW 2	-276	-299	-294	-301
	MC SE 1	-570	-533	-525	-527
	MC SE 2	-1430	-1336	-1315	-1310
	MC SW 1	-657	-626	-617	-619
	MC SW 2	-355	-352	-348	-351
Zone 3A-NE	IR 115	-432	-347	-328	-297
	IR 116	-681	-692	-688	-693
	IR118	-819	-836	-824	-834
	IR 119	-384	-336	-330	-329
	IR 190	-552	-578	-581	-582

The delivery of additional flow to the Everglades compared to the FWO would return many of the currently dehydrated areas to a level of hydration which moves toward the natural system condition. All alternatives act to rehydrate northern WCA 3A promoting peat accretion, reducing the potential for high intensity fires, and promoting the transition from upland to wetland vegetation. Implementation of the alternatives would achieve 79% of the target HUs for Zone 3A-NW (**Table G-6**), 72% of the target HUs for Zone 3A-MC (**Table G-7**), and 75% of the target HUs for Zone 3A-NE (**Table G-8**). The FWO would achieve 77, 70, and 74% of the target HUs for Zones 3A-NW, 3A-MC, and 3A-NE, respectively (**Table G-6, Table G-7, and Table G-8**).

G.2.2.2 Central and Southern WCA 3A (Zone 3A-C, 3A-S)

Central WCA 3A is considered to be fairly well conserved ridge and slough habitat. Vegetation and patterning in the central portion of WCA 3A resembles the pre-drainage conditions most closely and represents some of the best examples of Everglades habitat left in south Florida. This region of the Everglades appears to have changed little since the 1950s (which was already post-drainage) and contains a mosaic of tree islands, wet prairies, sawgrass stands, sawgrass ridges, and aquatic sloughs.

In central WCA 3A, alternatives provided minor improvements in hydrologic conditions in comparison to the FWO (**Table G-11**). Alternatives produced negligibly higher depths than the FWO as depicted by the normalized weekly stage duration curve for IR 122 (**Figure G-15**), an example IR for Zone 3A-C. Increases in depth within central WCA 3A were not as distinct as increases in observed depths relative to the FWO

in northern WCA 3A; however maintenance of existing conditions within this region of the project area is desirable as ridge and slough habitat is well conserved. Implementation of alternatives would achieve 81% of the target HUs for Zone 3A-C, consistent with the FWO (**Table G-11**).

Table G-11. Rescaled Performance Measure Scores (Zero to 100 Scale) for Central WCA 3A (Zone 3A C) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape - Timing	42	47	50	50	49
2.3	Sheetflow in the Ridge and Slough Landscape-Distribution	63	66	61	66	66
3.1	Hydrologic Surrogate for Soil Oxidation - Drought Intensity Index	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	74	82	82	82	82
5.2	Slough Vegetation Suitability -- Dry down	88	91	92	92	92
5.3	Slough Vegetation Suitability -- Dry Season Depth	42	43	44	45	45
5.4	Slough Vegetation Suitability -- Wet Season Depth	42	47	48	49	49
	Percentage of Target HU (HSI x 100)	**79**	**81**	**81**	**81**	**81**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

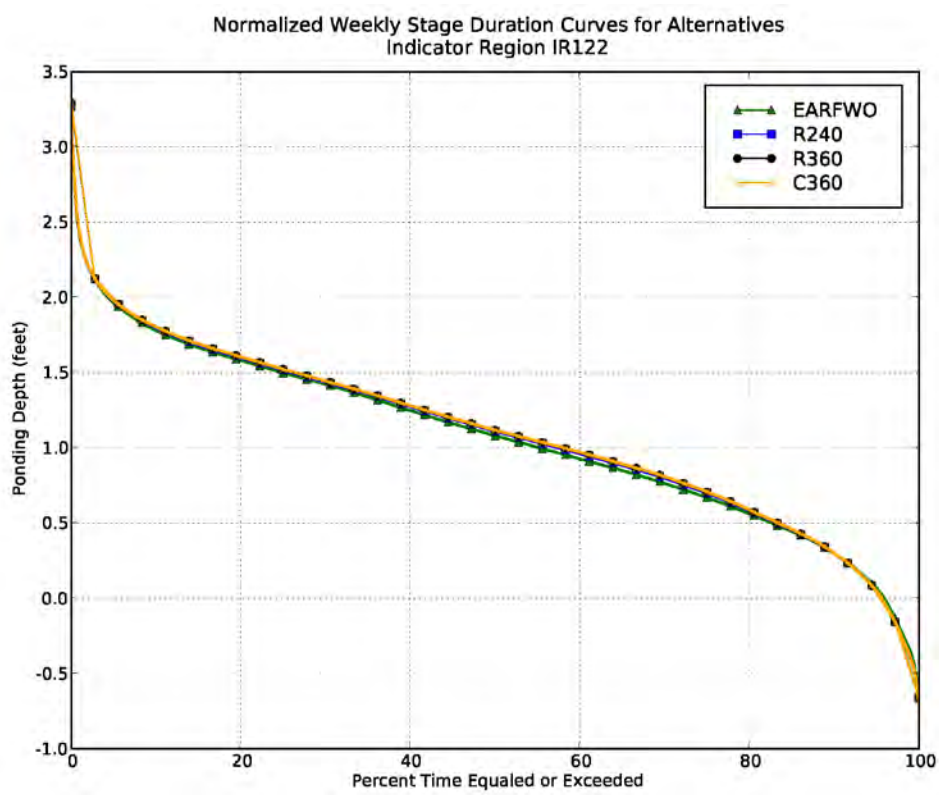


Figure G-15. Normalized Weekly Stage Duration Curve for Indicator Region 122 for each Alternative

The southern portion of WCA 3A is primarily affected by long durations of high water and a lack of seasonal variability in water depths created by impoundment structures (i.e., L-29 levee). The increased duration of high water events within southern WCA 3A has negatively impacted tree islands and caused fragmentation of the sawgrass ridges, again resulting in the loss of historic landscape patterning.

In southern WCA 3A, the ECB scored better in terms of meeting the desired performance measure targets relative to the FWO for slough vegetation suitability (**Table G-12**). CEPP and CEPP PACR alternatives performed slightly worse for measures of slough vegetation suitability relative to the ECB. Performance was explained by the operational targets that were used during plan formulation. Daily water management operations (WCA 3A Regulation Schedule) in WCA 3A was based on a 3 gage average. Operational targets used during CEPP aimed at keeping depth targets at existing conditions in central WCA 3A as it contains some of the best remaining ridge and slough habitat. In northeastern WCA 3A, where conditions tend to be too dry, depth targets were increased relative to existing conditions. In southern WCA 3A, where water is often too deep, depth targets were slightly decreased relative to existing conditions. This “pivot” around central WCA 3A minimized the increase of overall average water depths in WCA 3A. This resulted in slightly lower scores for the slough vegetation performance measure within southern WCA 3A which would indicate a potential shift toward conditions that are less suitable for emergent slough habitat in CEPP. The FWO for this CEPP PACR is the CEPP authorized project generally produced decreased depths by 0.2 to 0.3 ft with no significant change during extreme wet or extreme dry conditions.

Within southern WCA 3A, alternatives scored similarly to the FWO for sheetflow distribution, hydroperiods, and dry down. Alternatives produced similar depths to the FWO as depicted by the normalized weekly stage duration curve for IR 124 (**Figure G-16**); an example IR for Zone 3A-S.

However, shifts in slough vegetation suitability within this region of the project area are expected to have minor improvements from the FWO. These increased scores produce scores that more closely represent the higher quality existing condition for slough vegetation suitability dry and wet season depths. Prolonged high water levels currently experienced during both the wet and dry seasons have resulted in the loss of slough vegetation within southern WCA 3A. Implementation of alternatives would not significantly reduce the high water levels experienced in southern WCA 3A when compared with current water management practices.

Implementation of alternatives would achieve 84% of the target HUs for Zone 3A-S consistent with the existing conditions (**Table G-12**). The FWO would achieve 83% of the target HUs (**Table G-12**).

Table G-12. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern WCA 3A (Zone 3A S) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	45	50	54	53	53
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	60	61	61	61	61
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	84	83	83	83	83
5.2	Slough Vegetation Suitability -- Dry down	100	93	93	93	93
5.3	Slough Vegetation Suitability -- Dry Season Depth	82	72	75	75	75
5.4	Slough Vegetation Suitability -- Wet Season Depth	71	61	63	64	64
	Percentage of Target HU (HSI x 100)	**84**	**83**	**84**	**84**	**84**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

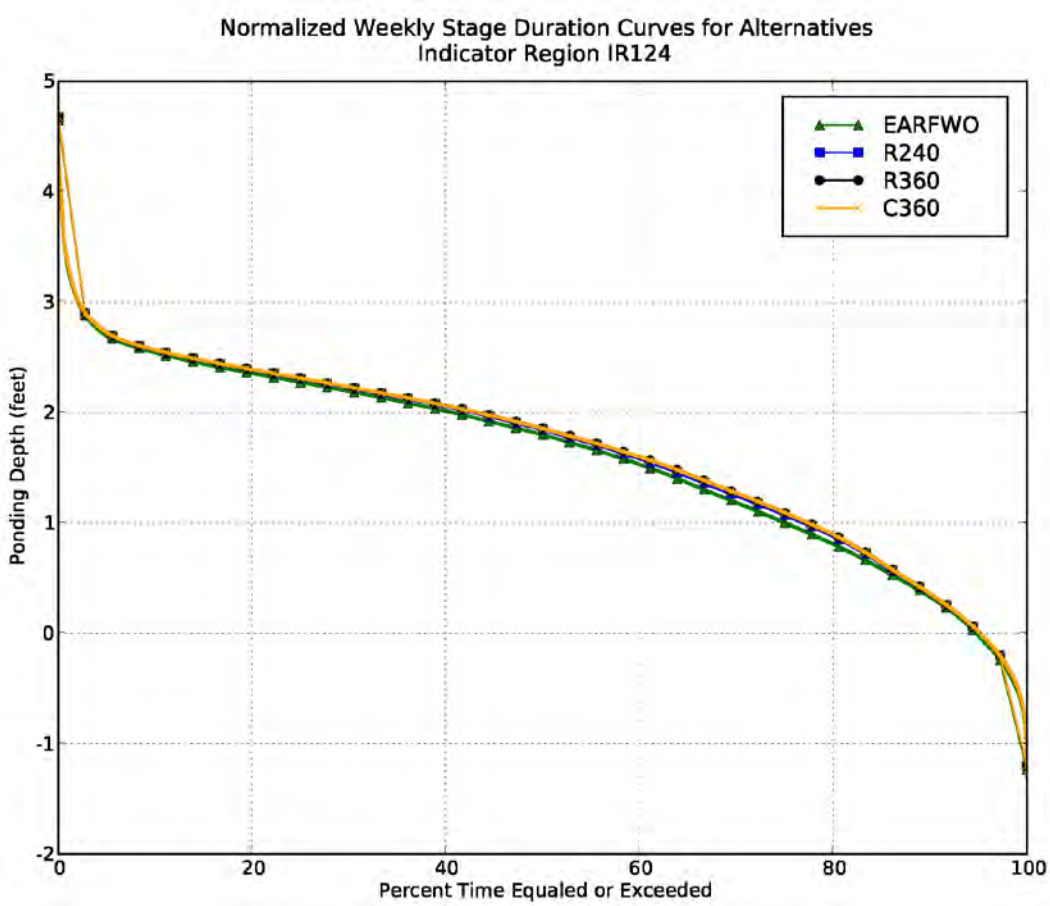


Figure G-16. Normalized Weekly Stage Duration Curve for Indicator Region 124 for Each Alternative

G.2.2.3 WCA 3B (Zone 3B)

Within WCA 3B, the ridge and slough landscape has been severely compromised by the virtual elimination of overland sheetflow since the construction of the L-67 Canal and Levee system. WCA 3B has become primarily a rain-fed compartment, experiencing very little overland flow and has largely turned into a sawgrass monoculture where relatively few sloughs or tree islands remain. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B, making them vulnerable to high water stages. The FWO generally produced lower dry season depths but the continuity of sheetflow was similar to existing conditions (**Table G-13**).

Alternatives improved hydrologic conditions in WCA 3B in comparison to the FWO by increasing depths and resulting hydroperiods within the area. Alternatives scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability (**Table G-13**). Implementation of alternatives would achieve 74-75% of the target HUs for Zone 3B compared to 73% for the FWO (**Table G-13**).

Table G-13. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3B (Zone 3B) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	86	93	94	94	95
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	0	0	0	0	0
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	40	41	41	41
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution-- Distribution	56	46	46	46	46
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	84	94	95	96	96
5.1	Slough Vegetation Suitability -- Hydroperiod	72	76	77	77	77
5.2	Slough Vegetation Suitability -- Dry down	86	89	90	90	90
5.3	Slough Vegetation Suitability -- Dry Season Depth	45	43	45	45	45
5.4	Slough Vegetation Suitability -- Wet Season Depth	28	33	34	35	35
	Percentage of Target HU (HSI x 100)	**65**	**73**	**74**	**75**	**75**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Poor performance was noted for measures of sheetflow. The timing, continuity, and distribution of sheetflow performance measures provide information about how flow timing and distribution within individual transects are altered by alternative project designs/operations (See **Section G.1.5.2.2**). Overland flow directionality generally showed poor alignment with landscape patterning due to the construction of the L-67 Canal and Levee system as described previously.

Figures G-17 through G-20 depict average annual overland flow vectors for the modeled period of record (1965-2005). These maps provide a visual representation of the movement of water over the landscape with the angle of each individual vector (arrow) representing the direction of flow and the color of the

vector representing the volume of flow. Overland flow vectors for the alternatives maintained the directionality of overland flow seen in the FWO. Changes in the overland flow are illustrated in the northeast corner of WCA 3A and the northern portion of WCA 2.

No change in sheetflow is illustrated in WCA 3B as reflected by the slight change in the continuity of sheetflow performance measure between the FWO and alternatives. Typical Everglades vegetation, including tree islands, wet prairies, sawgrass marshes, and sloughs occur throughout WCA 3B. Increases in depths and resulting hydroperiods would promote wetland vegetation transition, through contraction of sawgrass marshes and expansion of wet prairies. Poor alignment of overland flow with landscape patterning would have potential effects on what ridge and slough landscape currently remains within WCA 3B. Sheetflow plays an essential role in maintaining the directionality, and spatial extent of ridges and sloughs. Poor alignment of overland flow could impact microtopography within WCA 3B by reducing the current differences in elevations between ridges and sloughs. Approximately one-third of all tree islands within WCA 3B are elevated only 0.7-1.1 ft above the surrounding marsh. Tree islands within WCA 3B may also suffer from inundation and prolonged high water periods that may induce stress.

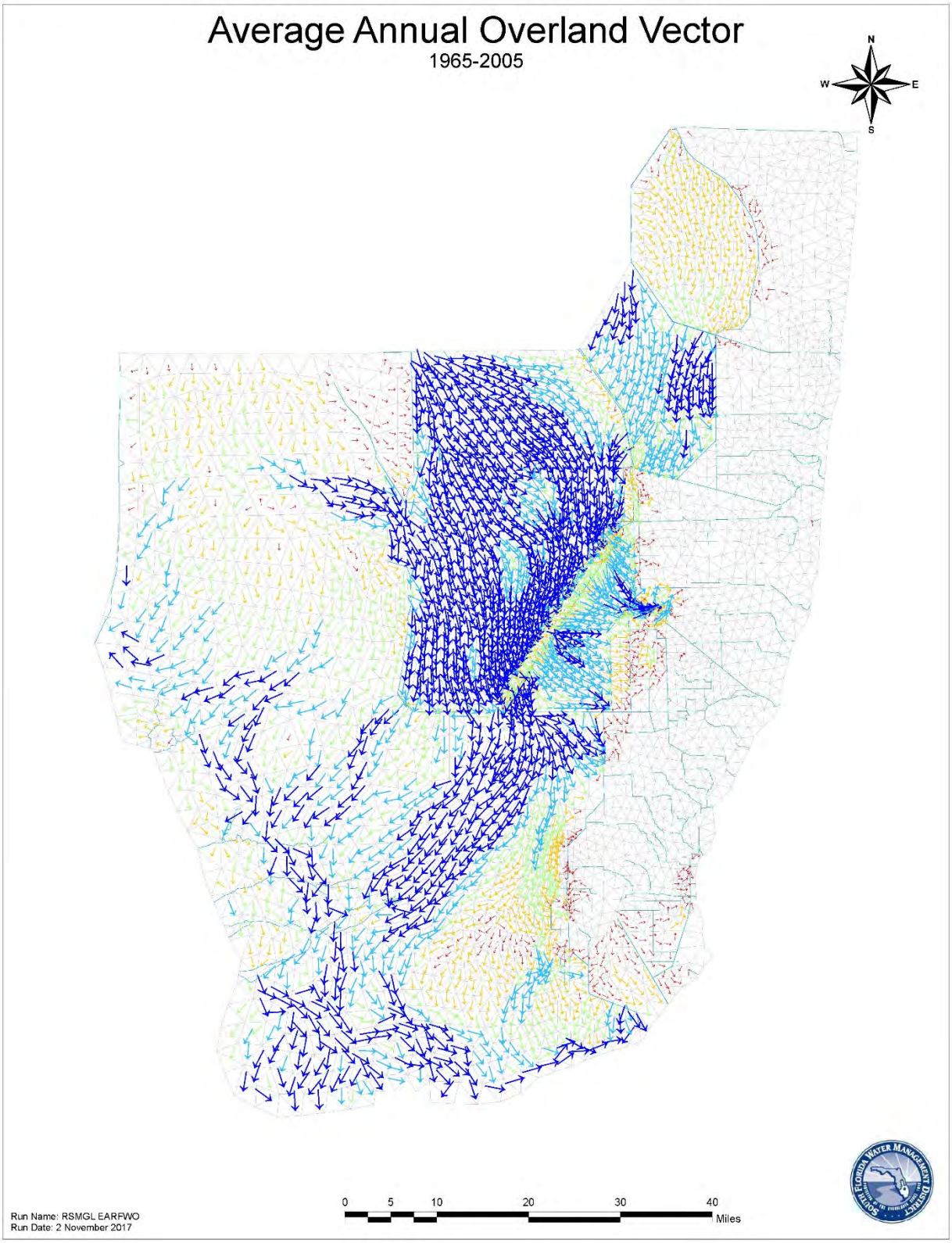


Figure G-17. Average Annual Overland Flow Vectors (1965-2005) for the FWO

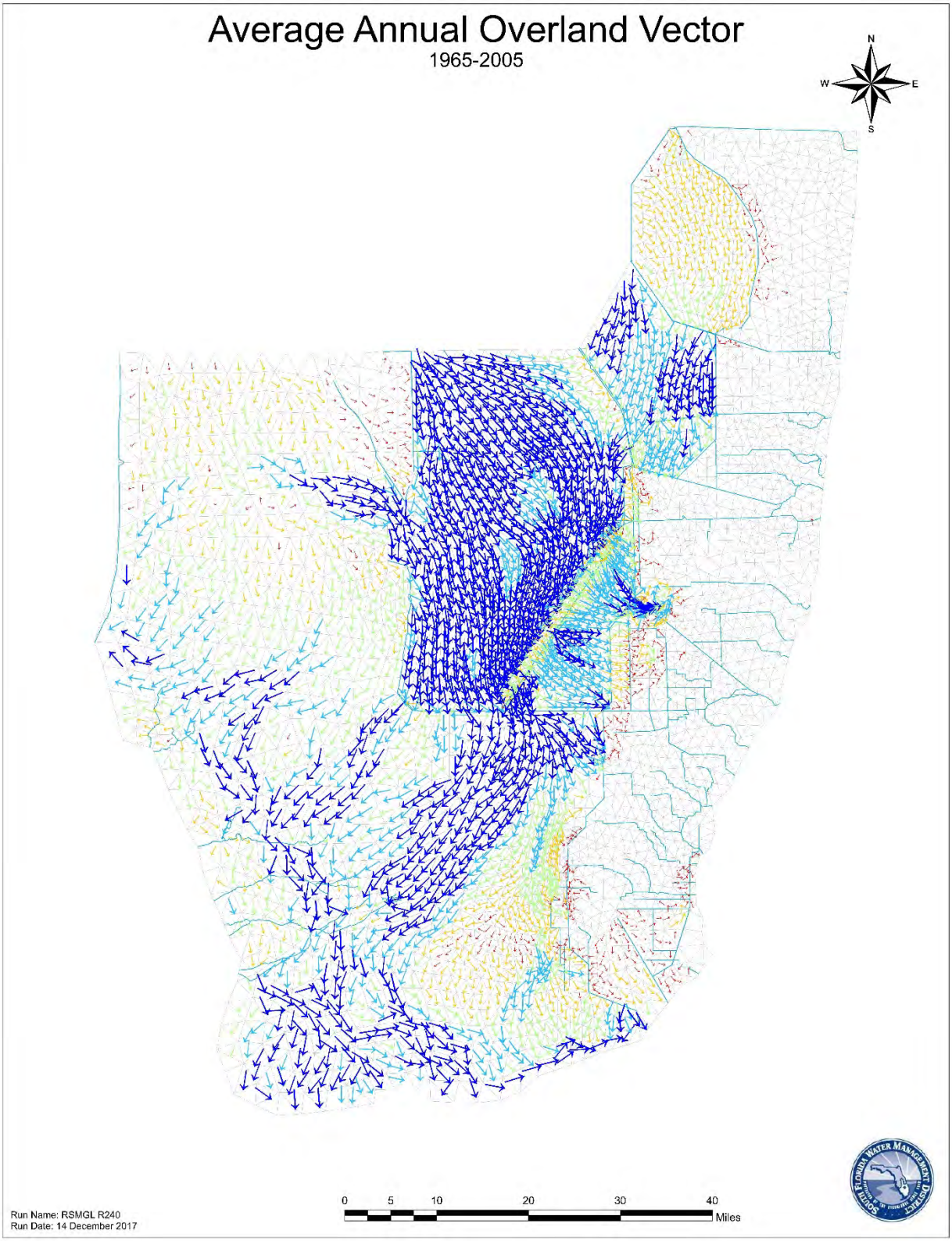


Figure G-18. Average Annual Overland Flow Vectors (1965-2005) for Alternative R240

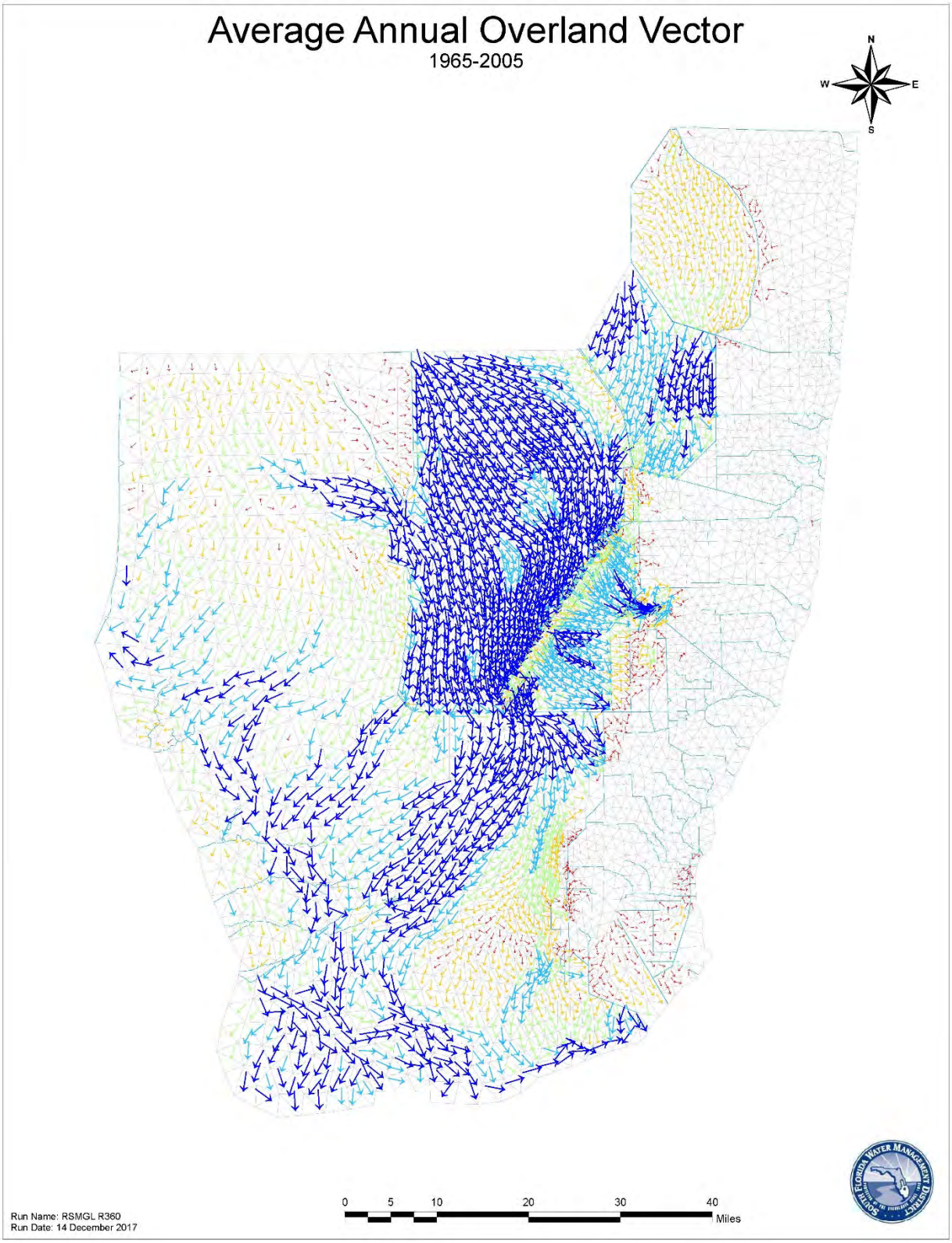


Figure G-19. Average Annual Overland Flow Vectors (1965-2005) for Alternative R360

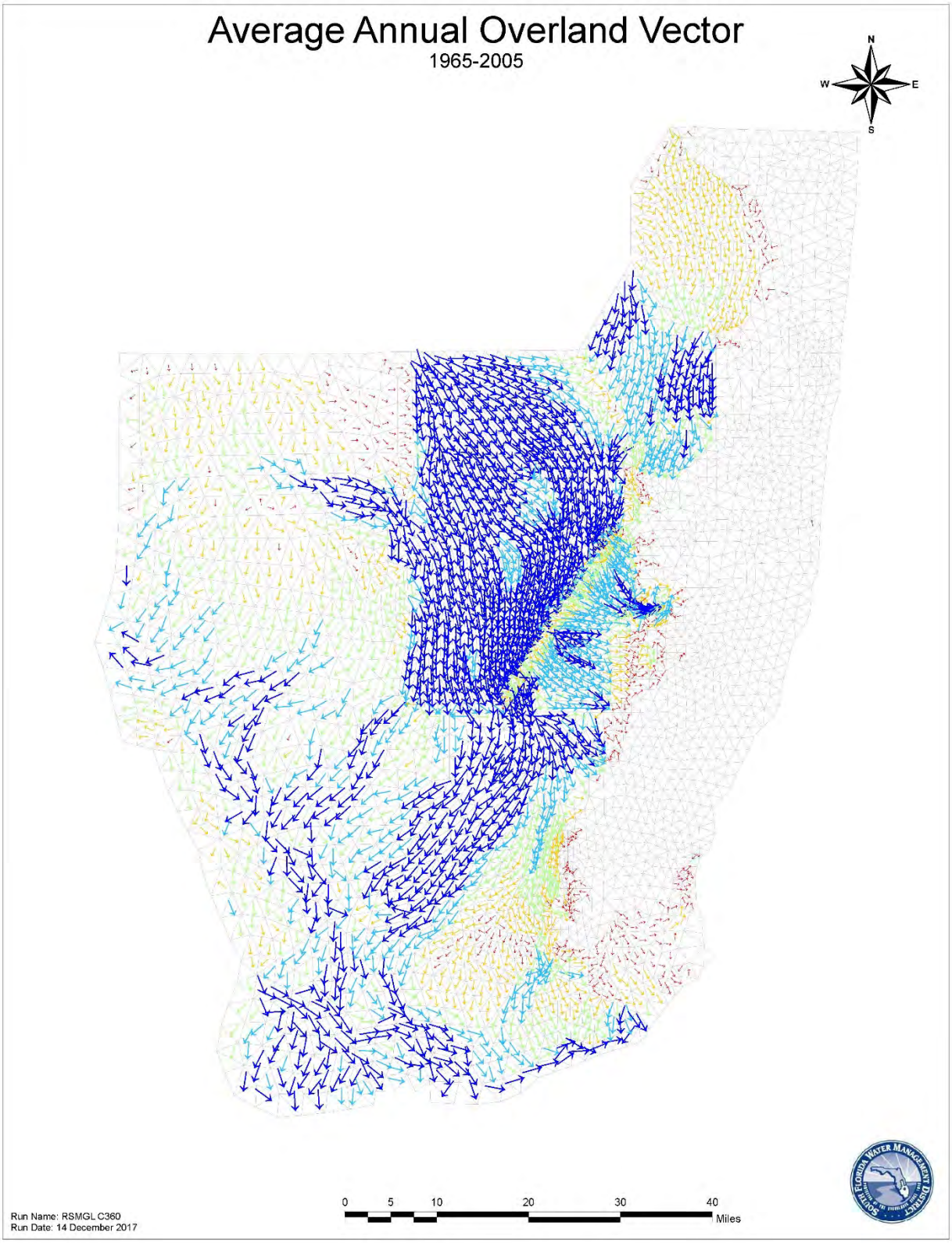


Figure G-20. Average Annual Overland Flow Vectors (1965-2005) for Alternative C360

In comparison to other regions of the project area where differences in hydrologic improvements between alternatives were seen, alternative performance was negligible in WCA 3B. Alternatives produced minor improved inundation patterns in WCA 3B. Indicator region 128 was inundated for 94% of the period of record for all alternatives compared to 93% in the FWO (**Figure G-21**); an example IR for Zone 3B. **Figure G-22** illustrates measures used to score benefits to slough vegetation.

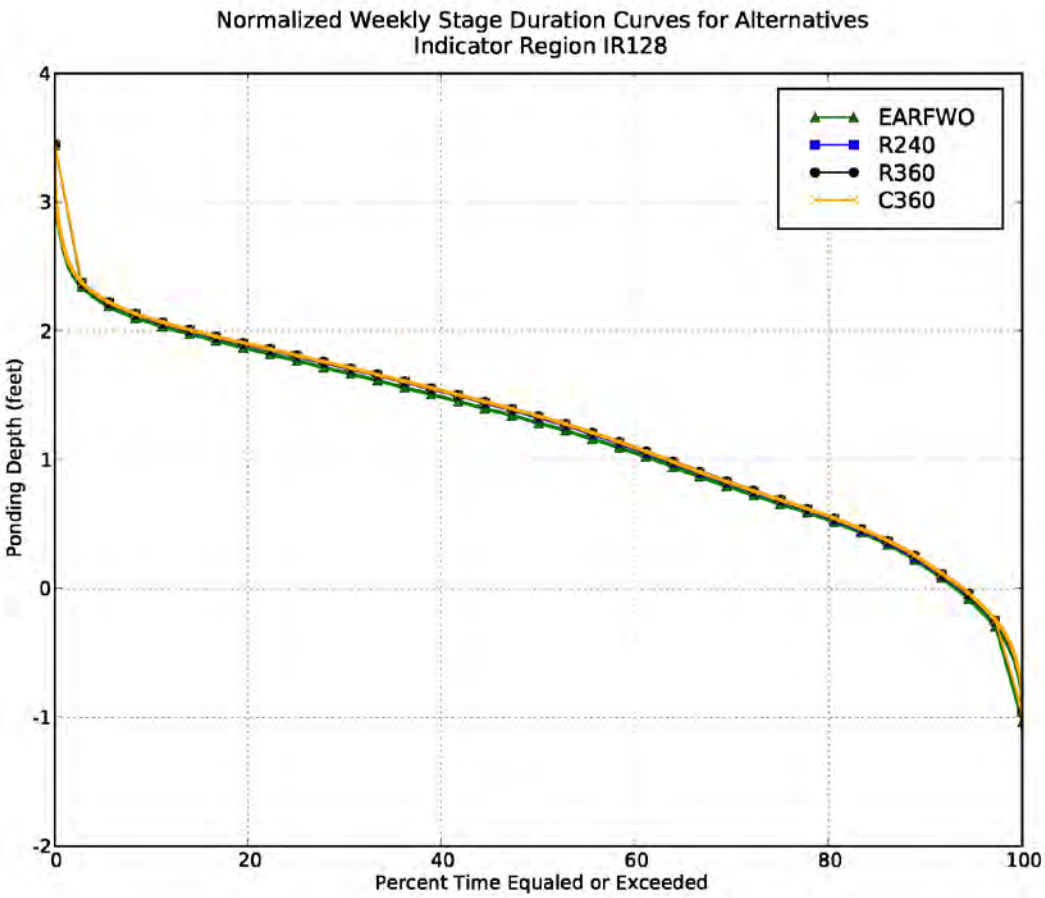


Figure G-21. Normalized Weekly Stage Duration Curve for Indicator Region 128 for Each Alternative

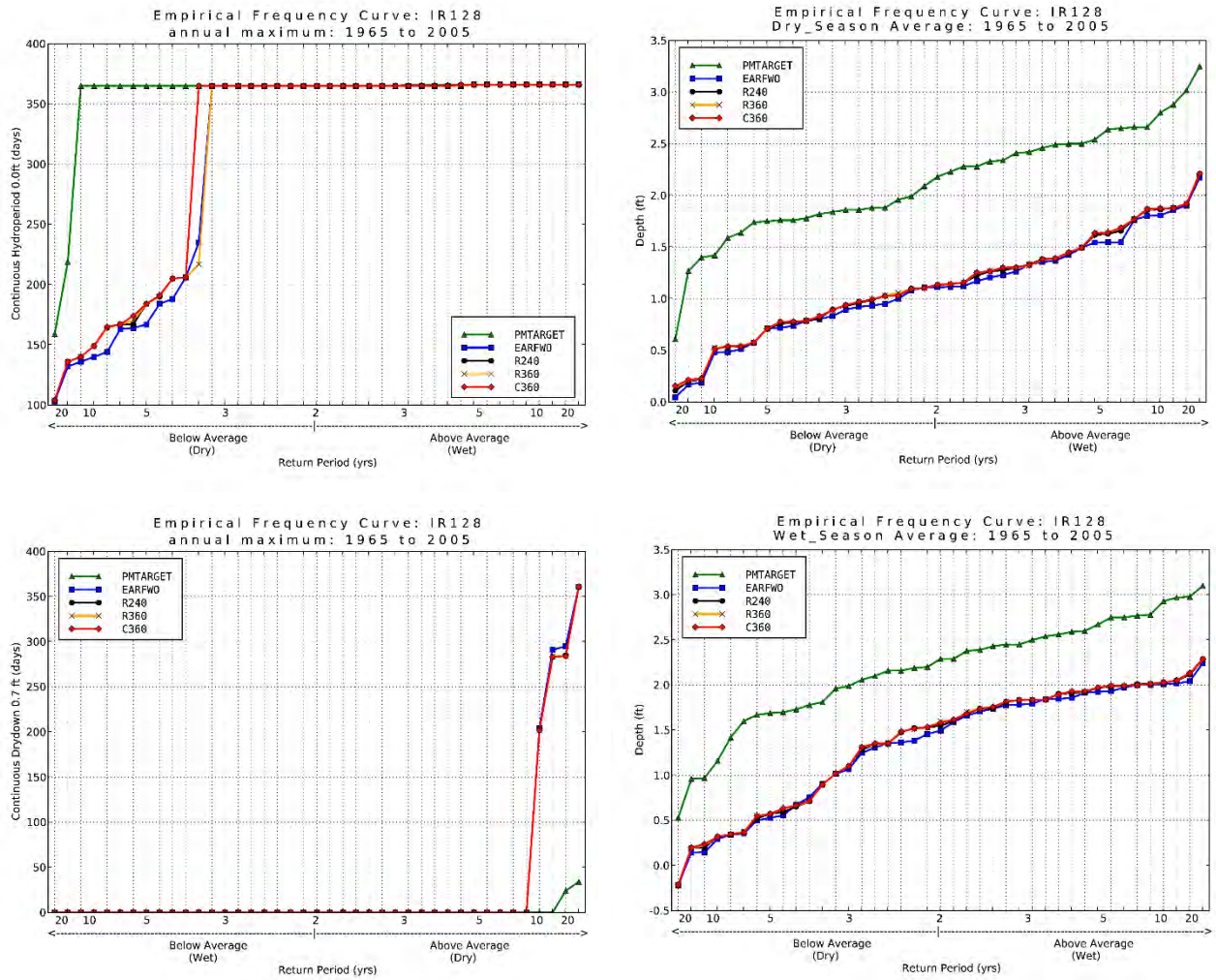


Figure G-22. Slough Vegetation Empirical Frequency Curves Indicator Region 128 for Each Alternative

It must be noted that there are no IRs west of the Blue Shanty Levee within WCA 3B to capture the potential benefits of the flow-way. Performance measure scores within WCA 3 and ENP are generated from hydrologic output from the RSM-GL using IRs and/ or flow transects. The location of these IRs were determined prior to the formulation of CEPP alternatives. The FWO produced desirable depths within the flow-way.

G.2.2.4 ENP (Zones ENP-N, ENP-S, ENP-SE)

Flows through Shark River Slough under current water management practices are much reduced when compared with pre-drainage conditions. The number, duration, and timing of dry events are more likely to reflect the needs of urban and agricultural water supply and flood control than the natural patterns of rainfall, evaporation, and transpiration. The result has been lower wet season depths and more frequent and severe dry downs in the sloughs and reduction in the extent of the important shallow water "edges." Dry downs that are too frequent or sever inhibit the productivity and resilience of animal populations, including the prey base (e.g., marsh fishes and other aquatic animals) and wading birds that depend upon

them. Over-drainage in the peripheral wetlands along the eastern flank of Northeast Shark River Slough (NESRS) has resulted in shifts in community composition, invasion by exotic woody species, and increased susceptibility to fire. Implementation of the CEPP is expected to rehydrate much of NESRS by providing a means for redistributing flows from WCA 3A through WCA 3B to ENP. Restoration of flow volumes will significantly improve hydroperiods and water depths while reducing the frequency and severity of dry downs.

Alternatives in this CEPP PACR yield similar results as the FWO in the ENP. Implementation of alternatives would achieve 80, 72-73, and 62% of the target HUs for the northern, southern, and southeastern ENP respectively (**Table G-14, Table G-15, and Table G-16**). The FWO would achieve 78% of the target HUs for Zone ENP-N, 71% for Zone ENP-S, and 62% for Zone ENP-SE (**Table G-14, Table G-15, and Table G-16**).

Improved hydrologic conditions in the northern and southern ENP (Zones ENP-N and ENP-S) in comparison to the FWO by minor changes in the performance measures (**Table G-14 and Table G-15**). In the northern ENP, alternative scores increased from the FWO in sheetflow, drought intensity, duration of dry events, and slough vegetation suitability with the exception of dry down which remained the same as the FWO (**Table G-14**). Similar changes occurred in the southern ENP, alternative scores increased from the FWO in inundation duration, sheetflow, drought intensity index, and slough vegetation suitability with the exception of dry down which remained the same as the FWO (**Table G-15**). The duration of dry events in the southern ENP moved further from the desired target when compared with the FWO while the number of dry events moved closer to the desired target. Alternatives performed similarly to the FWO in southeastern ENP (Zone ENP-SE) (**Table G-16**).

Table G-14. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northern ENP (Zone ENP-N) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	70	94	94	94	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	19	30	33	33	33
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	40	41	41	41
2.3	Sheetflow in the Ridge and Slough Landscape-- Distribution	50	53	54	54	54
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	52	89	90	90	91
4.1	Number and Duration of Dry Events -- Number	68	90	90	90	90
4.2	Number and Duration of Dry Events -- Duration	18	85	92	92	92
4.3	Number and Duration of Dry Events -- PPOR	1	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	59	86	89	89	89
5.2	Slough Vegetation Suitability -- Dry down	69	98	98	98	98
5.3	Slough Vegetation Suitability -- Dry Season Depth	24	56	58	58	59
5.4	Slough Vegetation Suitability -- Wet Season Depth	15	64	66	66	66
	Percentage of Target HU (HSI x 100)	**46**	**78**	**80**	**80**	**80**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Table G-15. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern ENP (Zone ENP-S) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	66	82	83	83	83
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	32	53	55	55	56
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	53	75	77	77	77
4.1	Number and Duration of Dry Events -- Number	61	70	72	72	72
4.2	Number and Duration of Dry Events -- Duration	74	96	92	95	95
4.3	Number and Duration of Dry Events -- PPOR	51	94	94	94	94
5.1	Slough Vegetation Suitability -- Hydroperiod	58	65	68	68	68
5.2	Slough Vegetation Suitability -- Dry down	82	96	96	96	96
5.3	Slough Vegetation Suitability -- Dry Season Depth	31	39	41	41	41
5.4	Slough Vegetation Suitability -- Wet Season Depth	26	35	37	37	37
	Percentage of Target HU (HSI x 100)	**52**	**71**	**72**	**73**	**73**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Table G-16. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southeastern ENP (Zone ENP-SE) for each Alternative[1]

Metric #	Performance Measure Metric	ECB	FWO	ALTR240	ALTR360	ALTC360
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape - Timing	13	25	25	25	25
2.3	Sheetflow in the Ridge and Slough Landscape- Distribution	48	49	49	49	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	14	9	10	10	10
5.2	Slough Vegetation Suitability -- Dry down	5	25	22	26	28
5.3	Slough Vegetation Suitability -- Dry Season Depth	1	3	3	3	3
5.4	Slough Vegetation Suitability -- Wet Season Depth	4	5	6	6	6
	Percentage of Target HU (HSI x 100)	**59**	**62**	**62**	**62**	**62**

[1] Values < 25 noted in red, values ≥25 and < 50 noted in yellow, values ≥ 50 to < 75 noted in green, and values ≥ 75 noted in blue

Performance for alternatives was similar in ENP (Zone ENP-N). Alternatives produced negligible higher depths than the FWO as depicted by the normalized weekly stage duration curve for IR 129 (**Figure G-23**)—an example IR for northern ENP (Zone ENP-N)—and IR 130 (**Figure G-24**)—an example IR for southern ENP (Zone ENP-S).

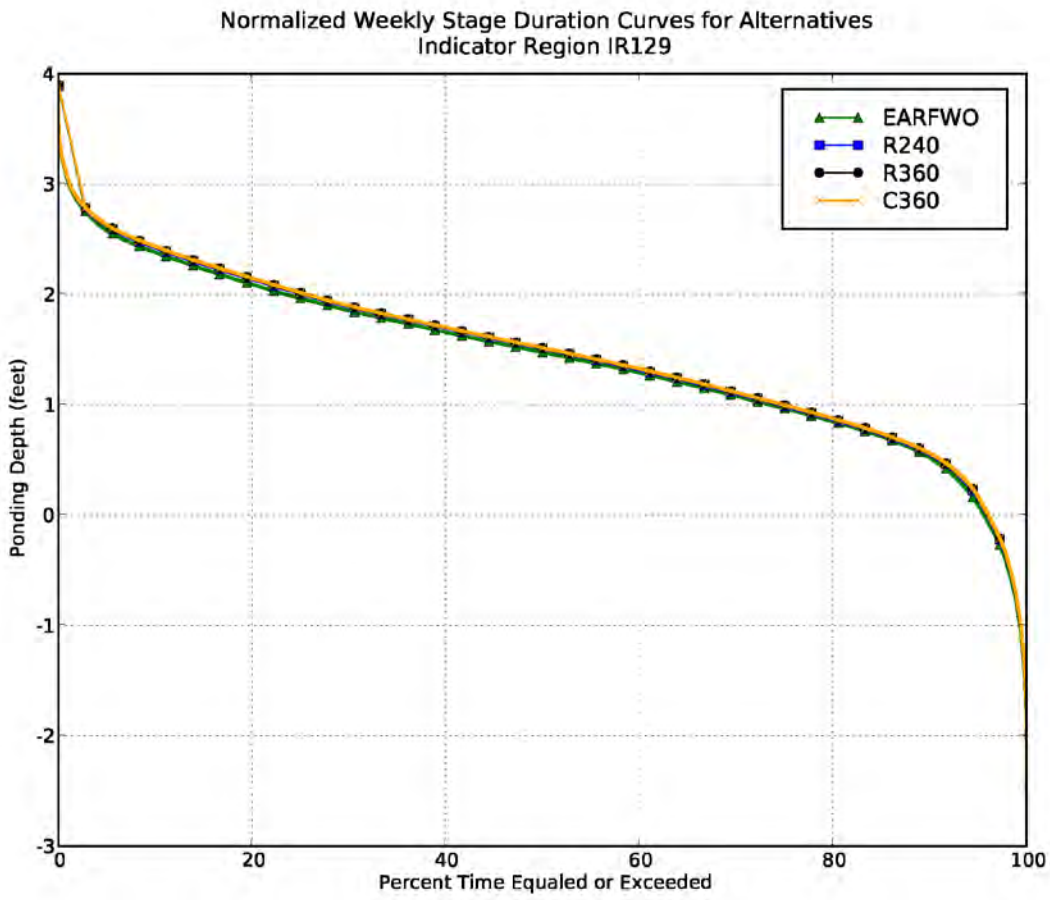


Figure G-23. Normalized Weekly Stage Duration Curve for Indicator Region 129 for Each Alternative

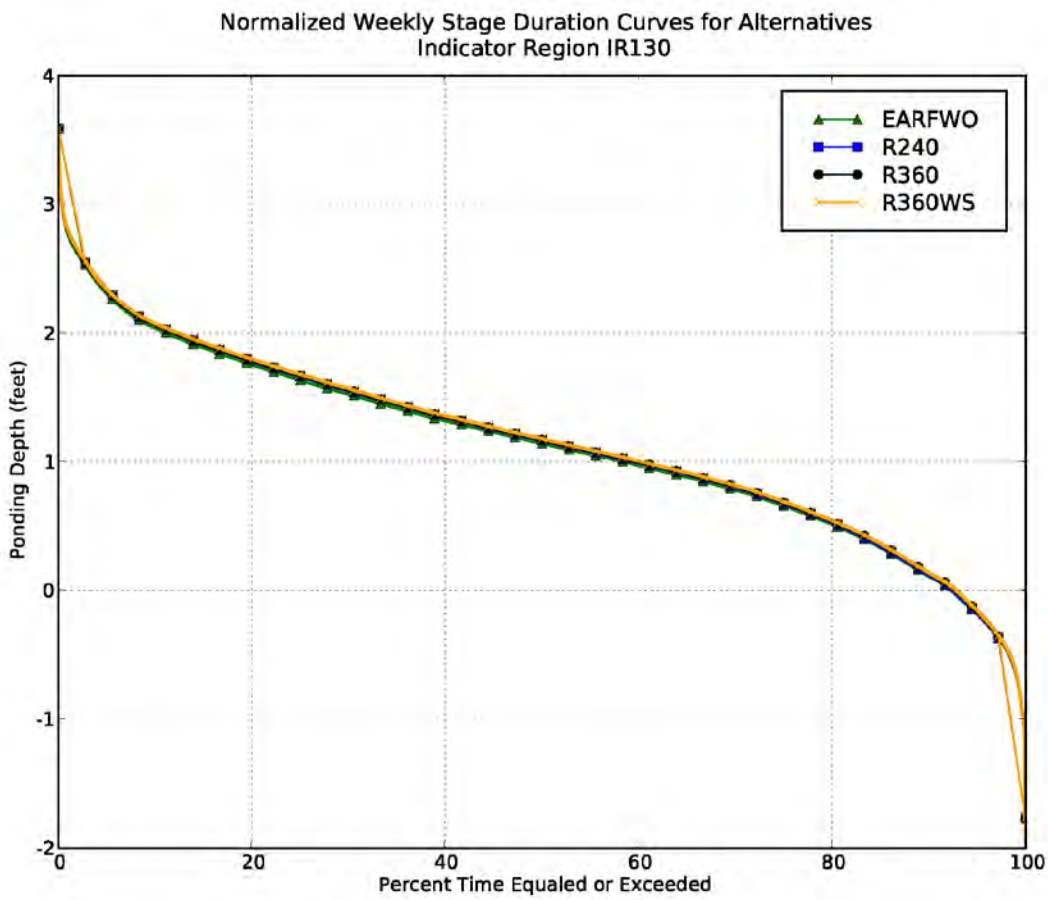


Figure G-24. Normalized Weekly Stage Duration Curve for Indicator Region 130 for Each Alternative

G.2.3 Florida Bay

Florida Bay is the main receiving waterbody of the Greater Everglades system and is heavily influenced by changes in the timing, distribution, and quantity of freshwater flows. Water management actions that result from CEPP have the potential to reduce the intensity, frequency, duration and spatial extent of hypersaline events in Florida Bay and establish a persistent and resilient estuarine zone that extends further into the bay than currently exists. This is expected to restore the bay to more natural conditions and increase biomass and diversity of bay flora and fauna.

Performance measures in Florida Bay were evaluated by the ENP, U.S. Department of Interior for this CEPP PACR. Alternatives improved hydrologic conditions in Florida Bay in comparison to the FWO by increasing overland flows. Water flowing through the Shark River Slough (SRS) reaches Florida Bay through the following routes: 1) surface water that enters the near-shore waters at the mouth of Whitewater Bay may flow around Cape Sable and into western Florida Bay, 2) surface water that flows north and west of the Rocky Glades may seep into southeastern Florida Bay, and 3) surface water can enter Florida Bay via Taylor Slough by seeping under the central and eastern Rocky Glades.

Freshwater deliveries through each of these routes have decreased with drainage of the Everglades over the last century. Only the first of these routes likely has influence on salinities in Florida Bay today.

Alternatives provided increased flows within central SRS in comparison to the FWO with annual flow increases above the FWO ranging from 53,000 ac-ft to 63,000 ac-ft on average per year for the alternatives (**Figure G-25**). Alternatives provided negligible increased flows within Taylor Slough in comparison to the FWO. Annual flow increases above the FWO in Taylor Slough were 2,000 ac-ft on average per year. Improved hydrologic conditions in central SRS directly resulted in improved salinity conditions in Florida Bay.

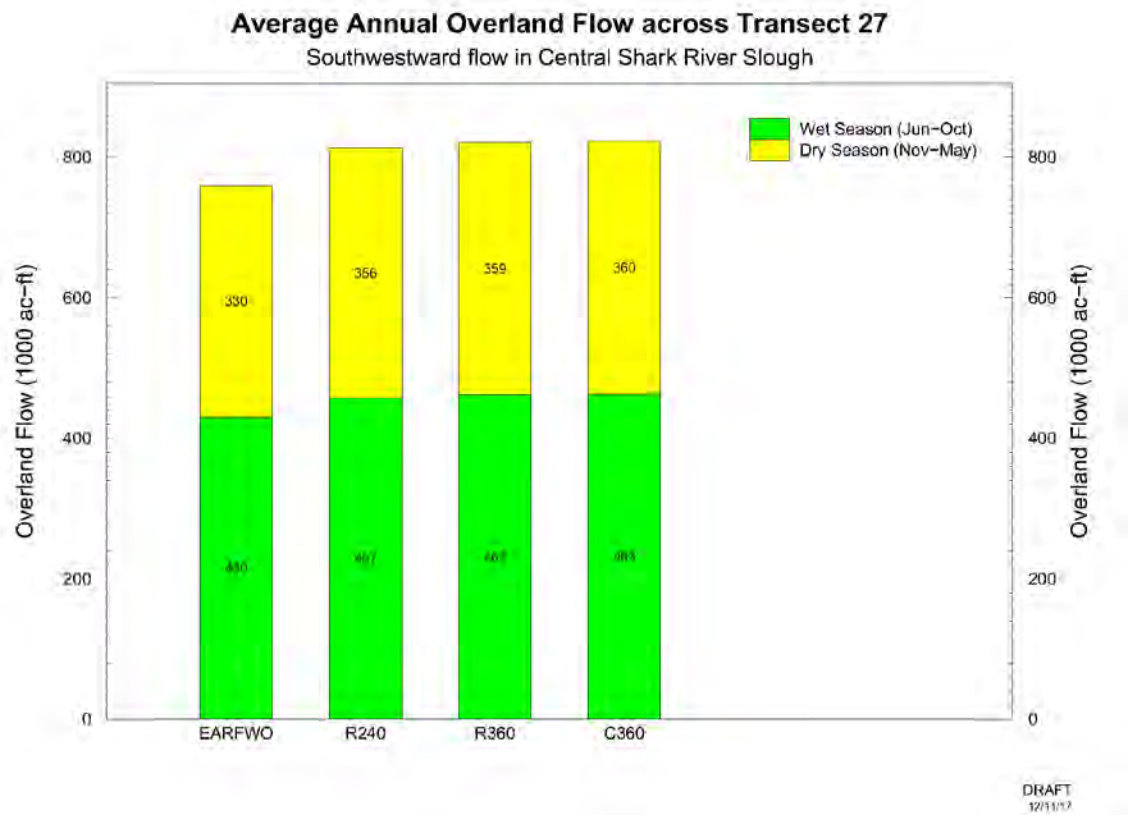
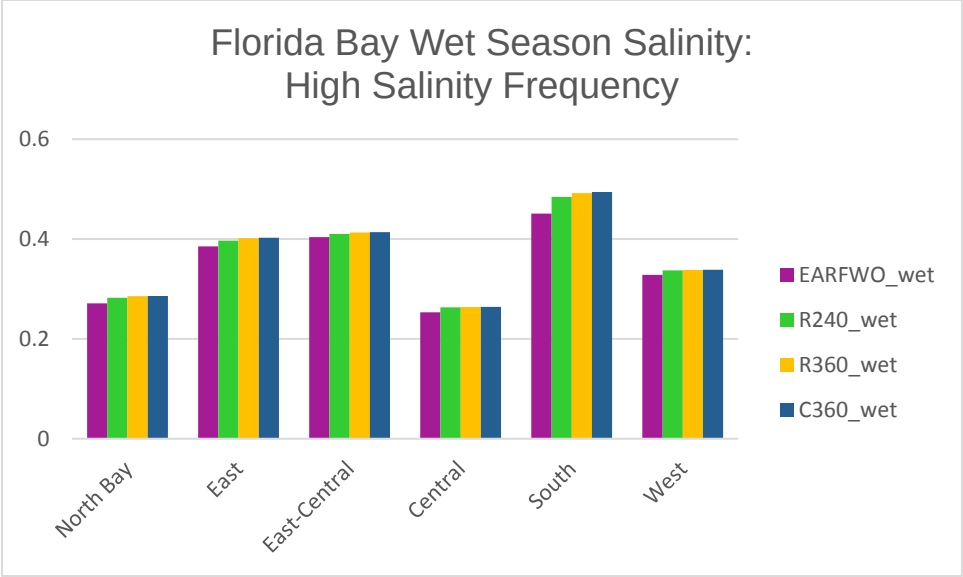


Figure G-25. Average Annual Overland Flow (1,000 ac-ft) across Transect 27 for Each Alternative

Performance of alternatives in Florida Bay was measured by evaluating improvements in salinity conditions in both the wet (June through November) and dry season (December through May). The regime overlap metric compares the distribution of salinities in the paleo-adjusted NSM record (target) to the predicted distribution (CEPP PACR alternative) of results between the 25th and 75th percentiles (hereafter referred to as the "mid-range"). The overlap between the mid-range distributions is determined on a seasonal basis and is reported as a proportion of the mid-range values of each alternative model output that falls within the mid-range of the target. This provides a "regime overlap score" for each month on a 0 to 1 scale (See **Section G.1.5.3.1**). **Figure G-26** depicts results for this performance measure for the wet season and dry season. Complete overlap with the target would yield a value of 1.0. Differences between alternatives were negligible and relative to the FWO.



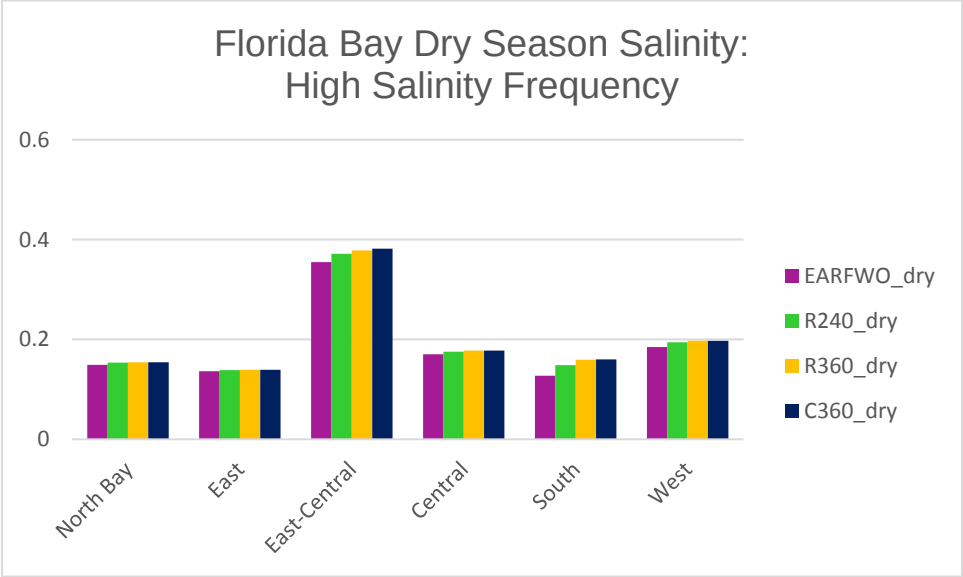


Figure G-26. Wet Season and Dry Season Regime Overlap Performance Measure for Florida Bay for each Alternative. Salinity Overlap Index (Dry Season) Equivalent to Zero for East Florida Bay

Table G-17 presents the HUs resulting from the performance measure scores for each zone in Florida Bay. The alternatives perform consistently with only slight differences. While the mean salinities for all alternatives are still higher than target conditions, implementation of alternatives brings salinities in Florida Bay closer to the additional freshwater flows of 500,000 to 700,000 ac-ft per year, annual average, necessary to bring Florida Bay to full restoration defined by CEPP.

Table G-17. Habitat Units for Florida Bay for Each Alternative

Florida Bay Zone	ECB	FWO	ALTR240	ALTR360	ALTC360
Florida Bay West	23,700	41,100	44,200	44,200	44,200
Florida Bay Central	8,200	13,950	15,600	15,600	15,600
Florida Bay South	16,600	28,300	30,300	30,300	30,300
Florida Bay East Central	22,000	34,300	36,100	36,900	36,900
Florida Bay North Bay	2,150	2,660	2,790	2,790	2,790
Florida Bay East	9,060	9,820	10,200	10,200	10,200

G.2.4 Conclusions

Alternatives provide improvements in hydrology relative to the FWO in most regions of the project area. **Table G-18** displays HU lift for the alternatives and also illustrates the similarities in benefits between alternatives.

Table G-18. Habitat Unit Lift Results for each Alternative

Project Region (Zone)	ALT R240[1]	ALT R360[1]	ALT C360[1]
Caloosahatchee Estuary (CE-1)	1,420	2,130	2,840
St Lucie Estuary (SE-1)	749	1,199	1,199
Total Northern Estuaries	**2,169**	**3,329**	**4,039**
WCA 3A Northeast (3A-NE)	1,234	1,234	1,234
WCA 3A Miami Canal (3A-MC)	1,564	1,564	1,564
WCA 3A Northwest (3A-NW)	1,408	1,408	1,408
WCA 3A Central (3A-C)	0	0	0
WCA 3A South (3A-S)	824	824	824
WCA 3B (3B)	857	857	857
ENP North (ENP-N)	2,502	2,502	2,502
ENP South (ENP-S)	2,386	4,772	4,772
ENP South East (ENP-SE)	0	0	0
Total WCA 3 and ENP	**10,775**	**13,161**	**13,161**
Florida Bay West (FB-W)	3,100	3,100	3,100
Florida Bay Central (FB-C)	1,650	1,650	1,650
Florida Bay South (FB-S)	2,000	2,000	2,000
Florida Bay East Central (FB-EC)	1,800	2,600	2,600
Florida Bay North Bay (FB-NB)	130	130	130
Florida Bay East (FB-E)	380	380	380
Total Florida Bay	**9,060**	**9,860**	**9,860**
Total All Regions	**22,004**	**26,350**	**27,060**

[1] HU lift values for alternatives represent those calculated in the year 2076.

G.3 SUMMARY OF TENTATIVELY SELECTED PLAN PERFORMANCE

Alternative R240A was identified as providing the greatest overall benefits with the least cost per habitat unit during plan formulation. The incremental annual average cost versus annual average habitat units illustrated that Alternative R240A ($2,564) is also incrementally more cost effective than Alternative C360C ($3,029). Learning from the operational benefits gained from Alternative C360C, similar operations were applied to the 240A design configuration. Operations were refined for Alternative R240A, creating Alternative C240A, to provide additional opportunities for other water-related needs (i.e., water supply)

in the EAA. The results of the additional modeling scenarios supported the selection of Alternative C240A as the Tentatively Selected Plan (TSP; Alternative R240A with multipurpose operations as previously described).

Modeled results were input to the CEPP Planning Model to define performance measures for Alternative C240A. The results yielded scores consistent with the performance measures for Alternative C360 further supporting selection of the lower cost design alternative. Alternative C240A achieved greater or equal percentage of the target HUs when compared to the FWO for all regions evaluated (see **Table G-19 through Table G-29**). The greatest increase in percentage of target HUs (55 to 62%) achieved is in the St. Lucie Estuary (Zone SE-1). No change in percentage of HUs achieved were noted for the central WCA 3A (Zone 3A C) and southeastern ENP (Zone ENP-SE). **Table G-30** compares the lift for all the alternatives with the FWO.

Table G-19. Rescaled Performance Measure Scores (Zero to 100 Scale) for Caloosahatchee Estuary (Zone CE-1) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
6.1	Caloosahatchee Estuary -- Low Flow	81	78
6.2	Caloosahatchee Estuary -- High Flow	29	38
	Percentage of Target HU (HSI x 100)	**55**	**58**

Table G-20. Rescaled Performance Measure Scores (Zero to 100 Scale) for St. Lucie Estuary (Zone SE-1) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
7.1	St. Lucie Estuary -- Low Flow	53	49
7.2	St. Lucie Estuary -- High Lake O. Discharge Events	57	74
	Percentage of Target HU (HSI x 100)	**55**	**62**

Table G-21. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northwestern WCA 3A (Zone 3A NW) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	95	99
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	34	41
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	61	65
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	68	70
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	97	100
5.1	Slough Vegetation Suitability -- Hydroperiod	80	82
5.2	Slough Vegetation Suitability -- Drydown	85	92
5.3	Slough Vegetation Suitability -- Dry Season Depth	38	44
5.4	Slough Vegetation Suitability -- Wet Season Depth	46	47
	Percentage of Target HU (HSI x 100)	**77**	**81**

Table G-22. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3A Miami Canal (Zone 3A MC) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape – PPOR Inundated	88	96
2.1	Sheetflow in the Ridge and Slough Landscape – Timing	32	37
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity	61	65
2.3	Sheetflow in the Ridge and Slough Landscape – Distribution	62	64
3.1	Hydrologic Surrogate for Soil Oxidation – Drought Intensity Index	75	84
5.1	Slough Vegetation Suitability – Hydroperiod	73	76
5.2	Slough Vegetation Suitability – Drydown	85	93
5.3	Slough Vegetation Suitability – Dry Season Depth	49	56
5.4	Slough Vegetation Suitability – Wet Season Depth	50	52
	Percentage of Target HU (HSI x 100)	**70**	**76**

Table G-23. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northeastern WCA 3A (Zone 3A NE) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape – PPOR Inundated	94	97
2.1	Sheetflow in the Ridge and Slough Landscape – Timing	30	33
2.2	Sheetflow in the Ridge and Slough Landscape – Continuity	59	62
2.3	Sheetflow in the Ridge and Slough Landscape – Distribution	57	59
3.1	Hydrologic Surrogate for Soil Oxidation – Drought Intensity Index	93	97
5.1	Slough Vegetation Suitability – Hydroperiod	66	70
5.2	Slough Vegetation Suitability – Drydown	82	90
5.3	Slough Vegetation Suitability – Dry Season Depth	45	51
5.4	Slough Vegetation Suitability – Wet Season Depth	41	42
	Percentage of Target HU (HSI x 100)	**74**	**77**

Table G-24. Rescaled Performance Measure Scores (Zero to 100 Scale) for Central WCA 3A (Zone 3A C) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	47	49
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	66	67
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	82	83
5.2	Slough Vegetation Suitability -- Drydown	91	91
5.3	Slough Vegetation Suitability -- Dry Season Depth	43	46
5.4	Slough Vegetation Suitability -- Wet Season Depth	47	48
	Percentage of Target HU (HSI x 100)	**81**	**81**

Table G-25. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern WCA 3A (Zone 3A S) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	50	51
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	61	61
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	83	83
5.2	Slough Vegetation Suitability -- Drydown	93	93
5.3	Slough Vegetation Suitability -- Dry Season Depth	72	75
5.4	Slough Vegetation Suitability -- Wet Season Depth	61	64
	Percentage of Target HU (HSI x 100)	**83**	**84**

Table G-26. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3B (Zone 3B) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	93	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	0	0
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	40	41
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	46	46
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	94	94
5.1	Slough Vegetation Suitability -- Hydroperiod	76	77
5.2	Slough Vegetation Suitability -- Drydown	89	91
5.3	Slough Vegetation Suitability -- Dry Season Depth	43	45
5.4	Slough Vegetation Suitability -- Wet Season Depth	33	35
	Percentage of Target HU (HSI x 100)	**69**	**70**

Table G-27. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northern ENP (Zone ENP-N) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	94	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	30	30
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	40	41
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	53	53
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	89	90
4.1	Number and Duration of Dry Events -- Number	90	90
4.2	Number and Duration of Dry Events -- Duration	85	92
4.3	Number and Duration of Dry Events -- PPOR	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	86	88
5.2	Slough Vegetation Suitability -- Drydown	98	98
5.3	Slough Vegetation Suitability -- Dry Season Depth	56	58
5.4	Slough Vegetation Suitability -- Wet Season Depth	64	67
	Percentage of Target HU (HSI x 100)	**78**	**79**

Table G-28. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern ENP (Zone ENP-S) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	82	83
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	53	53
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	75	76
4.1	Number and Duration of Dry Events -- Number	70	72
4.2	Number and Duration of Dry Events -- Duration	96	93
4.3	Number and Duration of Dry Events -- PPOR	94	94
5.1	Slough Vegetation Suitability -- Hydroperiod	65	68
5.2	Slough Vegetation Suitability -- Drydown	96	96
5.3	Slough Vegetation Suitability -- Dry Season Depth	39	41
5.4	Slough Vegetation Suitability -- Wet Season Depth	35	37
	Percentage of Target HU (HSI x 100)	**71**	**72**

Table G-29. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southeastern ENP (Zone ENP-SE) for the FWO and Alternative C240

Metric #	PM Metric	FWO	C240
1.1	Inundation Duration in the Ridge and Slough Landscape -- PPOR Inundated	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	25	25
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	49	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	9	9
5.2	Slough Vegetation Suitability -- Drydown	25	20
5.3	Slough Vegetation Suitability -- Dry Season Depth	3	3
5.4	Slough Vegetation Suitability -- Wet Season Depth	5	6
	Percentage of Target HU (HSI x 100)	**62**	**62**

Table G-30. Habitat Unit Lift Results for each Alternative

Project Region (Zone)	ALT R240[1]	ALT C240[1]	ALT R360[1]	ALT C360[1]
Caloosahatchee Estuary (CE-1)	1,420	2,130	2,130	2,840
St. Lucie Estuary (SE-1)	749	1,049	1,199	1,199
Total Northern Estuaries	**2,169**	**3,179**	**3,329**	**4,039**
WCA 3A Northeast (3A-NE)	1,234	3,704	1,234	1,234
WCA 3A Miami Canal (3A-MC)	1,564	4,692	1,564	1,564
WCA 3A Northwest (3A-NW)	1,408	2,815	1,408	1,408
WCA 3A Central (3A-C)	0	0	0	0
WCA 3A South (3A-S)	824	824	824	824
WCA 3B (3B)	857	857	857	857
ENP North (ENP-N)	2,502	1,251	2,502	2,502
ENP South (ENP-S)	2,386	2,386	4,772	4,772
ENP South East (ENP-SE)	0	0	0	0

Table G-30. Habitat Unit Lift Results for each Alternative (continued)

Project Region (Zone)	ALT R240[1]	ALT C240[1]	ALT R360[1]	ALT C360[1]
Total WCA 3 and ENP	**10,775**	**16,529**	**13,161**	**13,161**
Florida Bay West (FB-W)	3,100	3,100	3,100	3,100
Florida Bay Central (FB-C)	1,650	1,650	1,650	1,650
Florida Bay South (FB-S)	2,000	2,000	2,000	2,000
Florida Bay East Central (FB-EC)	1,800	1,800	2,600	2,600
Florida Bay North Bay (FB-NB)	130	130	130	130
Florida Bay East (FB-E)	380	380	380	380
Total Florida Bay	**9,060**	**9,060**	**9,860**	**9,860**
Total All Regions	**20,770**	**28,768**	**26,350**	**27,060**

[1] HU lift values for alternatives represent those calculated in the year 2076.

G.4 TECHNICAL QUALITY OF THE CEPP PLANNING MODEL

The CEPP and CEPP PACR are highly dependent on the results of dynamic regional hydrologic and ecologic simulation models. The CEPP Planning Model based its calculation of environmental benefits on inputs derived from the NSM, the RSM-GL, the RSM-BN and the working hypotheses set forth in the Northern Estuaries, Greater Everglades Ridge and Slough, and Florida Bay Conceptual Ecological Models (CEMs) (Barnes 2005, Sime 2005, Ogden 2005, Rudnick et al. 2005). These models are considered to be appropriate tools for planning for the CERP. The NSM, RSM-GL, and RSM-BN have been validated through the USACE Engineering Model Certification process established under the Engineering and Construction (E&C) Science and Engineering Technology (SET) initiative. Each of the project performance measures for the CEPP planning effort described above were derived from those performance measures approved for use by RECOVER. The scientists of RECOVER have extensive experience working in south Florida and Everglades wetlands ecosystems. These members are considered by their peers to be the experts in their fields. In addition, the CEMs from which the CEPP performance measures were developed have been extensively peer reviewed and provide the framework for the planning and assessment of the CERP.

G.5 STATEMENT ON THE CAPABILITIES AND LIMITATIONS OF THE CEPP PLANNING MODEL

Significant effort has been invested in the development and calibration of regional and sub-regional hydrologic models. However, recognition of model uncertainty is needed when interpreting the ecological significance of model output. There is uncertainty in the predictions derived from these models that stems from input variability and measurement errors, parameter uncertainty, model structure uncertainty and algorithmic (numerical) uncertainty as outlined in the CERP Model Uncertainty Workshop Report (RECOVER 2002), the CERP Model Needs Report (RECOVER 2005), and CERP System-Wide Performance Measure Report (RECOVER 2007a). These uncertainties are translated into uncertainty as to whether the specific performance indicators and measures used to characterize the overall system performance actually capture that overall performance.

The likelihood of capturing all the processes occurring in a system as complex as the Everglades within simulation models is low. There is uncertainty in predicting environmental benefits associated with any CERP project because of the size and complexity of the Everglades ecosystem and limitations on our

scientific understanding of its physical and biological processes. However, the outputs of the sub-regional hydrologic models and performance measures used to quantify ecosystem benefits for the CEPP utilized the best data available to predict the most-likely hydrologic and ecological changes as a result of the project.

Performance measures have been extensively peer reviewed and are considered to be the best available to the project for evaluating alternative performance. The performance measures reflect an understanding of the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the best biological attributes or indicators of these ecological responses. Increased scientific understanding of the Greater Everglades system and its attributes has been incorporated into these performance measures during the RECOVER review process. The performance measures are not intended to provide a measure of absolute performance at a small scale, but do provide for relative comparisons of alternatives. Performance measures were selected to measure project performance at key locations selected by design to provide the best overall measure of system wide benefits when aggregated into a single HU score. The method used for aggregation of performance measures provided a fair, un-biased evaluation of alternative performance that avoids subjective planning-level decision-making in selecting the best performing plan.

CEPP project team members reviewed the CEPP Planning Model and its constituent performance measures to develop an assessment of uncertainty in the overall benefits quantification. This was conducted to ensure that decision-makers are informed about uncertainties that affect interpretation of the CEPP Planning Model outputs. Five questions about model uncertainty were investigated and addressed in the CEPP Feasibility Study (FS)/Environmental Impact Statement (EIS).

G.6 ASSUMPTIONS OF THE CEPP PLANNING MODEL

There is no standardized methodology for predicting ecosystem benefits that result from habitat restoration projects. For the USACE planning process, the most apparent adverse risks of employing a given benefit estimation methodology are: 1) the most effective project alternative is not selected for implementation, 2) the selected project provides significantly fewer benefits than estimated, or 3) the selected project significantly harms the resource. The CEPP FS/EIS Appendix G Section G.5 addressed the assumptions used in the CEPP Planning Model that may influence the accuracy of its results.

G.7 PLAN IMPLEMENTATION

The 2014 CEPP PIR (USACE 2014) acknowledged that implementation of the CEPP plan will occur over many years and include many actions by the USACE and SFWMD. Appendix G (Section G.6) of the CEPP PIR evaluated implementation of the CEPP plan by way of three separate Project Partnership Agreements (PPAs), with each PPA covering a separable element that grouped inter-related project features to provide hydrologic and ecological benefits. These PPAs (PPA North, PPA South, and PPA New Water) include the construction of logical groupings of plan elements, agreed upon by the USACE and SFWMD, that would maximize benefits to the extent practicable consistent with project dependencies (see Section 6.7.1 of the CEPP PIR) and the Adaptive Management and Monitoring Plans (see Section 6.1.4 of the CEPP PIR and **Annex D**). The modifications to the authorized CEPP plan proposed in the CEPP PACR would affect only certain project features covered by the PPA New Water, namely the inclusion of the proposed A-2 storage

reservoir and A-2 STA, in lieu of the A-2 FEB, as well as improved conveyance features from Lake Okeechobee to the new reservoir. CEPP plan implementation and construction sequencing as presented in the CEPP PIR (**Section 6.7** of the main report and **Appendix G, Section G.6**) for the PPA South, PPA North, and PPA New Water (Seepage Barrier Only) would not change as a result of proposed modifications to the authorized CEPP plan. The proposed A-2 storage reservoir, A-2 STA, and associated conveyance features would be built concurrently with the CEPP features. CEPP, as modified by the PACR TSP, would deliver an average annual flow of approximately 370,000 ac-ft of new water to features included in portions of the CEPP study area covered by PPA South and PPA North.

G.8 REFERENCES

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