APPENDIX G

BENEFIT MODEL

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G BENEFIT MODEL

G.1 MODEL DOCUMENTATION

The Department of the Army Engineer 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) 1105-2-412, 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 HQUSACE Model Certification Panel approved the CEPP Planning Model on August 13, 2013.

G.1.1 Description of the CEPP Planning Model

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 project delivery team include 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 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).

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 was 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. Alternatives evaluated in the project included the future without project condition (FWO) and additional alternatives developed by the project delivery team.

G.1.2 Description of Project Performance Measures

To make the correlation between hydrologic output and ecosystem functions, the project delivery team utilized performance measures developed from the Northern Estuaries, Greater Everglades Ridge and

Slough, and Florida Bay Conceptual Ecological Models (CEMs) (Barnes 2005, Sime 2005, Ogden 2005a, 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. 2005b). 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 had one or more sub-metrics. A documentation sheet is maintained for each of the performance measures and can be found at http://www.evergladesplan.org/pm/recover/eval_team_perf_measures.aspx[1]. The documentation sheet provides the scientific basis and justification for the use of the performance measure 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 2.1Timing 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
- 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

[1] Note: The documentation sheets located at this 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 CEPP performance measures. Hydrologic models used for the CEPP are described in **Section G.1.3** (**Hydrologic Model Used**).

- 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 to project team members and was typically provided in a comma-separated-value (csv) format. Output from the csv files were then imported into the CEPP spreadsheet. 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 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
http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%202/modeling.

The hydrologic models referenced above have been validated through the Corps 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 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 CEPP will 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. It 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 psu. The salinity envelop target for the St. Lucie is a salinity range of 12 to 20 psu. Extensive monitoring of the Caloosahatchee and St. Lucie Estuaries as well as flows and loads from the associated basins and Lake Okeechobee has 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, the area within the Caloosahatchee and St. Lucie Estuary systems to be potentially affected by the project 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.

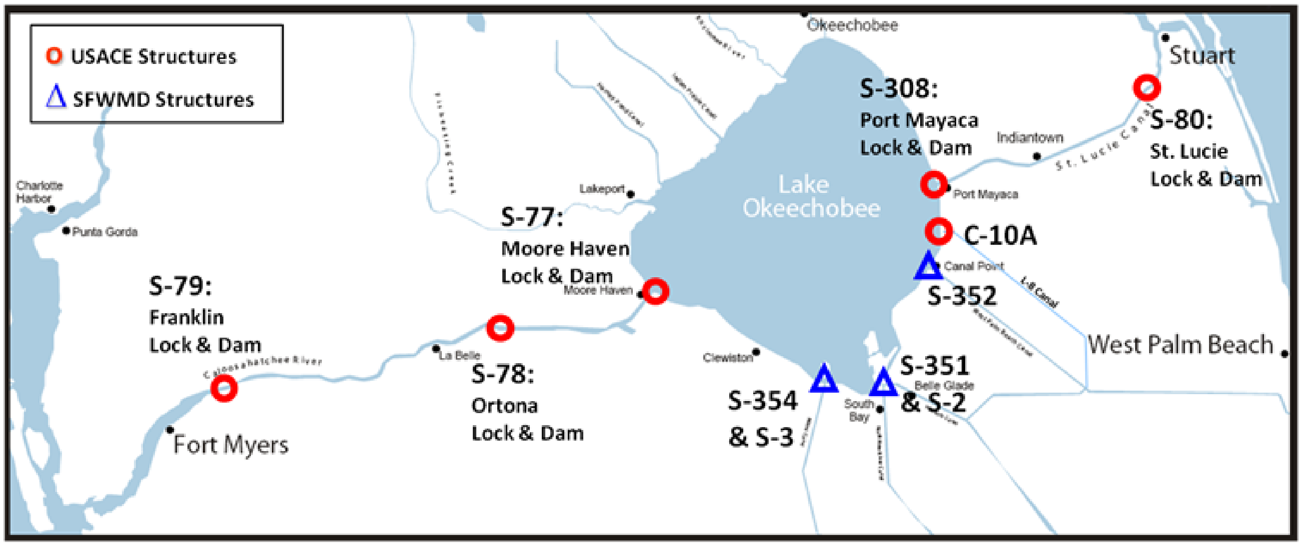


Figure G-1. Key Structures of Lake Okeechobee and the Northern Estuaries

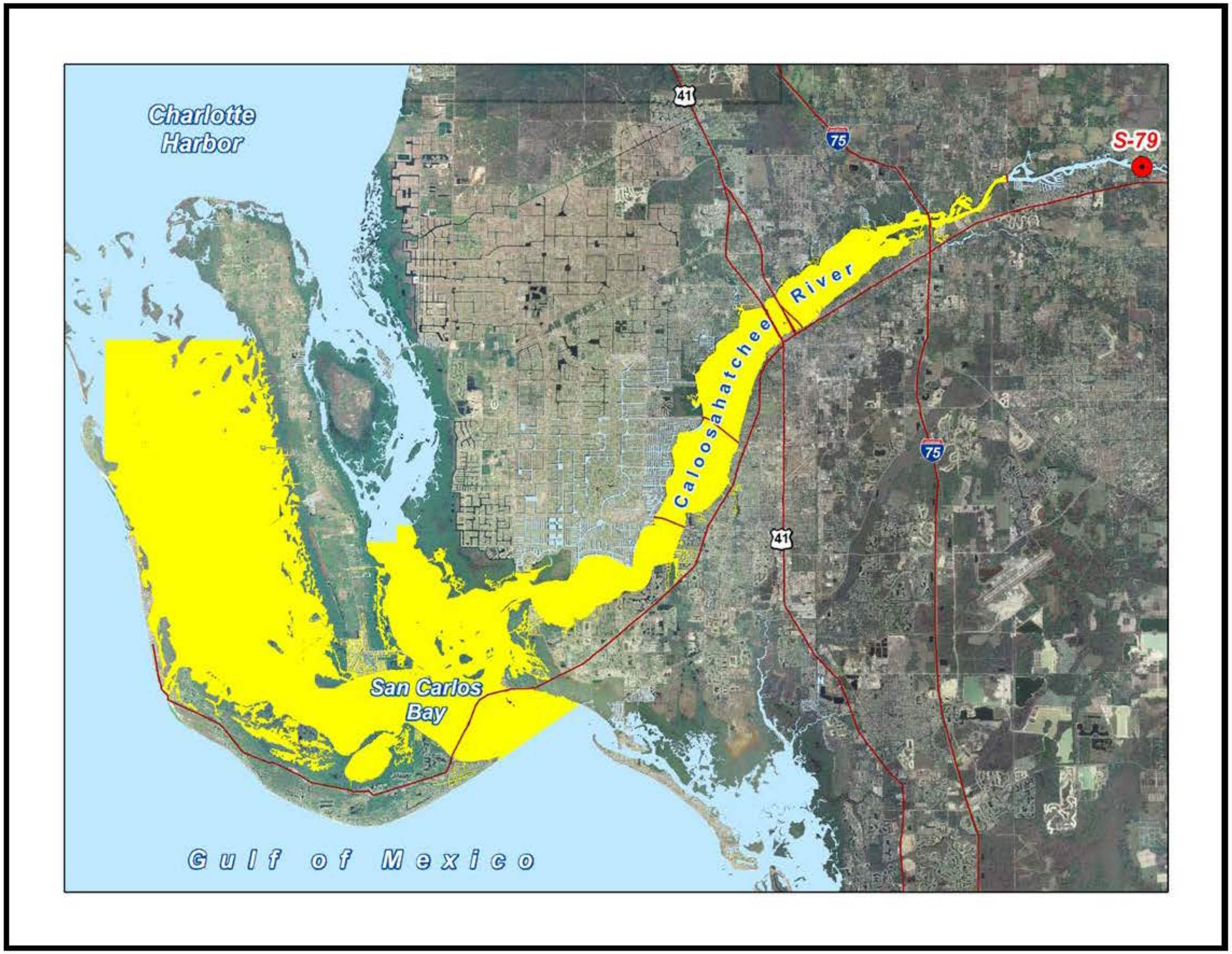


Figure G-2. Estimate of the Maximum Area of Potential Ecological Benefit for the Caloosahatchee Estuary (Zone CE-1)

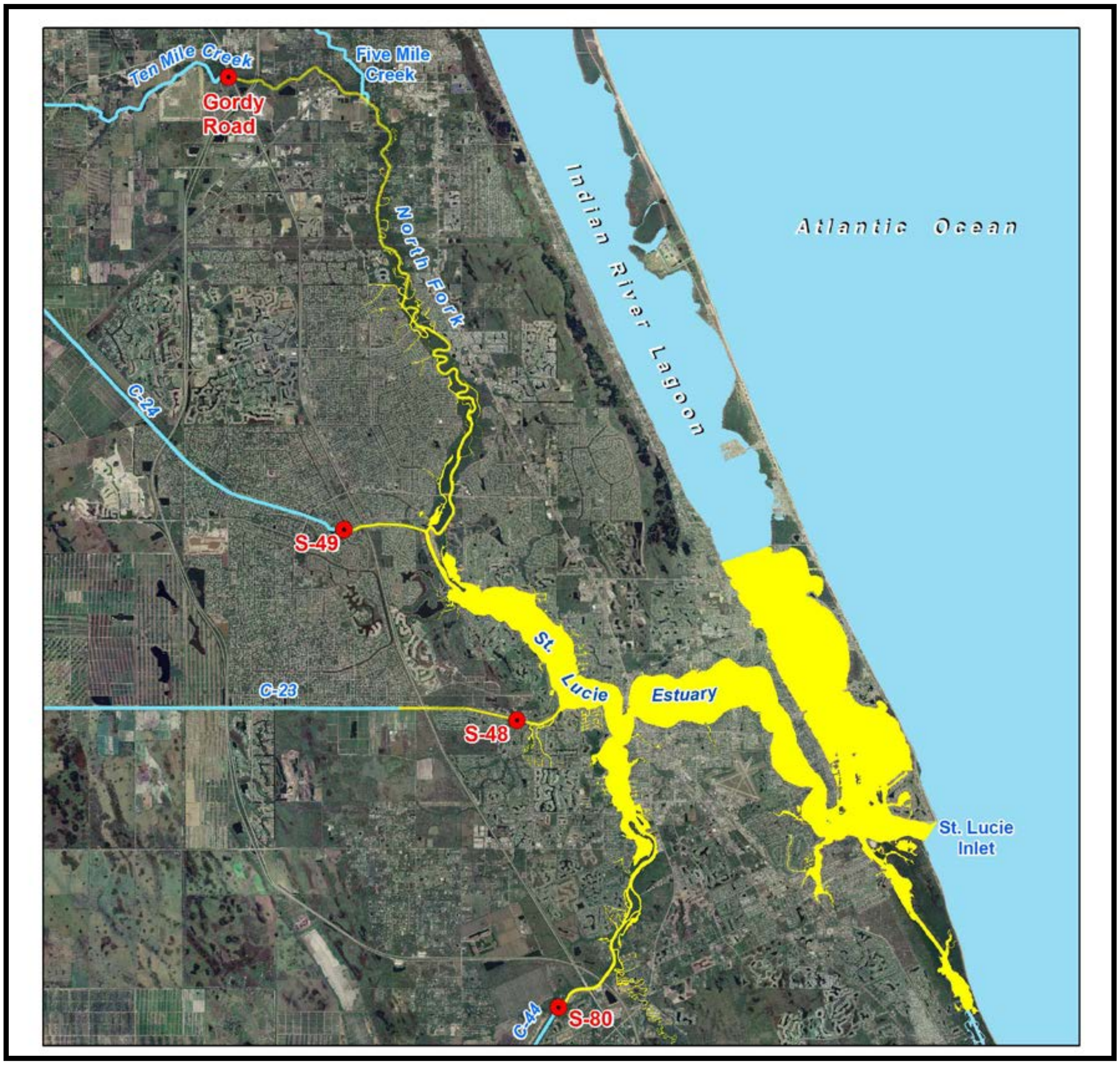


Figure G-3. Estimate of the Maximum Area of Potential Ecological Benefit for the St. Lucie Estuary (Zone SE-1)

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. Indicator regions included IR 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 128, 129, 130, 131, 132, 133, 140, and 190. These IRs were adapted from the South Florida Water Management Model (SFWMM) and represent those previously defined by RECOVER to represent ridge and slough habitat. IRs defined by RECOVER that are located within WCA 3A, 3B and ENP and are characterized as marl prairie habitat (IRs 141, 143, 144, 145, 147, and 148) were not evaluated in the CEPP planning model. IRs MC-NE1, MC-NE2, MC-NW1, MC-NW2, MC-CE1, MC-CE2, MC-CW1, MC-CW2, MC-SE1, MC-SE2, and MC-SW1, MC-SW2 were added 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 (*Sheetflow in the Ridge and Slough Landscape)*. Transects included T-5, T-6, T-7, T-8, T-12, T-15, ENP-1 (T-26), ENP-2 (T-17), T-18N, T-18S, ENP-3 (T-18S + T19) T-23A, T23B, T23C, and T-27. These transects were adapted from the SFWMM and represent those previously defined by RECOVER. T-MC1, T-MC2, T-MC3, T-MC4, and T-MC5 were added to capture the immediate hydrologic effects of the Miami Canal.

To further evaluate the spatial extent of the project's effects within WCA 3 and ENP, the project team evaluated performance measure output for individual zones within the study area. Because the IRs and transects covered only a portion of the project area, the region was divided into nine zones to extrapolate from the IRs and/or transects to the larger areas they represent. **Figure G-4** to **Figure G-7** illustrate the location of IRs and transects within the RSM-GL model mesh and each of the nine zones. 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. Zones were also delineated based on differences in existing conditions within the study area. Zones evaluated 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 is provided below.

> 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.

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).

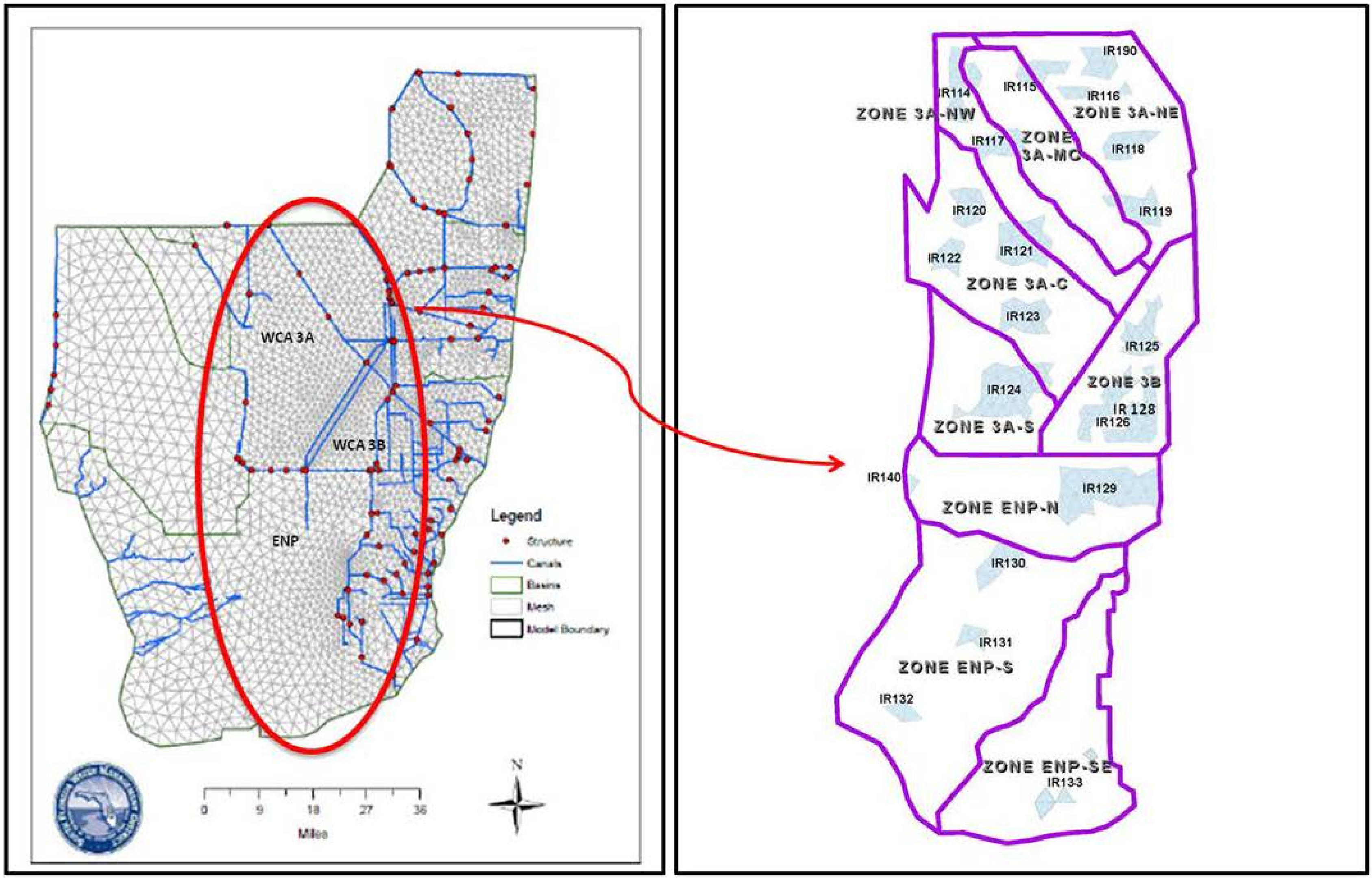


Figure G-4. Indicator Regions within the RSM-GL Model Mesh

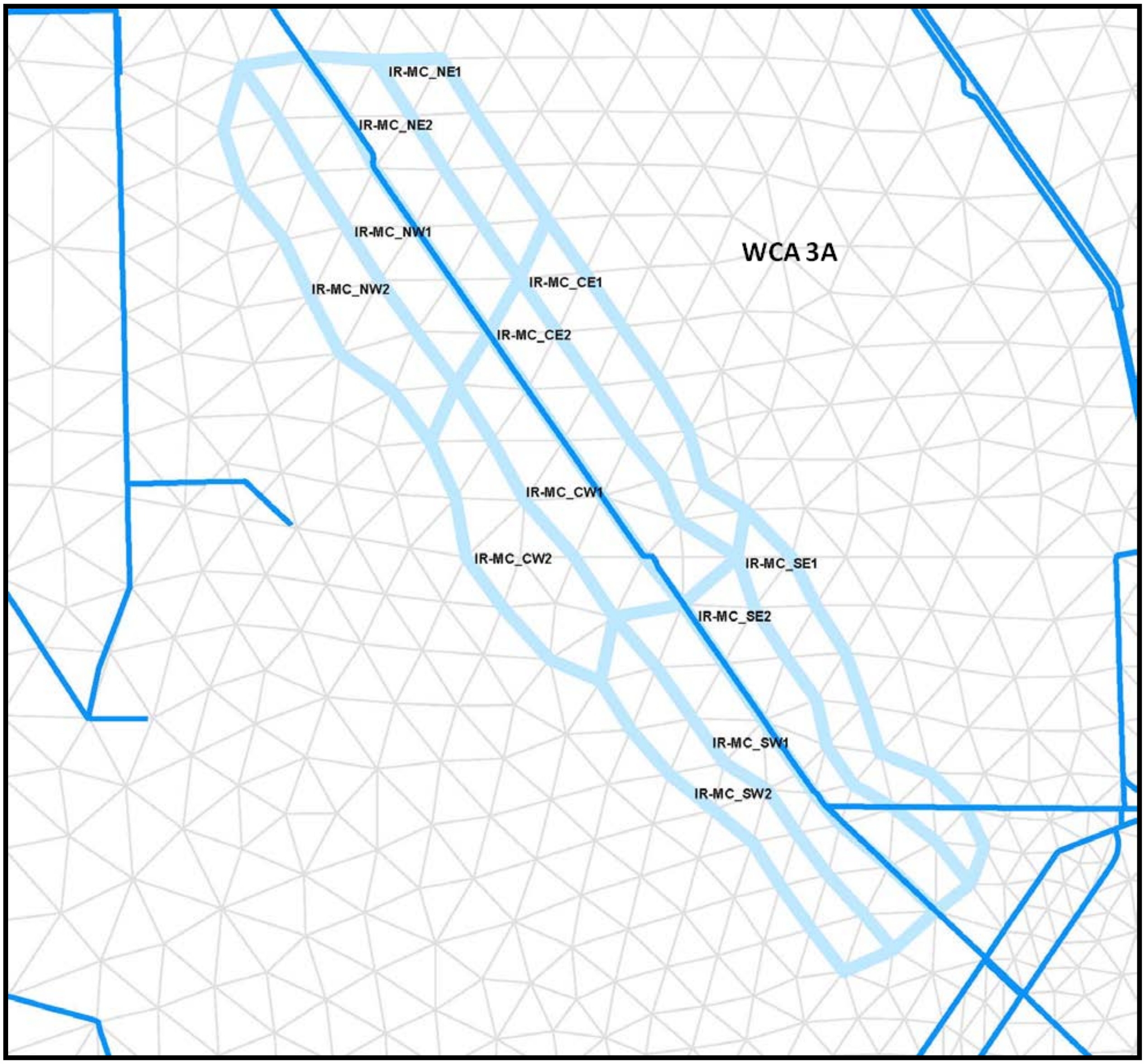


Figure G-5. Miami Canal Indicator Regions within RSM-GL Model Mesh

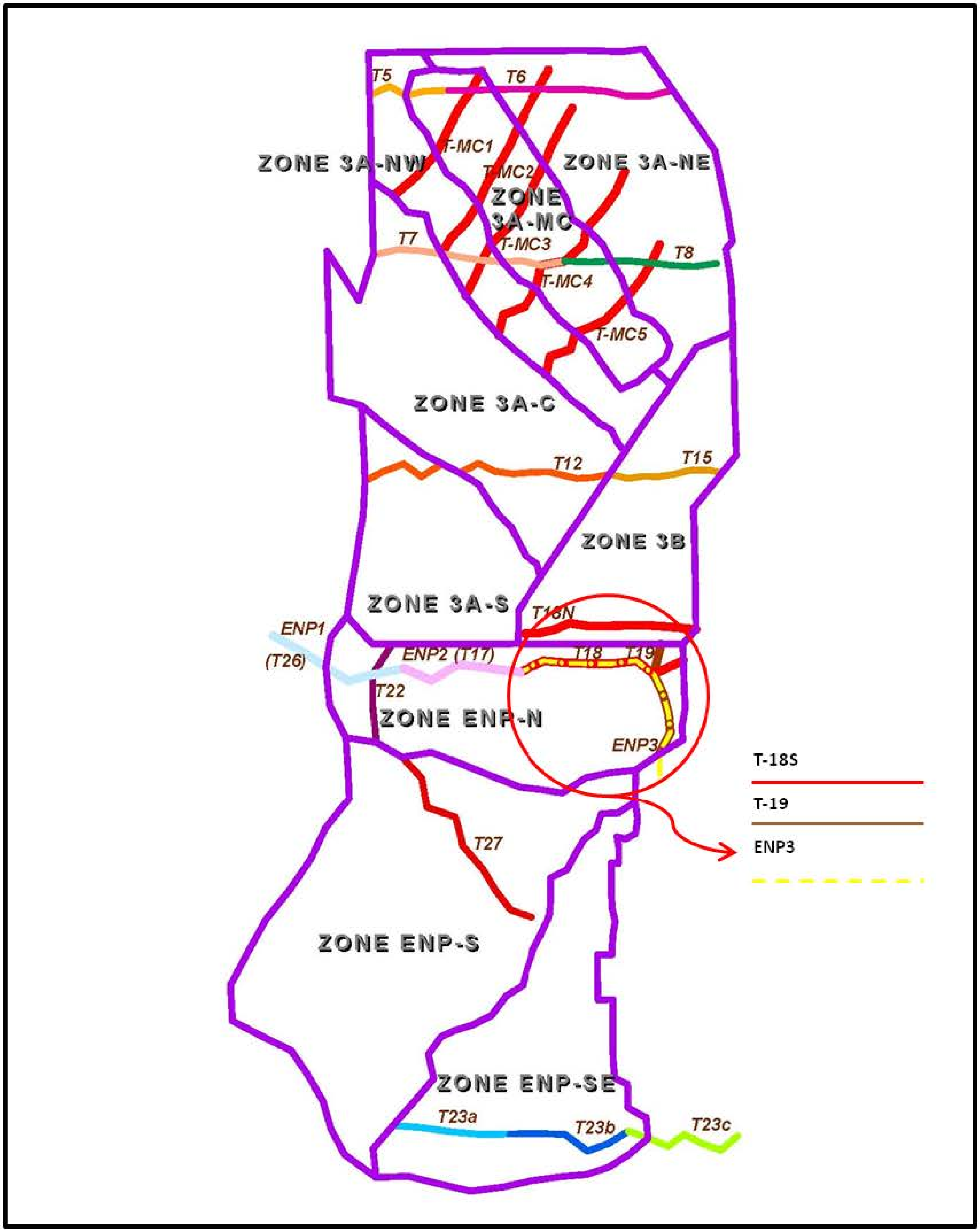


Figure G-6. Transects within the RSM-GL Model Mesh

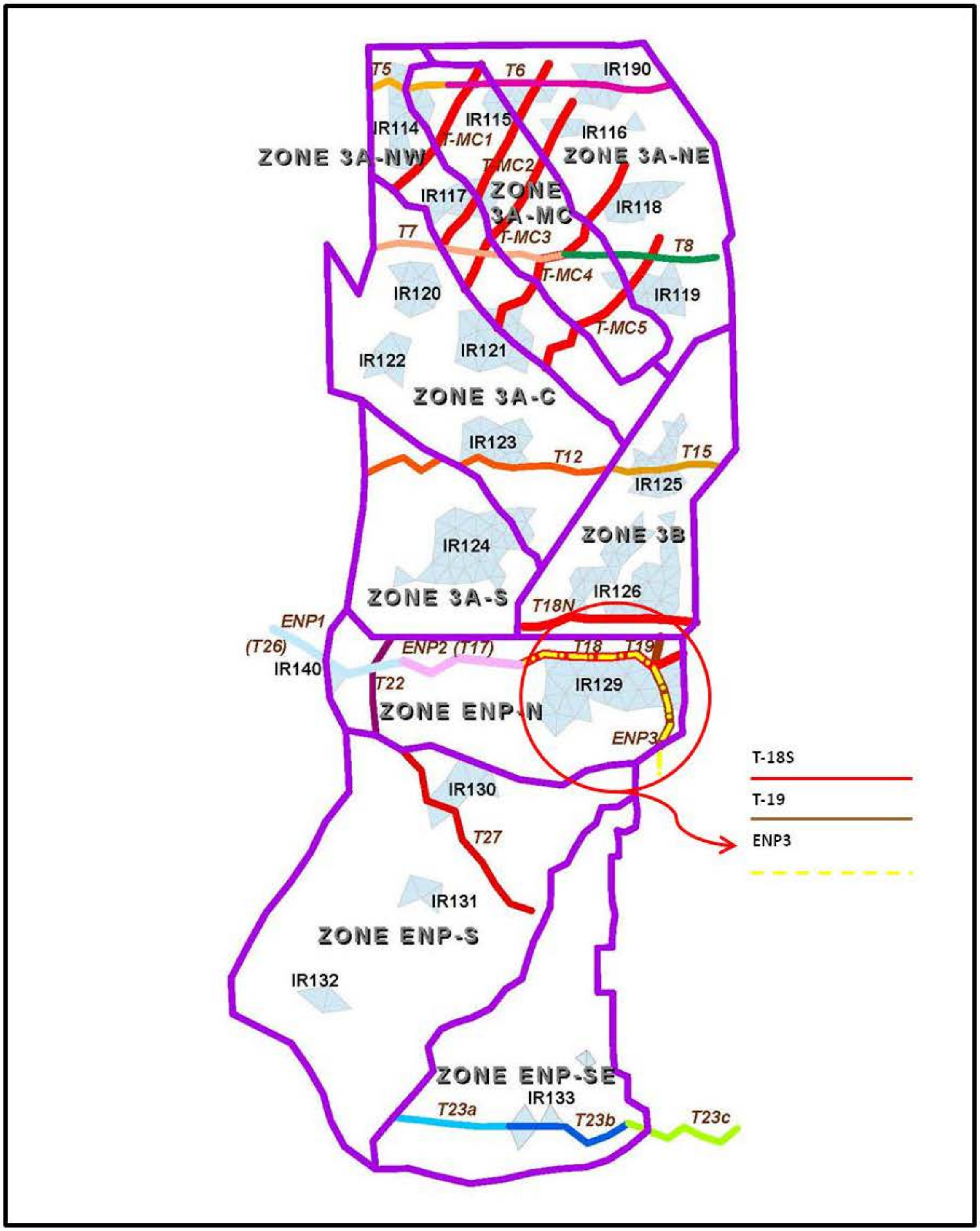


Figure G-7. Indicator Regions, Transects and Zones Within RSM-GL Model Mesh

Southern Coastal Systems Performance Measures

Performance measures for Florida Bay were used 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 project's effects, Florida Bay was divided into six zones of similarity based on water quality characteristics (**Figure G-8**). Zones evaluated 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 analytical purposes, the area within Florida Bay to be potentially affected by the project was assumed to encompass 476,096 acres (*i.e.* summation of acreages within each of the six zones).

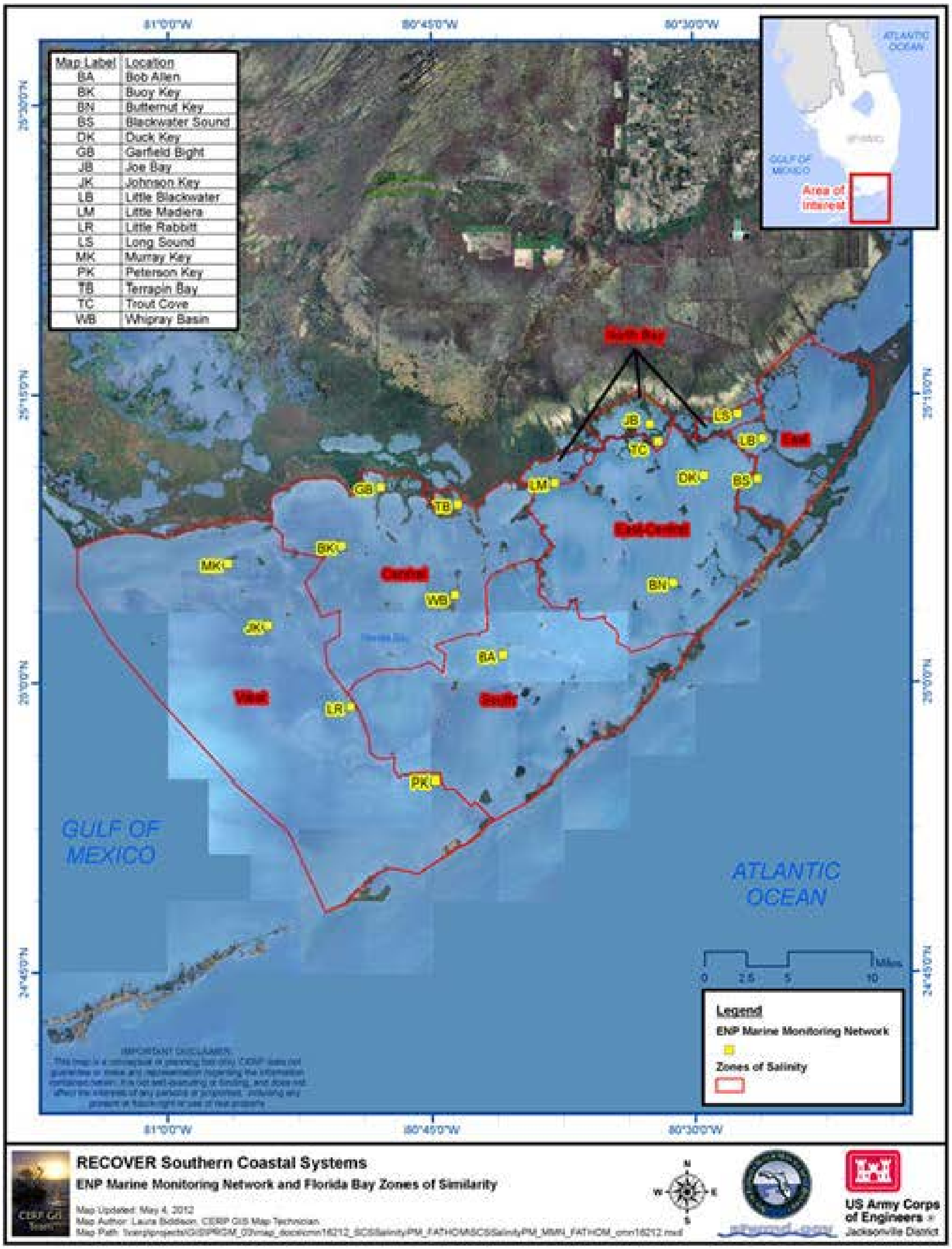


Figure G-8. Florida Bay Marine Monitoring Network and Florida Bay Zones of Similarity

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).

G.1.5.1 Northern Estuaries Performance Measures

G.1.5.1.1 Caloosahatchee Estuary

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 re-establishment 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 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 no months during October to July when 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

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 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 cubic feet per second (cfs).
- 0 Lake Okeechobee regulatory discharge events (14 day moving averages > 2000 cfs)

For each of the estuaries, scores will be reported for project alternatives indicating the numbers 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.

Further information for this performance measure can be found at:
http://www.evergladesplan.org/pm/recover/recover_docs/et/ne_pm_salinityenvelopes.pdf.

G.1.5.2 Greater Everglades Performance Measures

G.1.5.2.1 Inundation Duration in the Ridge and Slough Landscape

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 percent period of record 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-129, IR-140
ENP-S	IR-130, IR-131, IR-132
ENP-SE	IR-133

Further information for this performance measure can be found at:
http://www.evergladesplan.org/pm/recover/recover_docs/et/061807_prev_ge-2.pdf

G.1.5.2.2 Sheetflow in the Everglades Ridge and Slough Landscape

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.

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 distribution target is to have uniformity of flow along the length of each transect at each time step (monthly) and the continuity target is to have uniform flow across paired transects which cross barriers or canals 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), T-18S
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). The timing of flow (sub-metric 2.1) at each T-23 sub-transect is nearly the same, however, therefore 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 & T-23C).

Further information for this performance measure can be found at: http://www.evergladesplan.org/pm/recover/recover_docs/et/ge_sheetflow_01.pdf

G.1.5.2.3 Hydrologic Surrogate for Soil Oxidation

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 (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.

Further information for this performance measure can be found at:
http://www.evergladesplan.org/pm/recover/recover_docs/perf_measures/ge-03_090408.pdf[2]

G.1.5.2.4 Dry Events in Shark River Slough

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 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 percent period of record (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

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

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.

Further information for this performance measure can be found at:
http://www.evergladesplan.org/pm/recover/recover_docs/et/061807_prev_ge-1.pdf

G.1.5.2.5 Slough Vegetation Suitability

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 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.

Further information for this performance measure can be found at:
http://www.evergladesplan.org/pm/recover/recover_docs/perf_measures/ge_slough_veg_pm_final_092611.pdf

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 Marine Monitoring Network (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

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 mid-range 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

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.

Further information for this performance measure can be found at:

http://www.evergladesplan.org/pm/recover/recover_docs/perf_measures/062812_rec_pm_scs_salinity_flbay.pdf

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.

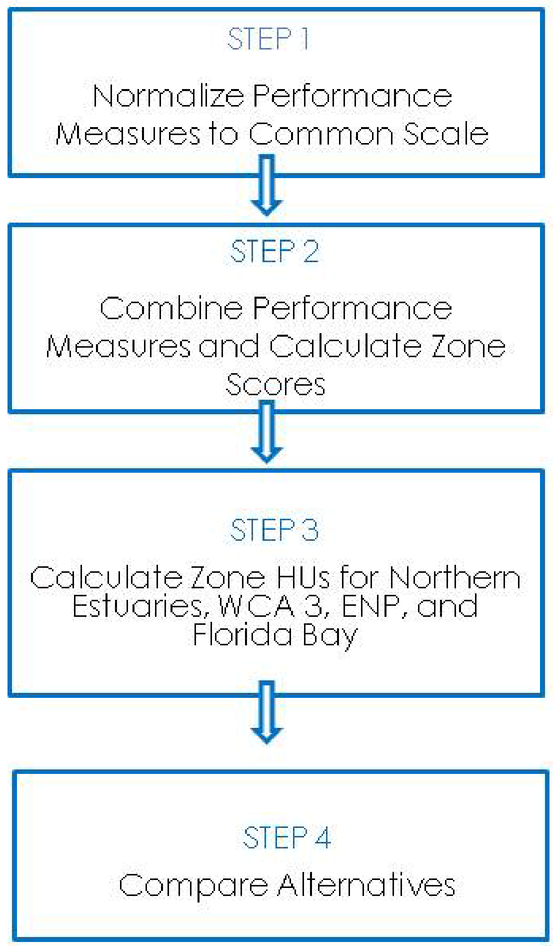


Figure G-9. Overview of Steps in Calculating Ecosystem Benefits and Numerical Outputs

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).

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 in order 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 as a whole.

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 & 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
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

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 without-project baselines 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, 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. 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 alternatives (*i.e.* Alternatives 1-4 and 4R) and the recommended plan (*i.e.* Alternative 4R2).

Results of the cost effectiveness incremental cost analysis (CE/ICA) identified Alternative 4 with modifications to the infrastructure of the hydropattern restoration feature and backfilling of the Miami Canal, denoted as Alternative 4M, as providing the greatest overall benefits with the least cost per habitat unit; however, the evaluation identified the need to revise operations of Alternative 4M to minimize localized adverse ecological effects to WCA 2 and Biscayne Bay and to ensure project savings clause constraints were met. Operations were also refined to provide additional opportunities for other water related needs (*i.e.* water supply) in the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC). Modeling scenarios were subsequently conducted to identify project effects resulting from operational changes (*i.e.* Alternatives 4R and 4R2). Results of the methodology used to quantify ecosystem benefits indicate a reduction in alternative performance for Alternative 4R and 4R2 in comparison to Alternatives 1-4. A similar reduction in benefits would be expected for each of the other four alternatives in the final array (*i.e.* Alternatives 1-4) if these considerations had been applied. Alternatives 4R and 4R2 are therefore not directly comparable to Alternatives 1-4. For this reason the evaluation of Alternatives 1 through 4 and Alternative 4R and 4R2 are presented separately in the following sections. A summary of performance for Alternatives 1 through 4 is described in **Sections G.2.1** through **G.2.4**. Performance of Alternatives 4R and 4R2 are described in **Sections G.2.5** through **G.2.8**.

Additional analyses of alternative performance are provided in the system-wide RECOVER evaluation (**Annex E**).

G.2.1 Northern Estuaries (Alternatives 1-4)

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 2800 cfs cause mortality of marine seagrasses and oysters in the lower estuary and at flows greater than 4500 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 350-2000 cfs range produce tolerable salinities. Flows greater than 2000 cfs result in low, intolerable salinity within the estuary. Flows greater than 3000 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 Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1-4
6.1	Low Flow (< 450 cfs)	4	78	78
6.2	High Flow (>2800 cfs)	4	17	31
	Percentage of Target HU (HSI x 100)	**4**	**48**	**55**

Table G-5. Rescaled Performance Measure Scores (Zero to 100 Scale) for St. Lucie Estuary (Zone SE-1) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1-4
7.1	Low Flow (< 350 cfs)	14	9	0
7.2	High Flow (>2000 cfs)	14	22	64
	Percentage of Target HU (HSI x 100)	**14**	**16**	**32**

In the Caloosahatchee Estuary, the FWO scored better in terms of meeting the desired performance measure targets relative to the ECB (**Table G-4**). The number of times mean monthly flows greater than 2,800 cfs were not met occurred 94 times for the ECB (**Figure G-10**). The number of times mean monthly flows greater than 2,800 cfs were not met for the FWO occurred 81 times. The number of times mean monthly flows less than 450 cfs were not met occurred 116 times for the ECB; 27 for the FWO (**Figure G-10**).

In the St. Lucie Estuary, the FWO scored better in terms of meeting the desired performance measure targets relative to the ECB (**Table G-5**). The number of times flows greater than 2,000 cfs from Lake Okeechobee regulatory releases were not met occurred 72 times for the ECB; 65 for the FWO (**Figure G-11**). The number of times flows less than 350 cfs were not met occurred 89 times for the ECB; 92 for the FWO (**Figure G-11**).

The FWO assumes the implementation of the C-43 Western Basin Storage Reservoir in the Caloosahatchee Estuary and the Indian River Lagoon South Project within the St. Luce Estuary. Differences in the number of times salinity criteria are not met between the ECB and FWO are likely attributable to the operation of these projects.

Modeling results of the CEPP 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 81 in the FWO to 68 with implementation of Alternatives 1-4. 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 65 in the FWO to 30 with implementation of Alternatives 1-4 (**Figure G-11**). Alternatives 1-4 maintained the number of low discharge events to the Caloosahatchee Estuary in comparison to the FWO. The number of low discharge events to the St. Lucie Estuary increased to 122 in comparison to the FWO which was roughly 92. 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**).

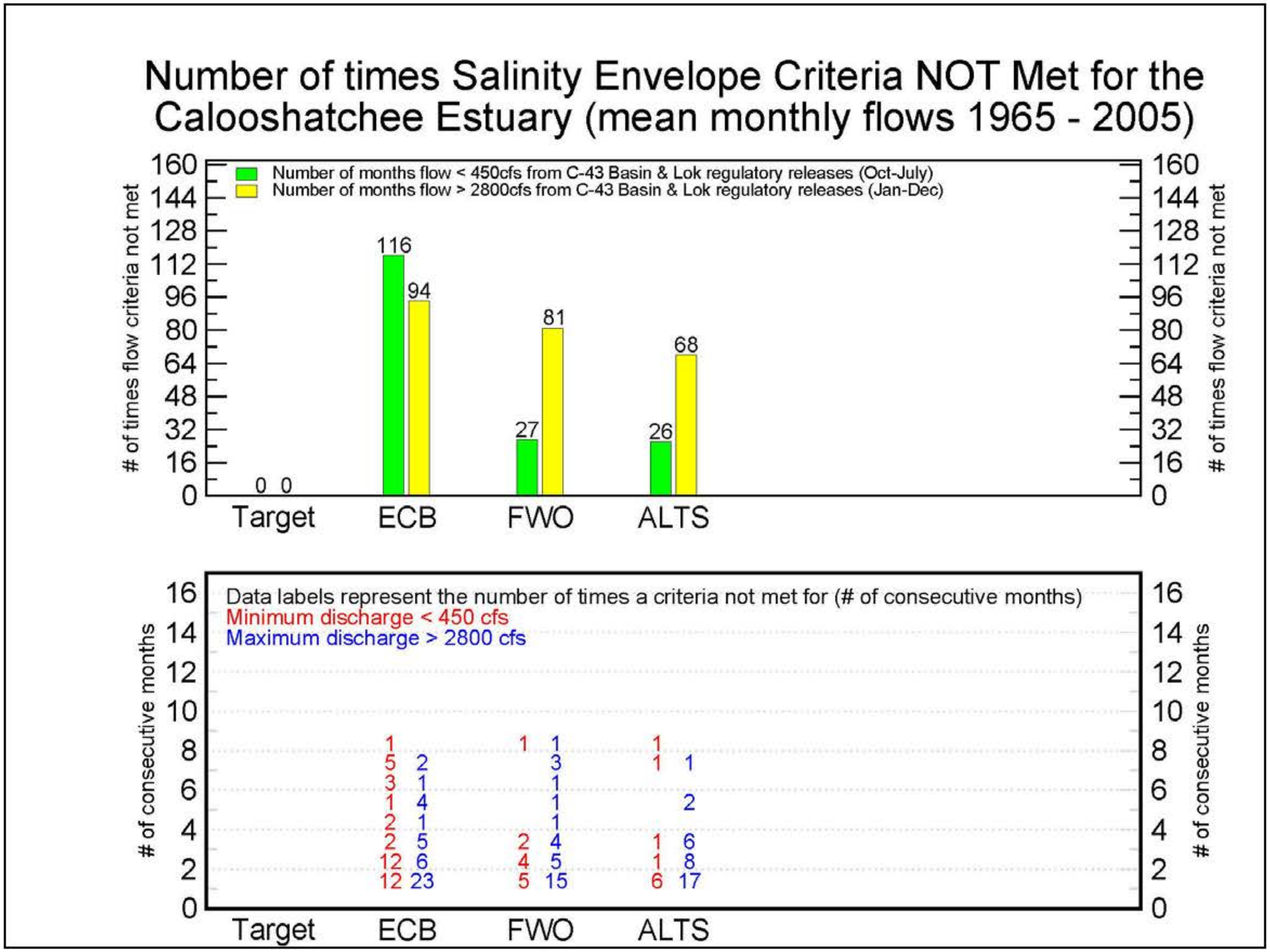


Figure G-10. Number of Times Salinity Criteria Not Met for the Caloosahatchee Estuary for Alternatives 1-4

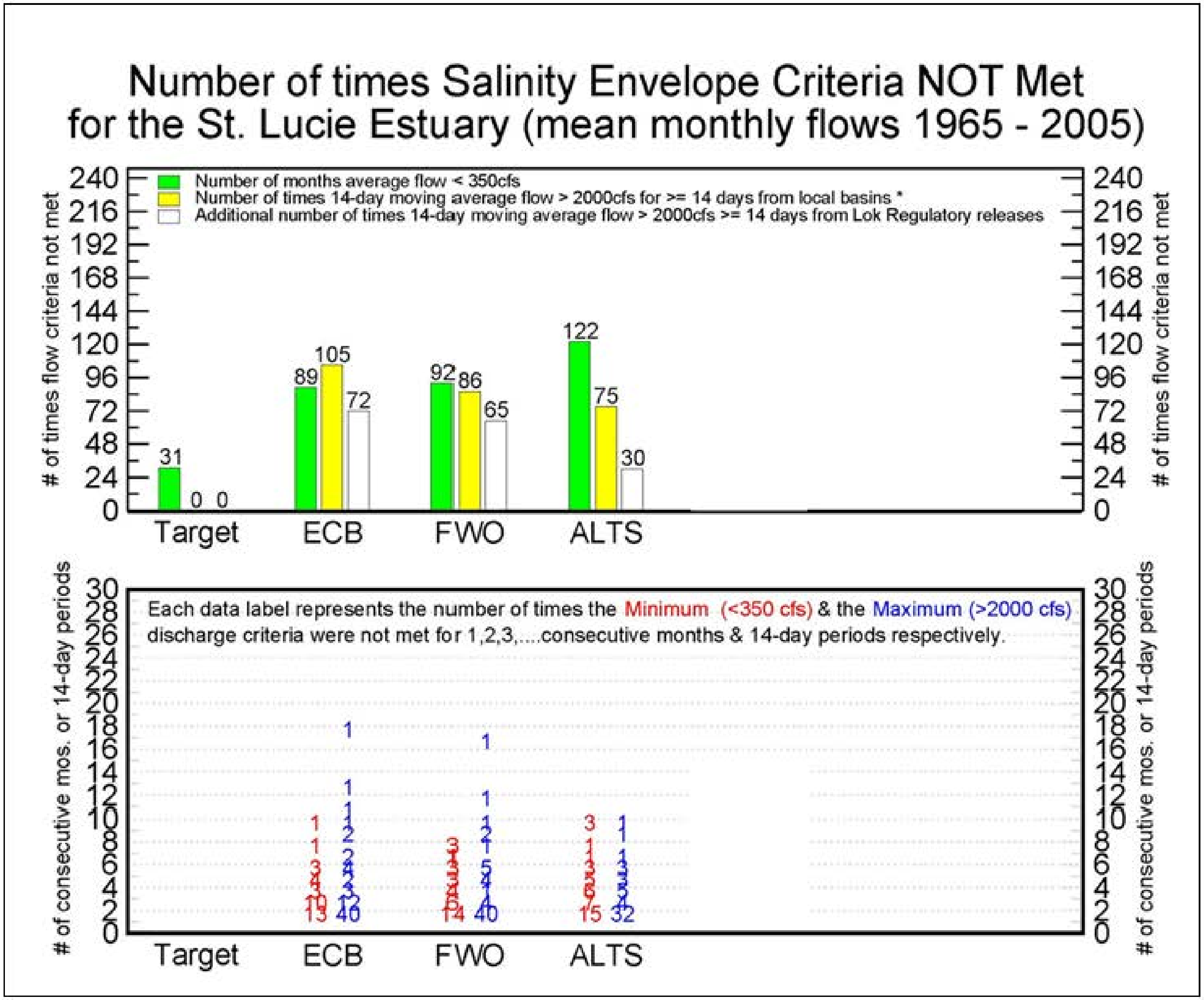


Figure G-11. Number of Times Salinity Criteria Not Met for the St. Lucie Estuary for Alternatives 1-4

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 St. Lucie Estuary. Although these extreme dry spells are rare in the SLE, unlike the CRE 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 Indian River Lagoon South 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 1-4 would achieve 55% and 22% of the target HUs for the Caloosahatchee and St. Lucie Estuaries respectively (**Table G-4** and **Table G-5**). The FWO would achieve 48% of the target HUs for the Caloosahatchee Estuary and 21% for the St. Lucie Estuary (**Table G-4** and **Table G-5**). Although the improvements in flows to the Northern Estuaries is small when CEPP is added onto the FWO as compared to the overall goal of CERP, the additional increment of improvement is one step closer to meeting restoration goals for the Northern Estuaries. Implementation of the CEPP 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 (Alternatives 1-4)

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 (Zones 3A-NW, 3A-MC, 3A-NE) (Alternatives 1-4)

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.

In northern WCA 3A, the ECB scored better in terms of meeting the desired performance measure targets relative to the FWO (**Table G-6**, **Table G-7**, and **Table G-8**).

Alternatives 1-4 improved hydrologic conditions in northern WCA 3A 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-6**, **Table G-7**, and **Table G-8**). Pertaining to slough vegetation suitability, greater performance was noted with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events below 0.7 ft. Scores for these performance measures fell within the 75 to 100 range for all alternatives. Alternatives 1-4 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing and distribution of sheetflow. Scores for these performance measures ranged from 25 to 68.

Variation in the distribution of inflows into northern WCA 3A and backfill of the Miami Canal did not significantly influence performance among alternatives. Differences in hydrologic improvements between Alternatives 1-4 were modest relative to the differences of the alternatives to the FWO. Slight differences occurred in northwestern WCA 3A (Zone 3A-NW); Alternative 1 scored the highest in terms of meeting the desired performance measure targets within this area (**Table G-6**). Differences in hydrologic improvements between Alternatives 1-4 at this location may be a direct consequence of the variation in the distribution of inflows into northern WCA 3A. Alternative 1 delivered a larger volume of water to this region of the project area.

Table G-6. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northwestern WCA 3A (Zone 3A NW) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	63	61	96	94	94	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	20	19	33	31	31	31
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	4	4	63	62	62	62
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	24	18	68	67	67	67
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	63	63	99	97	97	97
5.1	Slough Vegetation Suitability -- Hydroperiod	46	46	80	79	79	79
5.2	Slough Vegetation Suitability -- Dry down	51	48	86	84	84	84
5.3	Slough Vegetation Suitability -- Dry Season Depth	22	19	40	36	36	36
5.4	Slough Vegetation Suitability -- Wet Season Depth	22	20	48	45	44	45
	Percentage of Target HU (HSI x 100)	**44**	**43**	**78**	**76**	**76**	**76**

Table G-7. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3A Miami Canal (Zone 3A MC) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	55	45	93	92	91	92
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	18	17	30	28	28	28
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	4	4	63	62	62	62
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	28	23	62	63	63	63
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	52	44	85	82	81	83
5.1	Slough Vegetation Suitability -- Hydroperiod	42	35	77	76	75	76
5.2	Slough Vegetation Suitability -- Dry down	63	50	87	86	86	87
5.3	Slough Vegetation Suitability -- Dry Season Depth	37	32	52	50	50	51
5.4	Slough Vegetation Suitability -- Wet Season Depth	40	32	55	53	53	54
	Percentage of Target HU (HSI x 100)	**42**	**35**	**74**	**73**	**72**	**73**

Table G-8. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northeastern WCA 3A (Zone 3A NE) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	40	25	99	99	99	99
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	16	15	27	25	25	25
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	6	4	61	59	59	59
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	18	17	57	59	59	59
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	50	26	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	38	27	75	78	77	78
5.2	Slough Vegetation Suitability -- Dry down	58	51	86	87	87	88
5.3	Slough Vegetation Suitability -- Dry Season Depth	35	30	48	49	49	50
5.4	Slough Vegetation Suitability -- Wet Season Depth	30	26	47	48	48	49
	Percentage of Target HU (HSI x 100)	**36**	**24**	**78**	**78**	**78**	**78**

Alternative 1 generally produced improved inundation patterns in northwestern WCA 3A. Indicator region 114 was inundated for 92% of the period of record for Alternative 1; a 19% increase in inundation duration relative to the FWO. Alternatives 2-4 inundated this location for 91% of the period of record; a 18 % increase relative to the FWO. Alternative 1 generally produced higher depths within northwestern WCA 3A as depicted by the normalized weekly stage duration curve for IR 114 (**Figure G-12**); an example IR for Zone 3A-NW. Depths were significantly increased on average by 0.6 to 0.8 ft relative to the FWO. Alternatives 2-4 significantly increased depths on average by 0.5 to 0.7 ft at this location. Improvements in depth of water below ground surface were also noted. Cumulative drought intensity is the sum of the daily depth of stage below ground (negative ponded depth) across the period of record. Alternative 1 reduced drought intensity at IR 114 over the period of record by 1,081 ft-days relative to the FWO. Alternatives 2-4 provided a reduction of 1,010 ft-days over the period of record at this location. Improved inundation patterns in northwestern WCA 3A resulted in better suitability for slough vegetation for Alternative 1. Alternative 1 provided slightly improved conditions for slough vegetation relative to Alternatives 2-4 by increasing hydroperiods and reducing the duration of dry down events below 0.7 feet, as shown for IR 114 in **Figure G-13**. None of Alternatives 1-4 met the desired dry and wet season water depths for slough vegetation in northwestern WCA 3A; however, Alternative 1 slightly improved conditions for slough vegetation relative to Alternatives 2-4 by increasing water depths in both the wet and dry season at this location. Patterns of alternative performance were similar at IRs 117 and 121; however differences between Alternatives 1-4 were less notable at IR 121 which is located farther from the L-4/L-5 boundary.

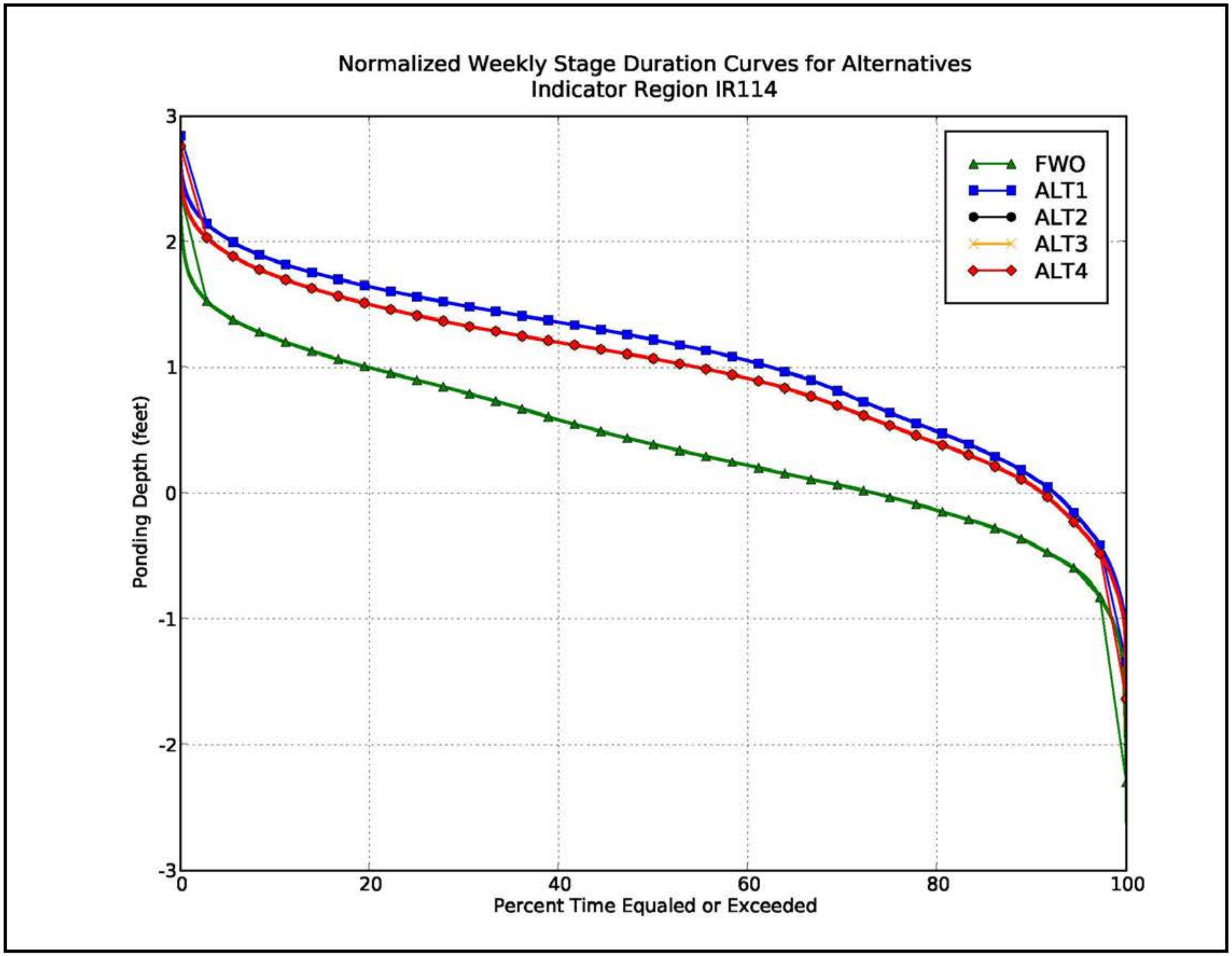


Figure G-12. Normalized Weekly Stage Duration Curve for Indicator Region 114 for Alternatives 1-4

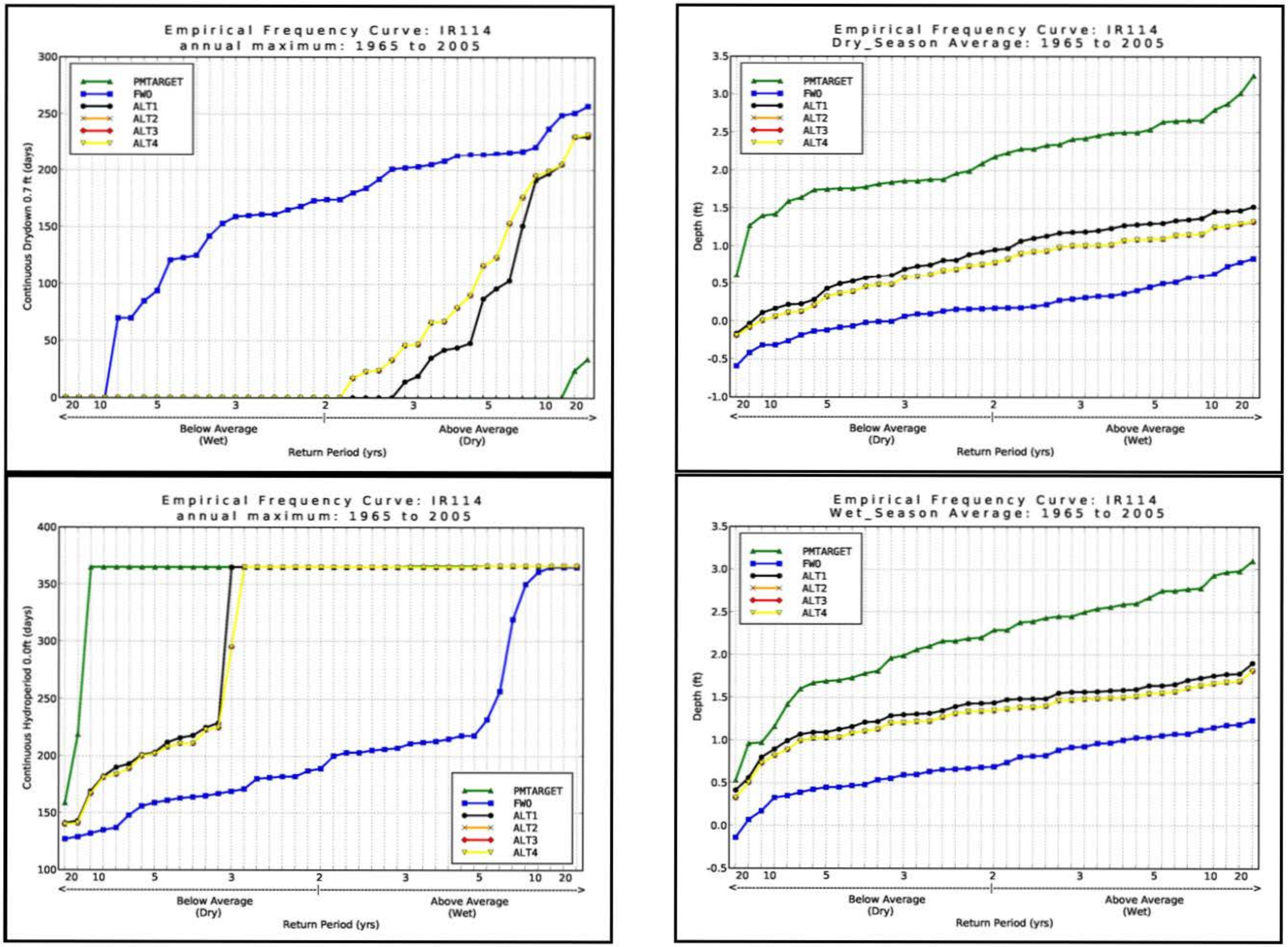


Figure G-13. Slough Vegetation Empirical Frequency Curves Indicator Region 114 for Alternatives 1-4

Alternatives 1-4 scored similarly in northeastern WCA 3A (Zone 3A-NE) (**Table G-8**). Alternatives 2-4 generally produced improved inundation patterns in northeastern WCA 3A in IRs located directly south of the eastern-most spreader located approximately 1.5 miles east of the G-206 structure. Alternatives 2-4 produced higher depths at IR 116 as depicted by the normalized weekly stage duration curve (**Figure G-14**); an example IR for Zone 3A-NE. Depths were significantly increased on average by 0.5 to 0.8 ft relative to the FWO with no significant change during extreme wet conditions and a slight increase in depth for extreme dry conditions. Alternative 1 significantly increased depths on average by 0.4 to 0.7 ft at this location. Alternatives 2-4 performed better for measures of inundation duration, drought intensity, and slough vegetation suitability. Alternative 1 produced slightly better performance for measures of sheetflow (*i.e.* timing and continuity) resulting in equivalent percent of target HUs achieved for this region of the project area (**Table G-8**). This suggests that a hydropattern restoration feature located west of the S-8 structure as modeled for Alternative 1 is sufficient in hydrating and improving sheetflow in this region relative to Alternatives 2-4.

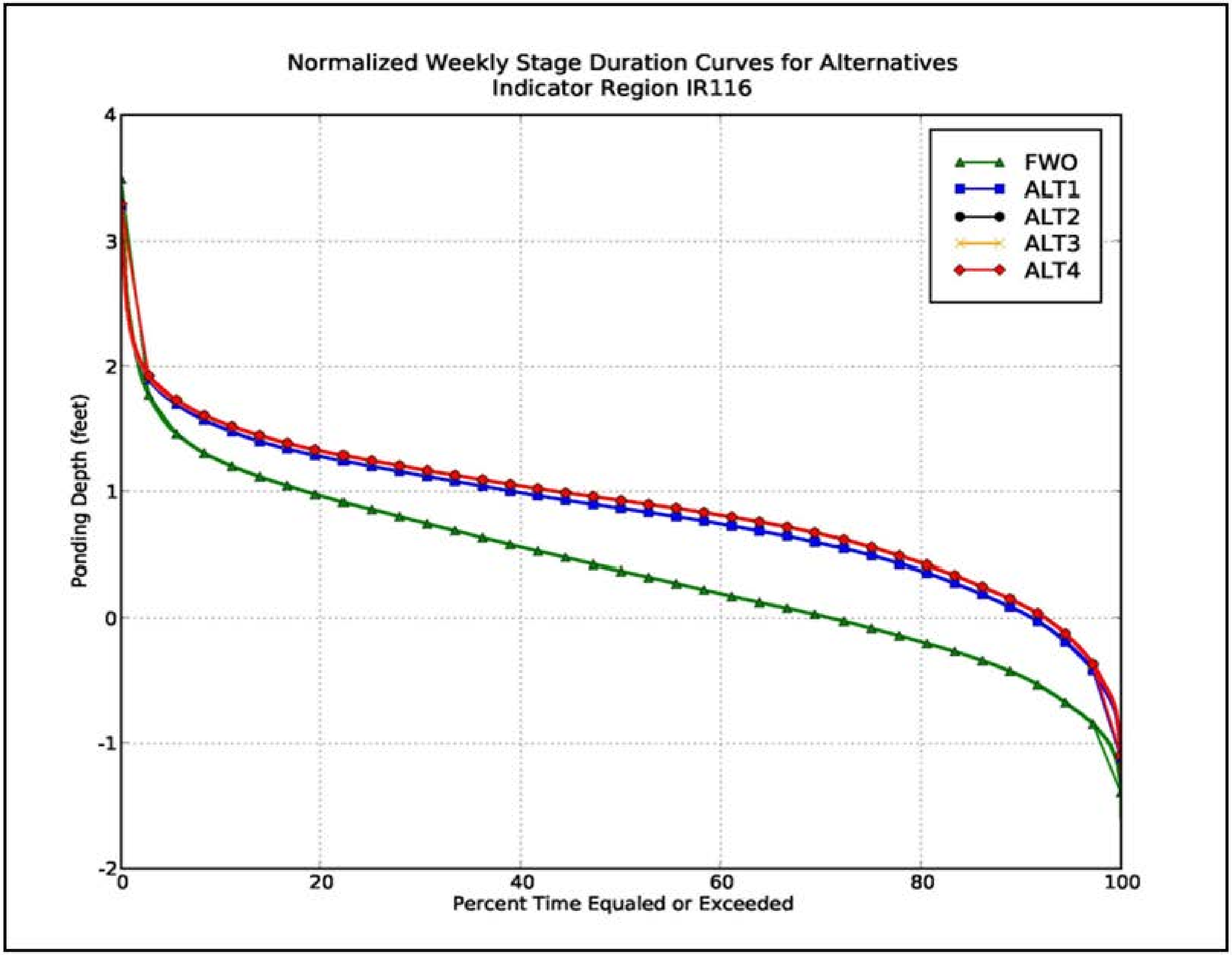


Figure G-14. Normalized Weekly Stage Duration Curve for Indicator Region 116 for Alternatives 1-4

If drainage and disrupted sheetflow continues as a result of the drainage effects of the Miami Canal within northern WCA 3A, further ridge and slough degradation and peat loss is expected due to continued increases in the frequency of fires and oxidation and decreased inundation durations. Reversal of soil loss and restoration of organic soil accretion will only be achieved through reducing the percent of time that soils are dry and vulnerable to fires. Hydrology in northern WCA 3A will be significantly affected by the implementation of CEPP. 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. Of the performance measures used, scores for Alternatives 1-4 for measures of inundation duration ranged from 87% of the period of record to 96% of the period of record across northern WCA 3A (**Table G-9**). Inundation duration for the FWO ranged from 60% of the period of record to 95% of the period of record (**Table G-9**). Reductions in drought intensity in northern WCA 3A relative to the FWO ranged from 8 to 6000 ft-days over the period of record (**Table G-10**).

Table G-9. Percent Period of Record of Inundation for Alternatives 1-4 (Raw Performance Measure Scores)

Zone	Indicator Region	FWO	ALT1	ALT2	ALT3	ALT4
Zone 3A-NW	IR 114	73	92	91	91	91
	IR 117	91	95	95	95	95
	IR 121	93	96	96	96	96
Zone 3A-MC	MC NE 1	64	94	94	94	94
	MC NE 2	60	96	95	95	95
	MC NW 1	75	94	93	93	93
	MC NW 2	72	91	90	90	90
	MC CE 1	79	93	93	93	93
	MC CE 2	72	88	88	87	88
	MC CW 1	83	92	91	91	91
	MC CW 2	88	95	94	94	94
	MC SE 1	92	94	94	94	94
	MC SE 2	93	91	91	90	91
	MC SW 1	91	93	92	92	93
	MC SW 2	91	94	94	94	94
Zone 3A-NE	IR 115	68	93	94	94	94
	IR 116	71	91	92	92	92
	IR118	77	91	91	91	91
	IR 119	95	96	96	96	96
	IR 190	73	92	93	93	93

Table G-10. Hydrologic Surrogate for Soil Oxidation (Water Depth Relative to Land Surface Elevation Ft-Days Below Ground) for Alternatives 1-4 (Raw Performance Measure Scores)

Zone	Indicator Region	FWO	ALT1	ALT2	ALT3	ALT4
Zone 3A-NW	IR 114	-1431	-350	-421	-421	-421
	IR 117	-461	-227	-255	-255	-255
	IR 121	-256	-140	-159	-159	-158
Zone 3A-MC	MC NE 1	-2172	-274	-260	-260	-260
	MC NE 2	-6218	-162	-212	-212	-212
	MC NW 1	-1398	-275	-345	-345	-345
	MC NW 2	-1752	-527	-622	-622	-622
	MC CE 1	-1206	-395	-393	-393	-391
	MC CE 2	-2911	-1284	-1360	-1397	-1314
	MC CW 1	-1040	-508	-551	-554	-545
	MC CW 2	-603	-259	-287	-287	-287
	MC SE 1	-447	-346	-367	-380	-340
	MC SE 2	-590	-956	-1030	-1084	-954
	MC SW 1	-533	-458	-506	-525	-476
	MC SW 2	-473	-294	-325	-331	-314
Zone 3A-NE	IR 115	-1861	-347	-298	-298	-298
	IR 116	-1705	-431	-367	-367	-365
	IR118	-1545	-502	-484	-486	-468
	IR 119	-172	-133	-156	-164	-131
	IR 190	-1417	-364	-318	-320	-316

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 Alternatives 1-4 would achieve 76-78% of the target HUs for Zone 3A-NW (**Table G-6**), 72-74% of the target HUs for Zone 3A-MC (**Table G-7**), and 78% of the target HUs for Zone 3A-NE (**Table G-8**). The FWO would achieve 43%, 35%, and 24% 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) (Alternatives 1-4)

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, the ECB scored better in terms of meeting the desired performance measure targets relative to the FWO (**Table G-11**). The FWO generally produced decreased depths relative to the ECB.

Depths were generally decreased by 0.1 to 0.2 feet, with no significant change during extreme wet or extreme dry conditions.

Alternatives 1-4 provided slight improvements in hydrologic conditions in comparison to the FWO (**Table G-11**). Alternatives 1-4 produced slightly 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. Depths in central WCA 3A are generally increased by 0.1 to 0.2 ft during average to dry conditions, with a slight depth reduction during the wettest 10% of conditions and no significant change during extreme dry conditions. Increases in depth within central WCA 3A were not as significant 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 1-4 would achieve 80% of the target HUs for Zone 3A-C (**Table G-11**). The FWO would achieve 77% of the target HUs (**Table G-11**).

Table G-11. Rescaled Performance Measure Scores (Zero to 100 Scale) for Central WCA 3A (Zone 3A C) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	42	43	46	46	45	46
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	63	60	64	65	65	65
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	74	72	82	80	78	80
5.2	Slough Vegetation Suitability -- Dry down	88	85	91	89	90	89
5.3	Slough Vegetation Suitability -- Dry Season Depth	42	37	43	41	41	42
5.4	Slough Vegetation Suitability -- Wet Season Depth	42	38	48	46	46	47
	Percentage of Target HU (HSI x 100)	**79**	**77**	**80**	**80**	**80**	**80**

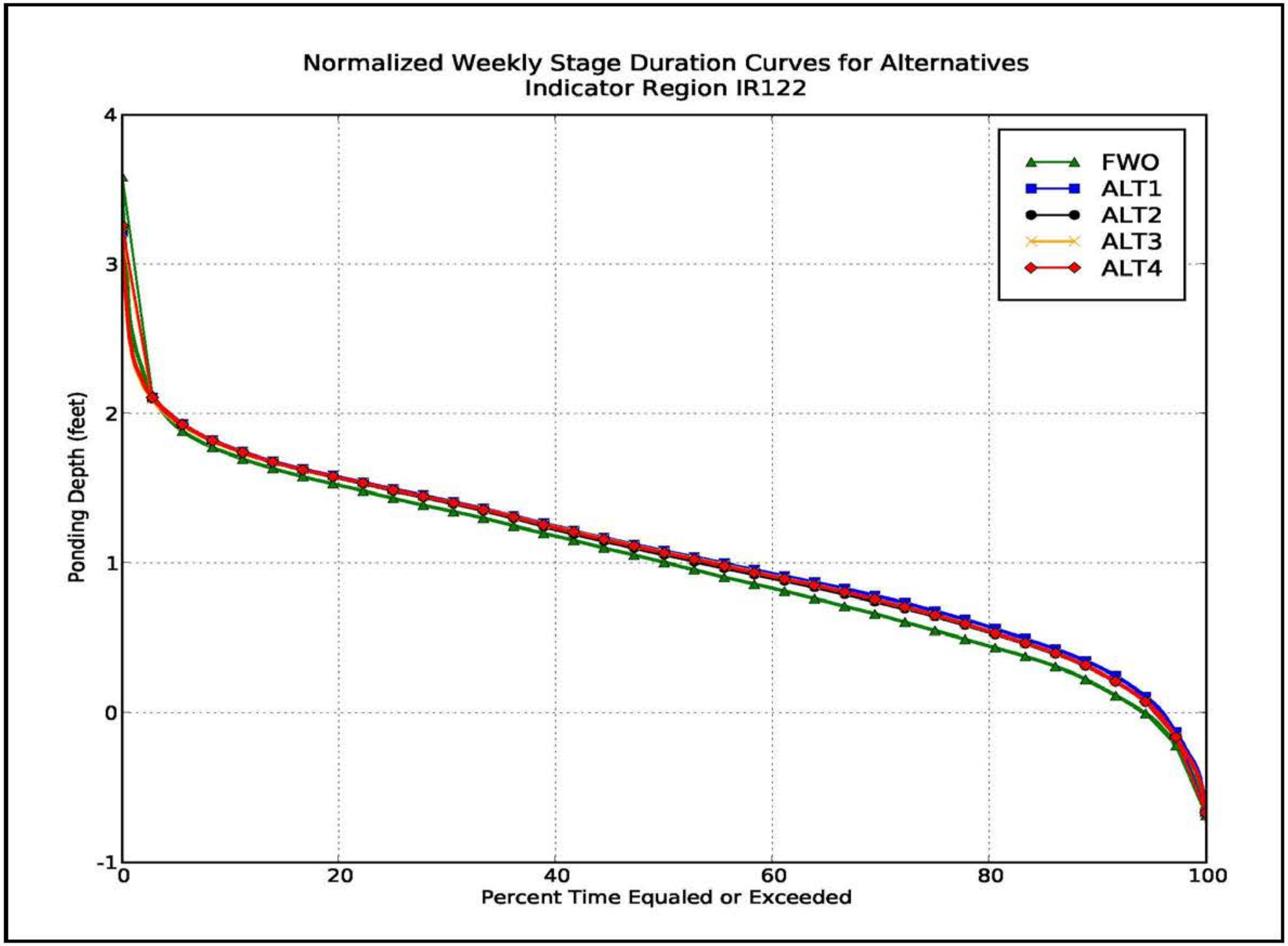


Figure G-15. Normalized Weekly Stage Duration Curve for Indicator Region 122 for Alternatives 1-4

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 (**Table G-12**). The FWO generally produced decreased depths by 0.2 to 0.3 feet with no significant change during extreme wet or extreme dry conditions.

Within southern WCA 3A, Alternatives 1-4 scored similarly to the FWO in terms of meeting the desired targets for each of the performance measures (**Table G-12**). Alternatives 1-4 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. It should be noted that Alternatives 1-4 performed slightly worse for measures of slough vegetation suitability relative to the FWO (**Table G-12**). Performance with respect to this metric can best be explained by the operational targets that were used during plan formulation. Daily water management operations (WCA 3A Regulation Schedule) in WCA 3A are based on a 3 gauge average. These gauges are located in northeast, central and southern WCA 3A. Operational targets used during plan formulation 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.

However, significant shifts in slough vegetation within this region of the project area are not expected as a result of implementation of Alternatives 1-4. 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 1-4 would not significantly reduce the high water levels experienced in southern WCA 3A when compared with current water management practices.

Implementation of Alternatives 1-4 would achieve 82-83% of the target HUs for Zone 3A-S (**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 Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	45	47	50	50	48	50
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	60	59	61	58	59	60
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	84	82	82	80	79	82
5.2	Slough Vegetation Suitability -- Dry down	100	95	93	93	93	93
5.3	Slough Vegetation Suitability -- Dry Season Depth	82	73	73	70	71	72
5.4	Slough Vegetation Suitability -- Wet Season Depth	71	64	62	59	61	62
	Percentage of Target HU (HSI x 100)	**84**	**83**	**83**	**82**	**82**	**83**

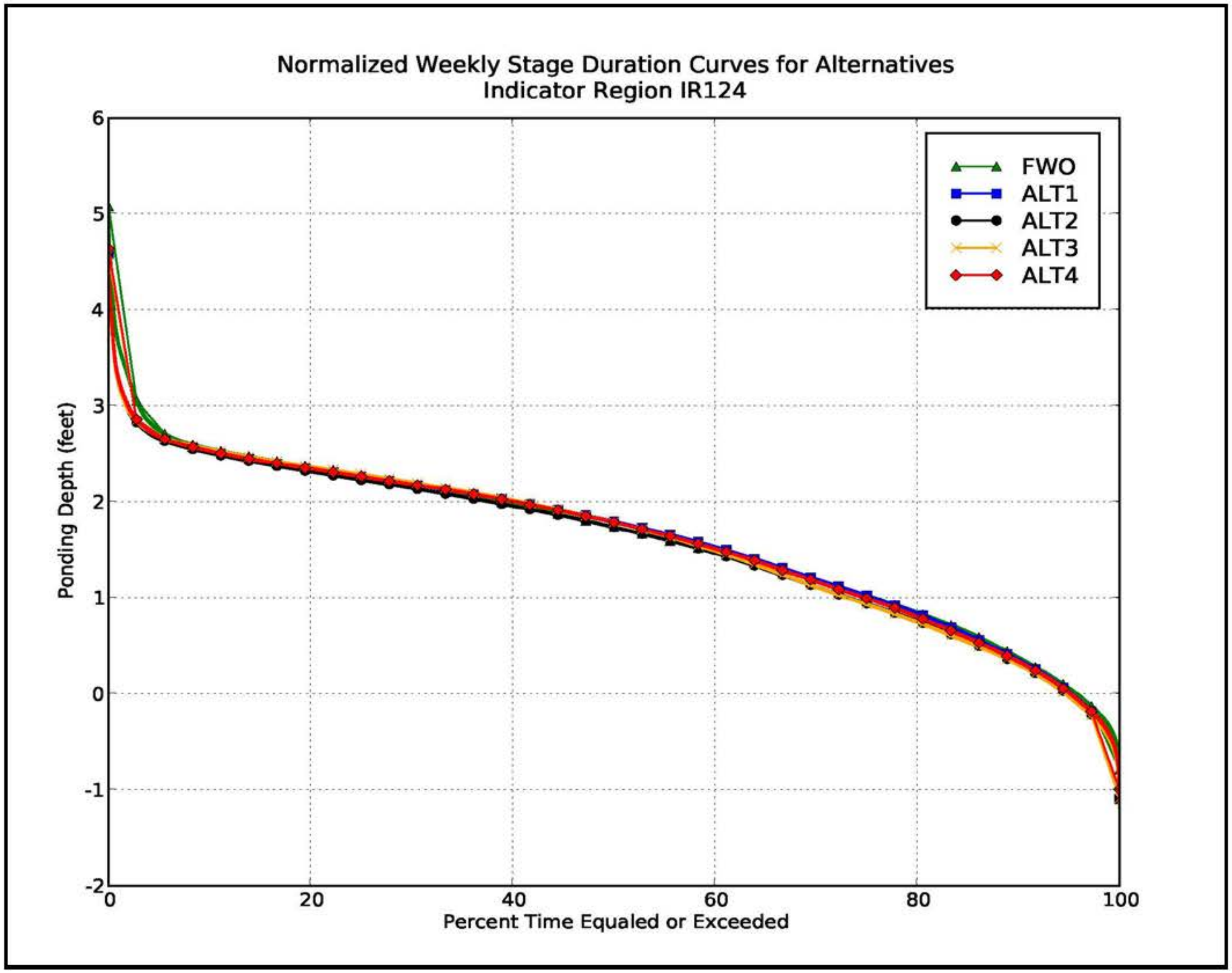


Figure G-16. Normalized Weekly Stage Duration Curve for Indicator Region 124 for Alternatives 1-4

G.2.2.3 WCA 3B (Zone 3B) (Alternatives 1-4)

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. Alternatives for the CEPP consist of variations in the construction of conveyance features on the L-67 A, C and L-29 levees in addition to variations in levee removal. Alternatives for the CEPP also include operational modifications to existing structures and the construction of seepage management features. Implementation of the CEPP is expected to begin to re-establish hydrologic connectivity of WCA 3A, WCA 3B, and ENP.

In WCA 3B, the ECB scored better in terms of meeting the desired performance measure targets relative to the FWO (**Table G-13**). The FWO generally produced lower depths within WCA 3B. Depths were decreased by 0.1 to 0.2 feet during normal to dry conditions.

Alternatives 1-4 improved hydrologic conditions in WCA 3B in comparison to the FWO by increasing depths and resulting hydroperiods within the area. Alternatives 1-4 scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability (**Table G-13**). Pertaining to slough vegetation suitability, greater performance was noted with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events below 0.7 ft. Scores for these performance measures ranged from 74 to 97. Alternatives 1-4 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing and distribution of sheetflow. Scores for these performance measures ranged from 0 to 58.

Table G-13. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3B (Zone 3B) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	86	76	93	97	95	88
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	0	0	0	0	0	2
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	35	36	33	29	27
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	56	58	35	7	14	47
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	84	71	93	96	95	86
5.1	Slough Vegetation Suitability -- Hydroperiod	72	63	77	82	79	74
5.2	Slough Vegetation Suitability -- Dry down	86	80	91	95	95	88
5.3	Slough Vegetation Suitability -- Dry Season Depth	45	38	46	58	46	40
5.4	Slough Vegetation Suitability -- Wet Season Depth	28	23	34	48	35	29
	Percentage of Target HU (HSI x 100)	**65**	**57**	**68**	**69**	**67**	**64**

Poor performance was noted for measures of sheetflow. The timing, continuity, and distribution of sheetflow performance measure provides 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.

Figure G-17 depicts average annual overland flow vectors for the 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 FWO were directed toward the southeast corner of WCA 3B. Alternatives 2 and 3 produced overland flow vectors in a west to east direction. In some instances overland flow vectors were oriented in a south north direction for these two alternatives. Alternatives 1 and 4 maintained the directionality of overland flow seen in the FWO. Alternative 4 improved overland flow directionality in the southwest corner of WCA 3B west of the Blue Shanty levee where vectors were more aligned in a north to south direction. 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 feet above the surrounding marsh. Tree islands within WCA 3B may also suffer from inundation and prolonged high water periods that may induce stress.

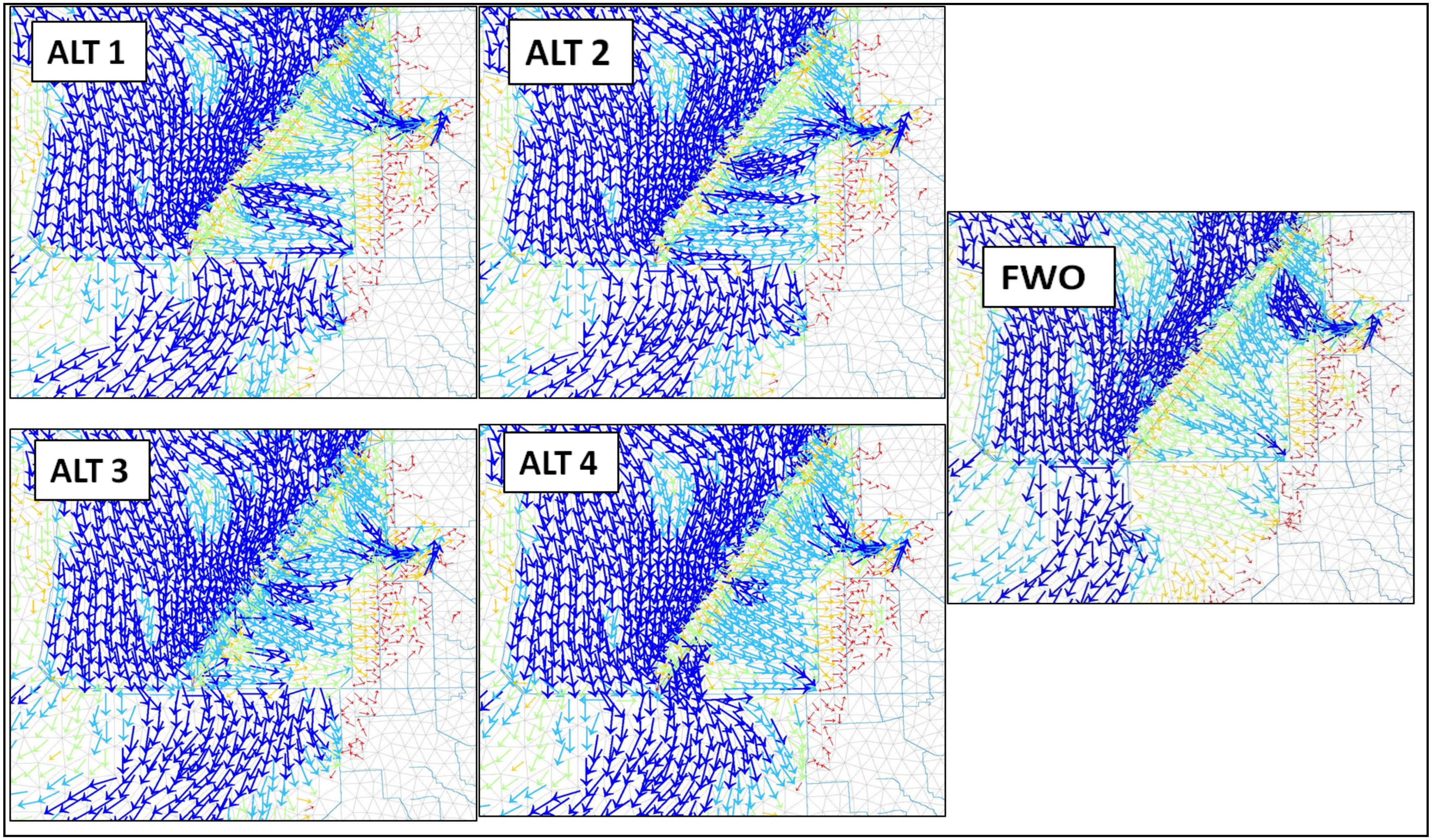


Figure G-17. Average Annual Overland Flow Vectors (1965-2005) for the FWO and Alternatives 1-4

In comparison to other regions of the project area where differences in hydrologic improvements between Alternatives 1-4 were modest, alternative performance varied greatly in WCA 3B. Alternative 2 scored the highest in terms of meeting the desired performance measure targets within this area (**Table G-13**), followed by Alternatives 1 and 3. Alternative 4 performed poorly relative to the other alternatives.

Alternative 2 generally produced improved inundation patterns in WCA 3B. Indicator region 128 was inundated for 95% of the period of record for Alternative 2; an 11% increase in inundation duration relative to the FWO. Alternatives 3, 1, and 4 inundated this location for 94%, 93%, and 90% of the period of record respectively. Alternative 2 generally produced higher depths within WCA 3B as depicted by the normalized weekly stage duration curve for IR 128 (**Figure G-18**); an example IR for Zone 3B. Depths were significantly increased on average by 0.2 to 0.4 ft relative to the FWO under all hydrologic conditions. Alternative 3 significantly increased depths by 0.2 to 0.3 feet during the wettest 10% of conditions and during dry to normal conditions. Alternative 1 increased depths by 0.1 to 0.2 feet during the wettest 10% of conditions and during normal to dry conditions. Alternative 4 slightly increased depths during the wettest 10% of conditions and increased by 0.1 to 0.2 feet during normal to dry conditions. Alternative 2 reduced drought intensity at IR 128 over the period of record by 842 ft-days relative to the FWO. Alternatives 3, 1, and 4 provided reductions of 810 ft-days, 763 ft-days, and 499 ft-days over the period of record at this location.

Alternative 2 provided slightly improved conditions for slough vegetation relative to Alternatives 3, 1, and 4 by increasing hydroperiods and reducing the duration of dry down events below 0.7 feet, as shown for IR 128 in **Figure G-19**. None of Alternatives 1-4 met the desired dry and wet season water depths for slough vegetation in WCA 3B. Patterns of alternative performance were similar at IRs 125 and 126.

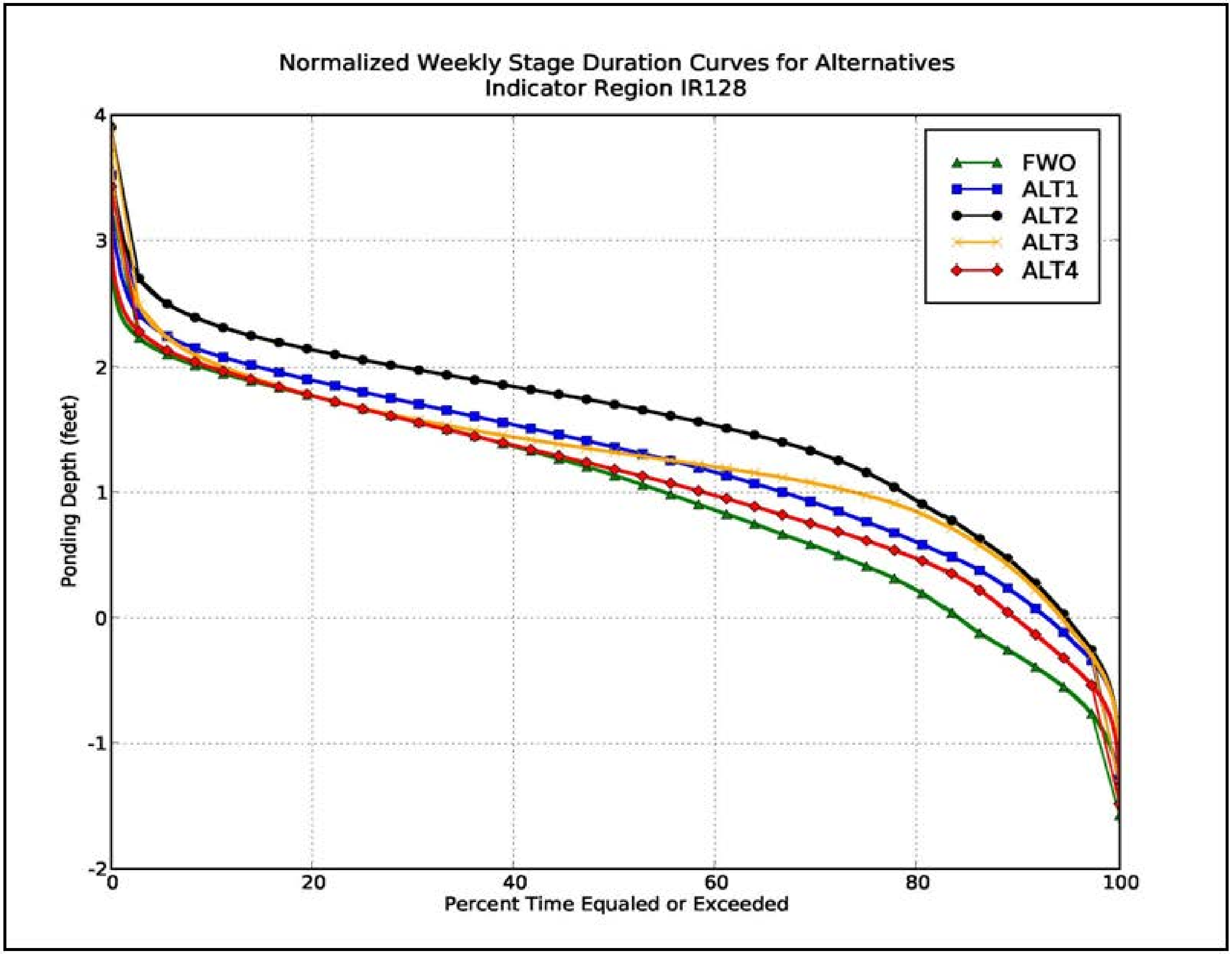


Figure G-18. Normalized Weekly Stage Duration Curve for Indicator Region 128 for Alternatives 1-4

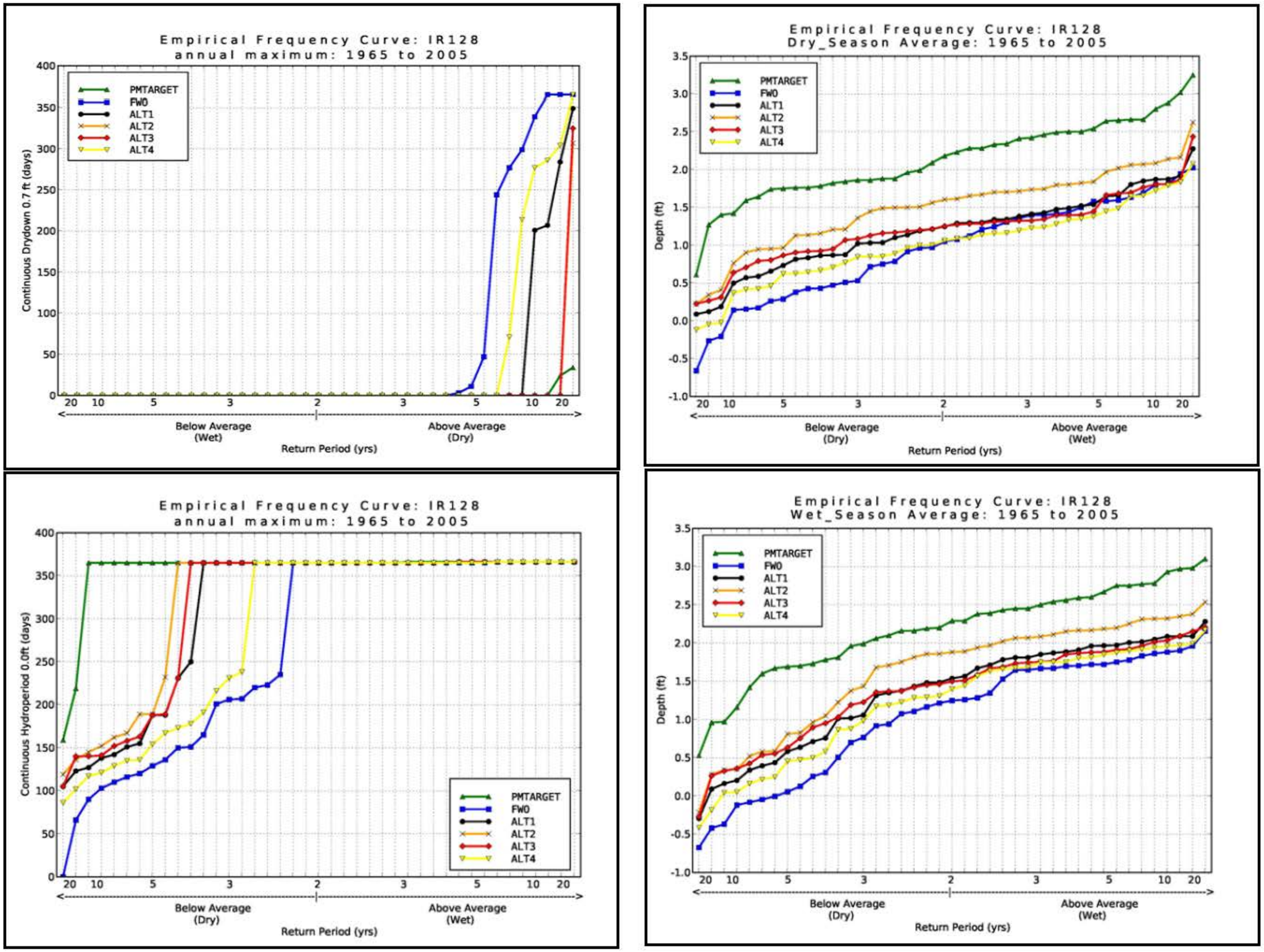


Figure G-19. Slough Vegetation Empirical Frequency Curves Indicator Region 128 for Alternatives 1-4

Observed patterns of hydrology can best be explained by the current topography within WCA 3B and the influence of adjacent canal stages. Water stages and depths in WCA 3B are typically much lower than water stages and depths in WCA 3A due to limited surface water inflows into WCA 3B and the reduction of seepage from WCA 3A to WCA 3B due to the design of the L-67 canal and levee system. Water levels in WCA 3B are affected by seepage losses to the east towards the L-30 borrow canal and to the south towards the L-29 canal. Stages within the L-29 canal must be lower than those in the adjacent marsh in order for water to pass southward into ENP. Alternatives 4 allowed water to pass southward from WCA 3B into ENP as a result of the additional pump stations located on the L-29 and the removal of the L-29 levee west of where it intersects the Blue Shanty levee.

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 generated by Alternative 4. 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. Alternative 4 produced desirable depths within the flow-way. The flow-way generated by the Blue Shanty levee increased flows through western WCA 3B (**Figure G-20**) while maintaining protective water depths (*i.e.* a reduction in extreme high water depths or wet season highs greater than 2 feet) in eastern WCA 3B (**Figure G-18**). Alternative 4 also best achieved the goal of re-establishing hydrologic and ecologic connectivity of WCA 3A, WCA 3B, and ENP by degrading the L-67 C and L-29 levees west of the Blue Shanty levee. Long, continuous and uninterrupted patterns of sheetflow from north to south are a defining characteristic of the Everglades. Overland flow vectors for Alternative 4 were oriented in a north to south direction within the flow-way created by the Blue Shanty levee.

Implementation of the Alternatives 1-4 improved inundation patterns within WCA 3B by re-hydrating much of the area. Implementation of Alternatives 1-4 would achieve 64-69% of the target HUs for Zone 3B (**Table G-13**). The FWO would achieve 57% of the target HUs (**Table G-13**).

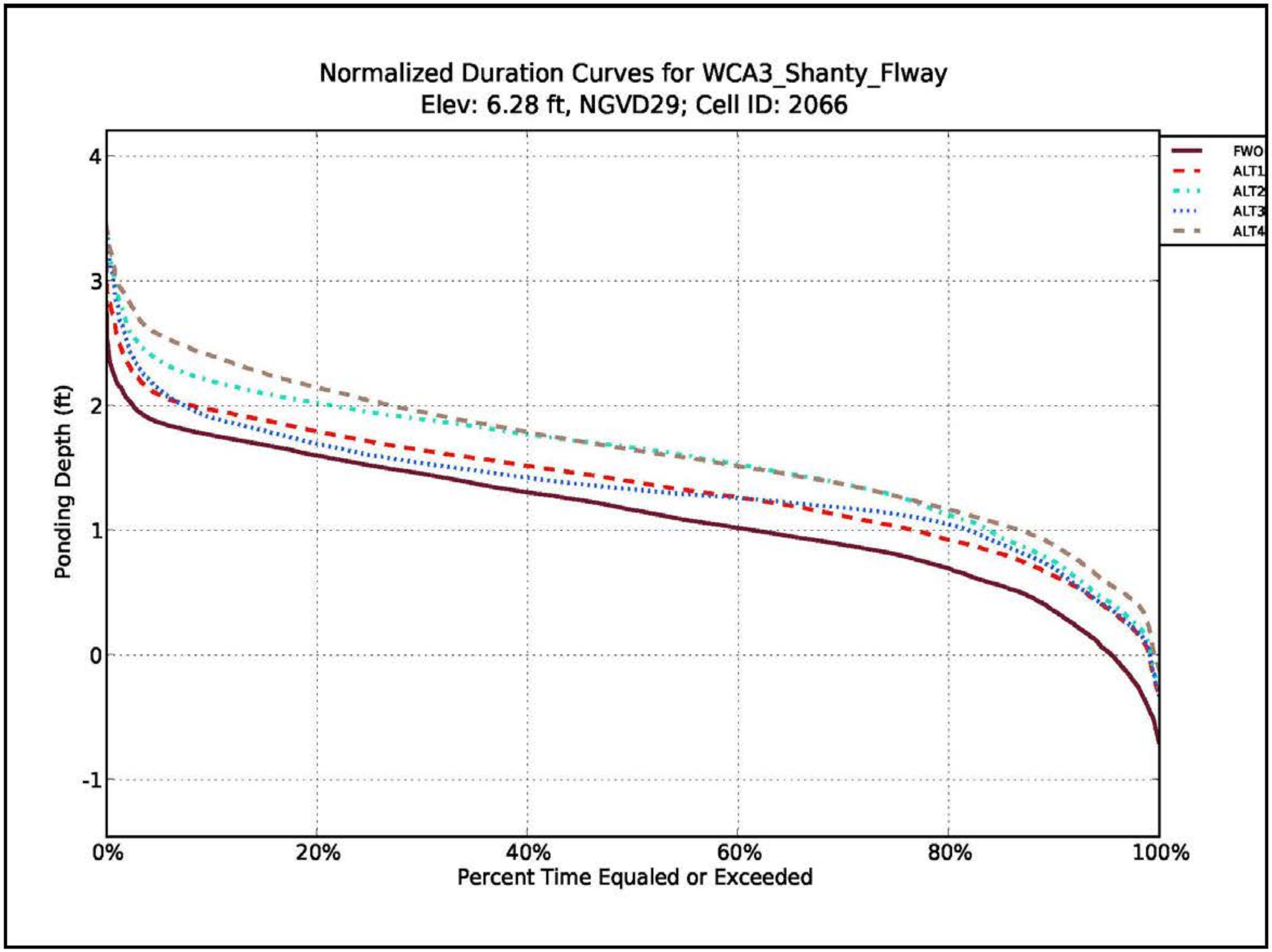


Figure G-20. Normalized Weekly Stage Duration Curve for Gage in Blue Shanty Flow-Way for Alternatives 1-4

G.2.2.4 ENP (Zones ENP-N, ENP-S, ENP-SE) (Alternatives 1-4)

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 (i.e. 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.

The ECB scored better in terms of meeting the desired performance measure targets relative to the FWO within northern ENP (Zone ENP-N) (**Table G-14**). The FWO generally produced slightly reduced depths within northern ENP during normal to dry conditions. The FWO performed slightly better relative to the ECB for portions of southern and southeastern ENP (Zone ENP-S and ENP-SE) (**Table G-15**) and (**Table G-16**).

Alternatives 1-4 improved hydrologic conditions in northern and southern ENP (Zones ENP-N and ENP-S) in comparison to the FWO by significantly increasing depths and resulting hydroperiods in NESRS (**Table G-14**, and **Table G-15**). Alternatives 1-4 scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability. Alternatives 1-4 also consistently improved the number and duration of dry events in NESRS in comparison to the FWO. Scores for these performance measures generally ranged from 68 to 100. Alternatives 1-4 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing of sheetflow. Scores for these performance measures ranged from 18 to 75. Alternatives 1-4 performed similarly to the FWO in southeastern ENP (Zone ENP-SE) (**Table G-16**). Performance measure scores for slough vegetation were notably low.

Table G-14. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northern ENP (Zone ENP-N) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	70	68	97	95	98	97
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	19	21	18	27	32	32
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	35	36	33	29	27
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	50	46	60	59	59	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	52	50	95	91	96	95
4.1	Number and Duration of Dry Events -- Number	68	60	90	93	95	95
4.2	Number and Duration of Dry Events -- Duration	18	26	100	100	100	100
4.3	Number and Duration of Dry Events -- PPOR	1	2	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	59	53	90	90	92	92
5.2	Slough Vegetation Suitability -- Dry down	69	69	98	99	99	100
5.3	Slough Vegetation Suitability -- Dry Season Depth	24	23	63	61	66	65
5.4	Slough Vegetation Suitability -- Wet Season Depth	15	12	74	72	75	74
	Percentage of Target HU (HSI x 100)	**46**	**44**	**82**	**81**	**83**	**82**

Table G-15. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern ENP (Zone ENP-S) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	66	65	83	83	88	92
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	30	35	52	53	57	57
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	53	51	77	77	84	89
4.1	Number and Duration of Dry Events -- Number	61	62	73	72	75	78
4.2	Number and Duration of Dry Events -- Duration	74	75	93	91	88	100
4.3	Number and Duration of Dry Events -- PPOR	51	52	84	82	73	100
5.1	Slough Vegetation Suitability -- Hydroperiod	58	58	68	68	70	75
5.2	Slough Vegetation Suitability -- Dry down	82	86	96	96	96	96
5.3	Slough Vegetation Suitability -- Dry Season Depth	31	32	40	40	43	44
5.4	Slough Vegetation Suitability -- Wet Season Depth	26	24	37	36	39	41
	Percentage of Target HU (HSI x 100)	**52**	**53**	**71**	**71**	**74**	**79**

Table G-16. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southeastern ENP (Zone ENP-SE) for Alternatives 1-4

Metric #	Performance Measure Metric	ECB	FWO	ALT1	ALT2	ALT3	ALT4
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	13	20	24	24	24	24
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	48	48	49	49	49	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	14	11	14	14	18	15
5.2	Slough Vegetation Suitability -- Dry down	5	4	17	7	13	17
5.3	Slough Vegetation Suitability -- Dry Season Depth	1	0	1	1	1	1
5.4	Slough Vegetation Suitability -- Wet Season Depth	4	4	5	5	5	5
	Percentage of Target HU (HSI x 100)	**59**	**60**	**61**	**61**	**61**	**62**

Performance for Alternatives 1-4 was similar in northern ENP (Zone ENP-N). Alternatives 1-4 produced significantly higher depths than the FWO as depicted by the normalized weekly stage duration curve for IR 129 (**Figure G-21**); an example IR for northern ENP (Zone ENP-N). Alternatives 1-4 significantly increased depths by 0.7 to 1.0 ft under all hydrologic conditions. **Figure G-22** depicts the average annual hydroperiod distribution for the period of record (1965-2005) in ENP. NESRS is inundated on average for 300 to 330 days per year in the FWO and in some locations 240 to 300 days per year. Alternatives 1-4 improve hydroperiods in NESRS by extending periods of inundation on average to 330 to 365 days per year.

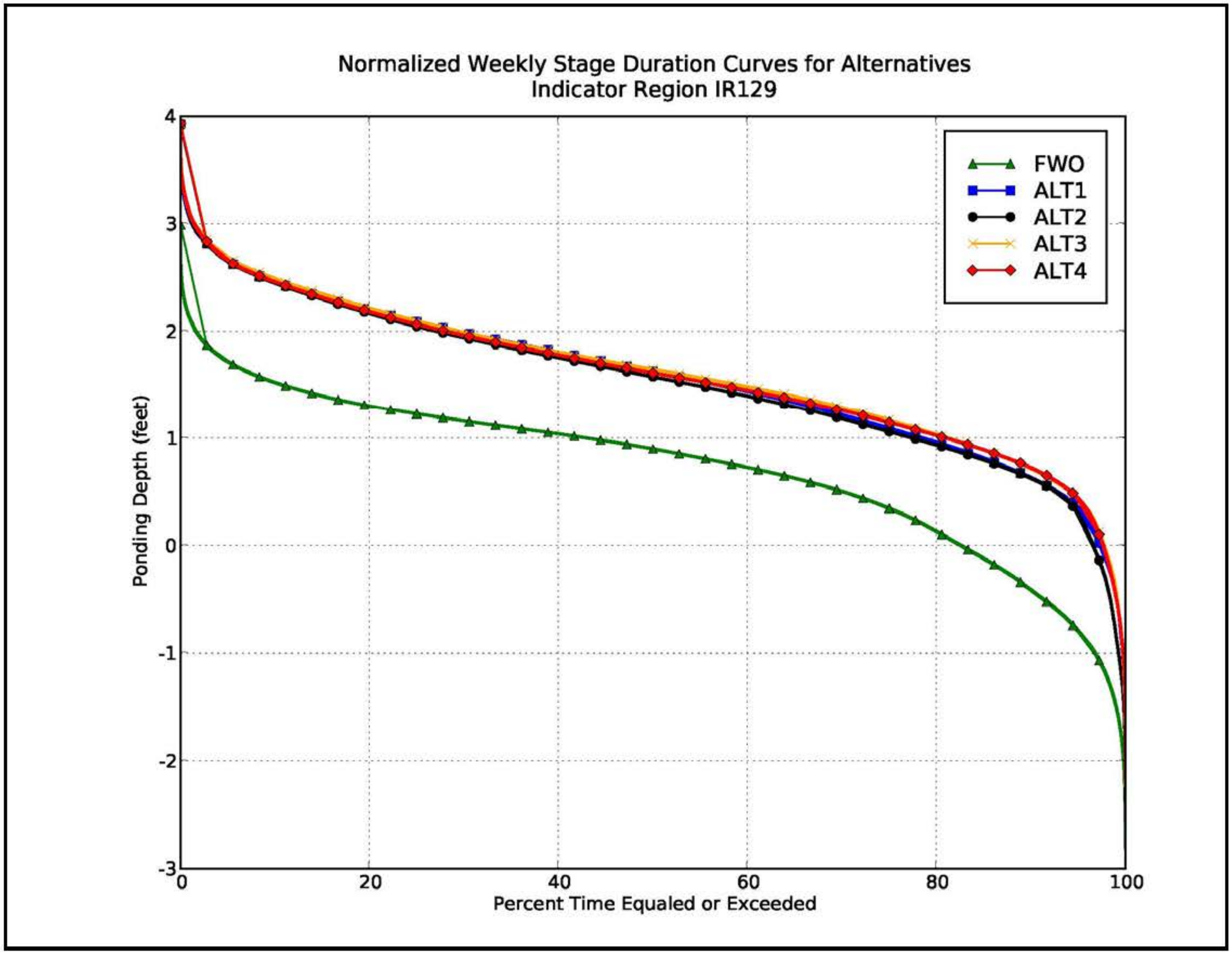


Figure G-21. Normalized Weekly Stage Duration Curve for Indicator Region 129 for Alternatives 1-4

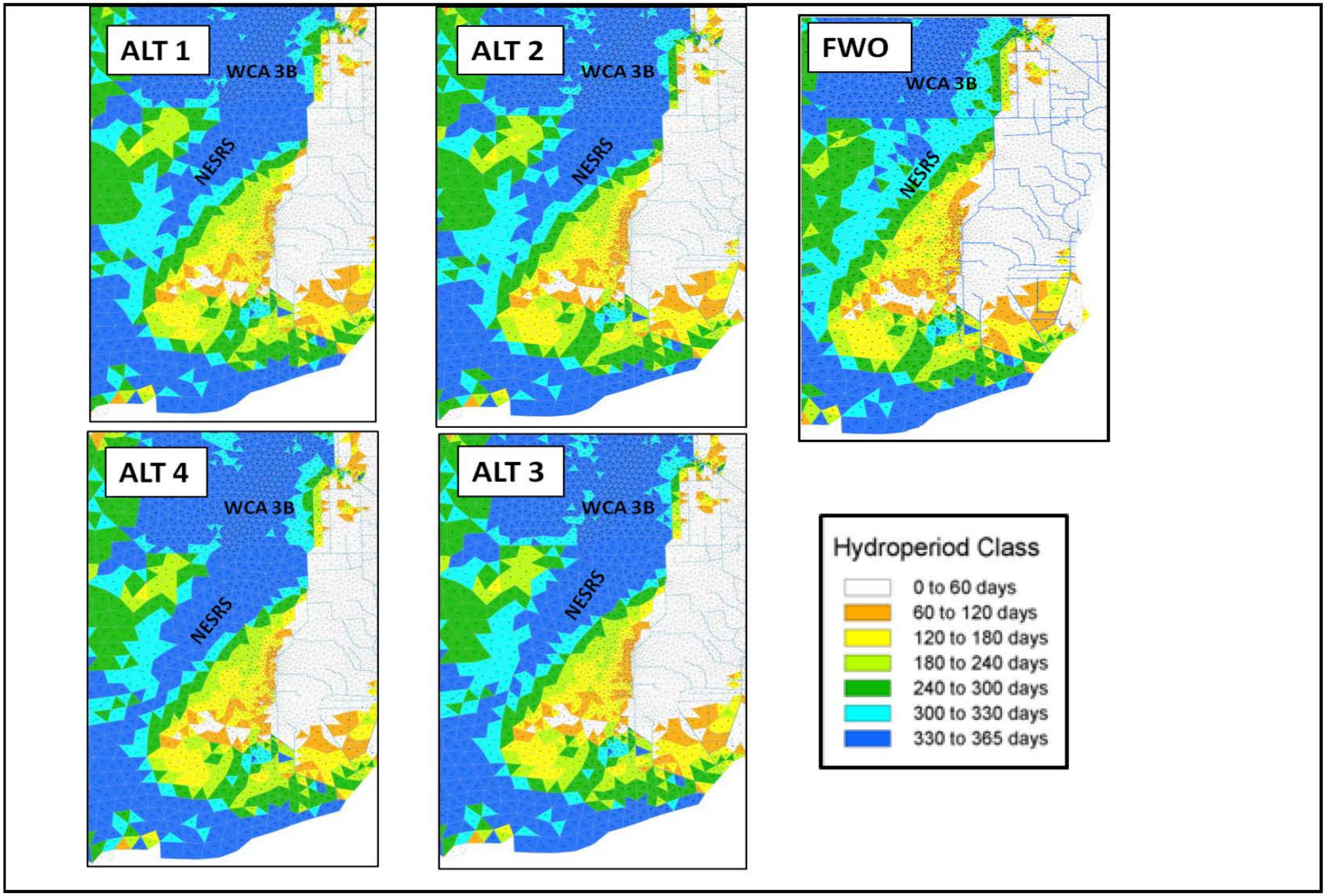


Figure G-22. Average Annual Hydroperiod Distribution for the Period of Record (1965-2005) for Alternatives 1-4

Differences in performance occurred primarily in southern ENP (Zone ENP-S). Performance for Alternatives 1-4 in southern ENP is contradictory to alternative performance in WCA 3B where Alternatives 3 and 4 performed poorly in comparison to Alternatives 1 and 2. Within southern ENP, Alternatives 3 and 4 produced slightly higher depths as depicted by the normalized weekly stage duration curve for IR 130 (**Figure G-23**); an example IR for southern ENP (Zone ENP-S). Alternative 4 produced slightly higher depths than Alternative 3. Within southern ENP, Alternative 4 produced significantly higher performance measure scores by approximately 10 points relative to Alternatives 1, 2, and 3.

Alternative 4 generally produced improved inundation patterns in southern ENP. Indicator region 130 was inundated for 96% of the period of record for Alternative 4; a 9% increase in inundation duration relative to the FWO. Alternative 3 inundated this location for 95% of the period of record. Alternatives 1-2 inundated this location for 93% of the period of record. Alternative 4 reduced drought intensity at IR 130 over the period of record by 676 ft-days relative to the FWO. Alternatives 3, 2, and 1 provided a reduction of 558, 477, and 456 ft-days over the period of record at this location respectively. Alternative 4 improved the number and duration of dry events in NESRS relative to the remaining alternatives at several of the IRs in Zone ENP-S (**Table G-17**). Improved inundation patterns in southern ENP resulted in better suitability for slough vegetation for Alternative 4 (**Figure G-24**). Patterns of performance for Alternatives 1-4 were similar at IRs 131 and 132; however differences between alternatives were less notable at IR 132 which is located farther from the L-29 Levee. Seepage management features associated with these alternatives may have influenced improved hydrologic conditions in southern ENP by reducing the amount of water flowing east. Both Alternatives 3 and 4 contain a partial seepage barrier wall spanning 5 miles south of Tamiami Trail along L-31 N.

Efforts to provide flood control and water supply for the LEC have resulted in over-drying and adverse ecological effects in eastern portions of ENP. Hydrology in northern ENP will be significantly affected by the implementation of Alternatives 1-4. Implementation of the Alternatives 1-4 would achieve 81-83% of the target HUs for Zone ENP-N (**Table G-14**) and 71-79% of the target HUs for Zone ENP-S (**Table G-15**). The FWO would achieve 44% of the target HUs for Zone ENP-N and 53% for Zone ENP-S (**Table G-14** and **Table G-15**).

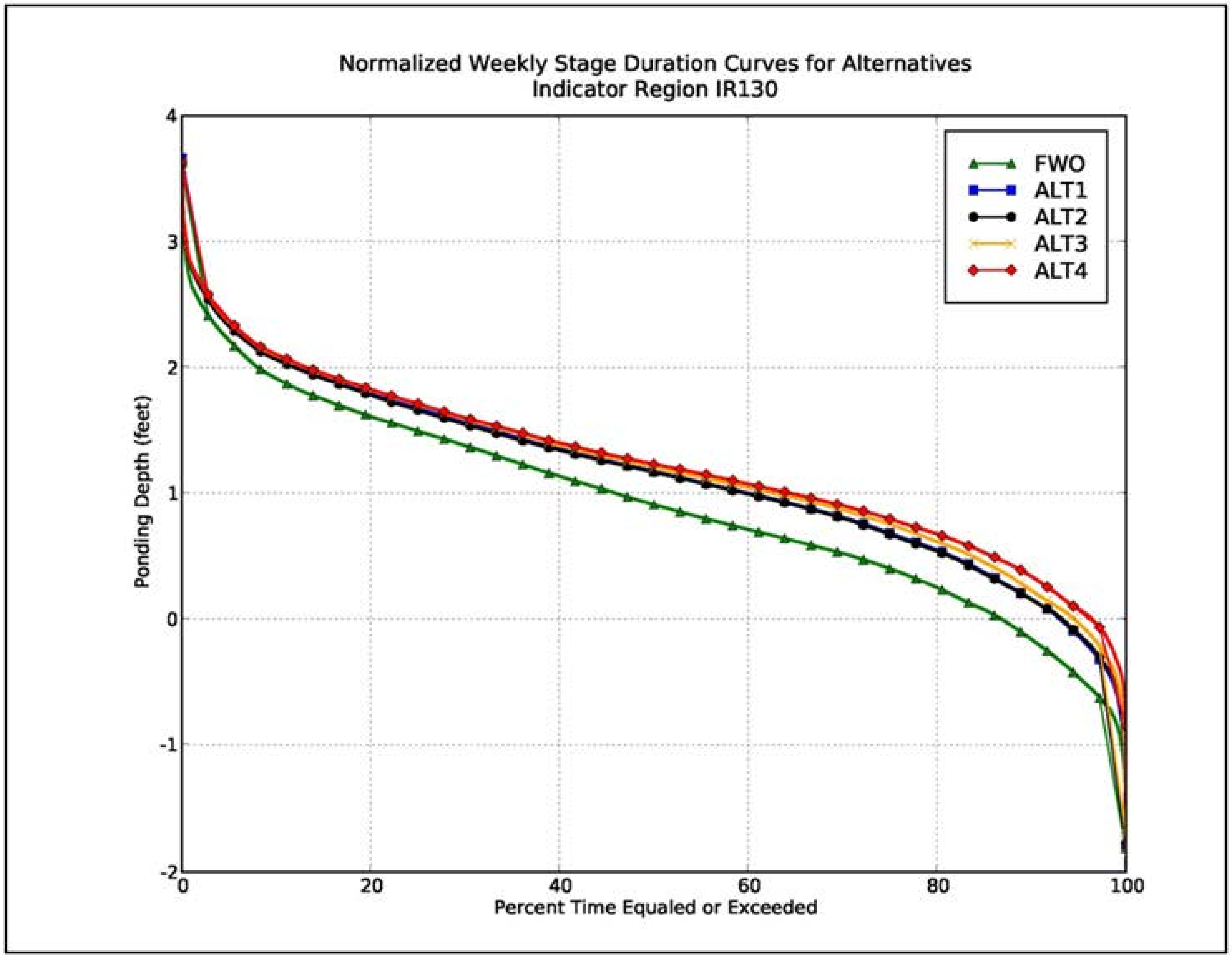


Figure G-23. Normalized Weekly Stage Duration Curve for Indicator Region 130 for Alternatives 1-4

Table G-17. Number and Duration of Dry Events in Northeast Shark River Slough for Alternatives 1-4 (Raw Performance Measure Scores)

Zone	Indicator Region	Metric	FWO	ALT1	ALT2	ALT3	ALT4
Zone ENP-N	129	Number	18	6	5	4	4
		Average Duration (Weeks)	20	8	7	7	6
Zone ENP-S	130	Number	16	11	10	8	7
		Average Duration (Weeks)	17	14	15	16	9
	131	Number	20	15	16	14	14
		Average Duration (Weeks)	16	14	13	14	12
	132	Number	22	18	20	21	19
		Average Duration (Weeks)	12	13	12	11	12

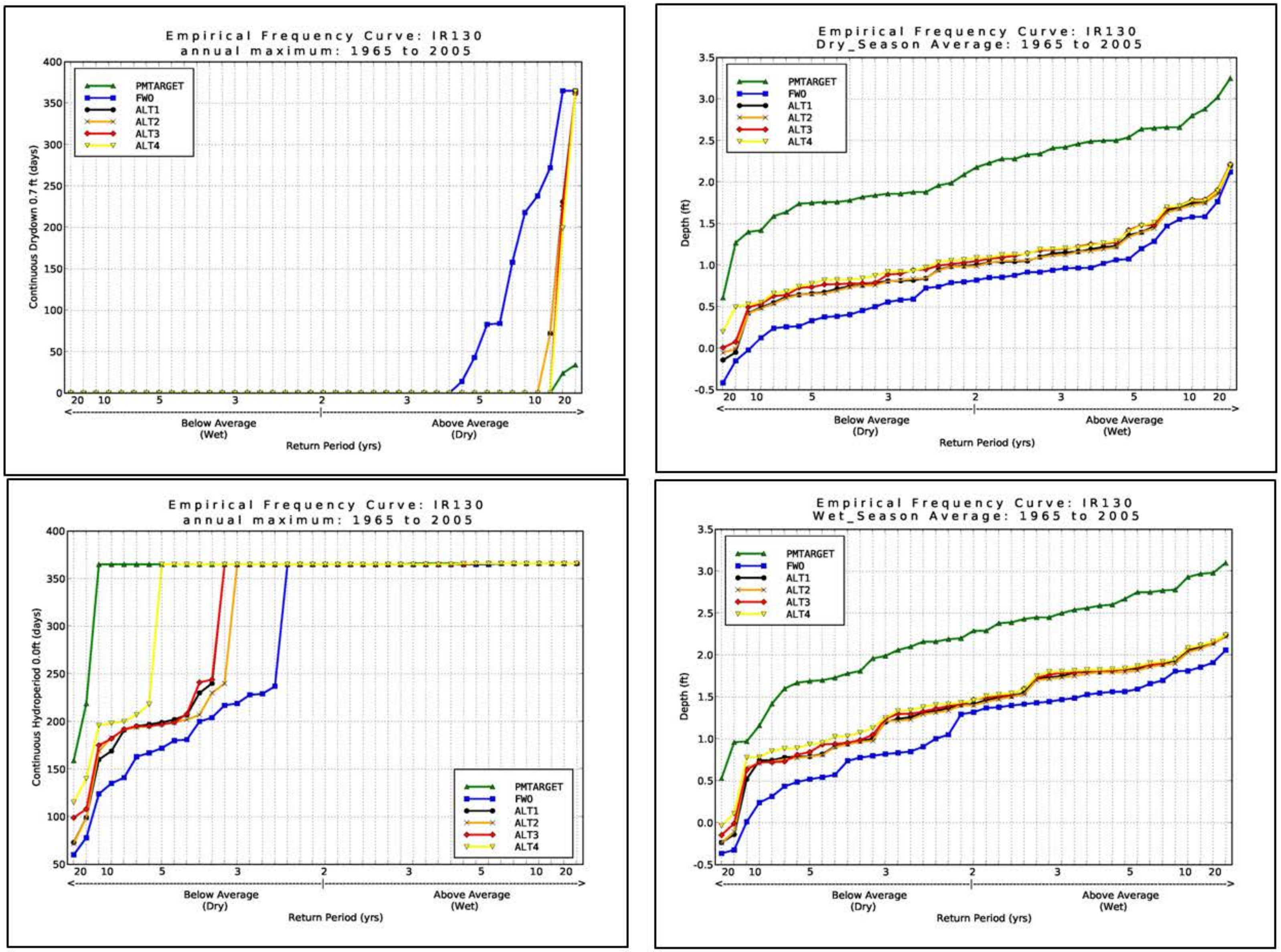


Figure G-24. Slough Vegetation Empirical Frequency Curves Indicator Region 130 for Alternatives 1-4

G.2.3 Florida Bay (Alternatives 1-4)

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.

In Florida Bay, the ECB scored better in terms of meeting the desired performance measure targets relative to the FWO (**Table G-18**). Compared to the ECB, combined average annual overland flows from southern ENP to Florida Bay at Transect 27 are decreased by 8,000 acre-feet (ac-ft) under the FWO. Transect 27 is used to measure southward flow in central SRS. Transect 23 is used to measure southward flow in Taylor Slough. Compared to the ECB, combined average annual overland flows from Taylor Slough at Transect 23 are decreased by 14,000 ac-ft under the FWO.

Alternatives 1-4 improved hydrologic conditions in Florida Bay in comparison to the FWO by significantly increasing overland flows. Water flowing through 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 1-4 provided increased flows within central SRS in comparison to the FWO with annual flow increases above the FWO ranging from 262,000 ac-ft on average per year for Alternative 4 to 192,000 ac-ft on average per year for Alternative 2 (**Figure G-25**). Alternatives 1-4 provided increased flows within Taylor Slough in comparison to the FWO; however, increases in flow were not as significant as increases in observed flows in SRS. Annual flow increases above the FWO in Taylor Slough ranged from 7,000 ac-ft on average per year for Alternatives 1, and 2 to 9,000 and 10,000 ac-ft per year for Alternatives 3 and 4 respectively. Improved hydrologic conditions in central SRS directly resulted in improved salinity conditions in Florida Bay.

Performance of Alternatives 1-4 in Florida Bay was measured by evaluating improvements in salinity conditions in both the wet (June through November) and dry season (December though May). The regime overlap metric compares the distribution of salinities in the paleo-adjusted NSM record (target) to the predicted distribution (CEPP 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 CEPP 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 modest relative to the differences of the alternatives to the FWO. Alternatives 1-4 scored the highest in terms of meeting the desired targets during the wet season. Improvements in salinity conditions relative to the FWO were of greater magnitude in the east central, central, south, and west Florida Bay zones. Alternative 4 scored the highest in all Florida Bay zones.

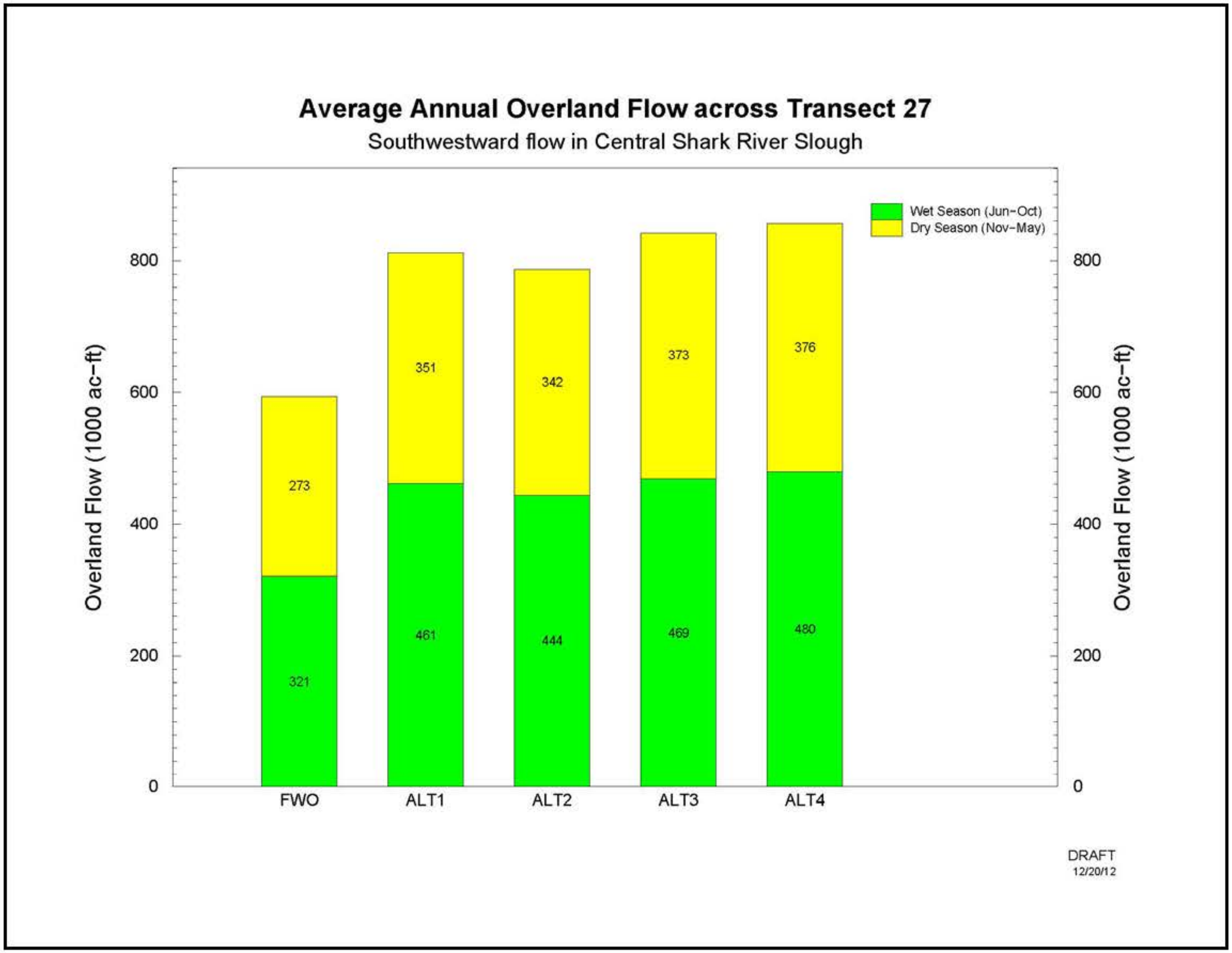


Figure G-25. Average Annual Overland Flow (1000 ac-ft) Across Transect 27 for Alternatives 1-4

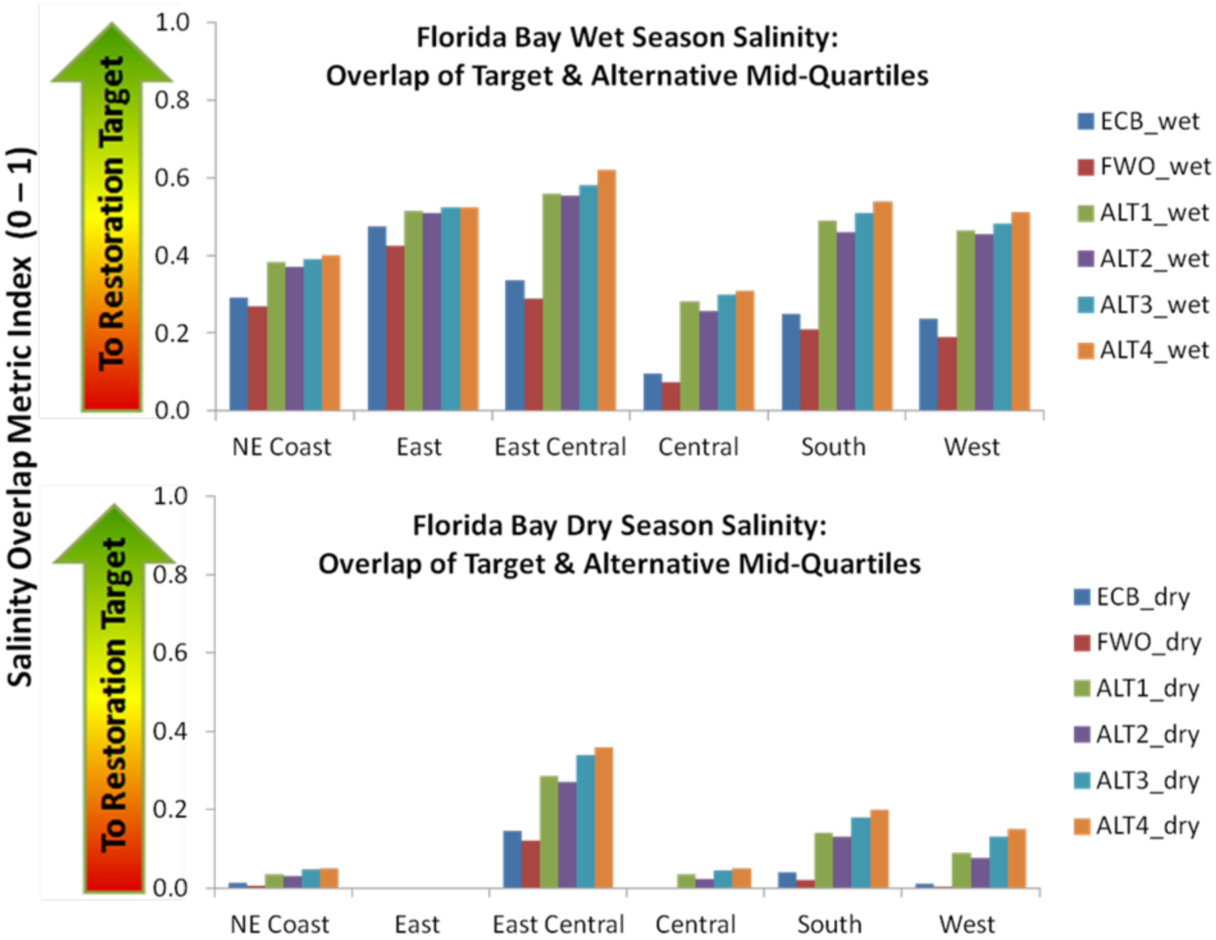


Figure G-26. Wet Season and Dry Season Regime Overlap Performance Measure for Florida Bay for Alternatives 1-4. Salinity Overlap Index (Dry Season) Equivalent to Zero for East Florida Bay.

The high salinity metric focuses on the frequency of unnatural and harmful high salinity conditions. 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 (See **Section G.1.5.3.2**). **Figure G-27** depicts the results for this performance measure for the wet season and dry season. Similar patterns were observed to that of the regime overlap performance measure. Differences between Alternatives 1-4 were modest relative to the differences of the alternatives to the FWO. Alternatives 1-4 scored the highest in terms of meeting the desired targets during the wet season. Improvements in salinity conditions relative to the FWO were of greater magnitude in the east central, central, south, and west Florida Bay zones. Alternative 4 scored the highest in all Florida Bay zones.

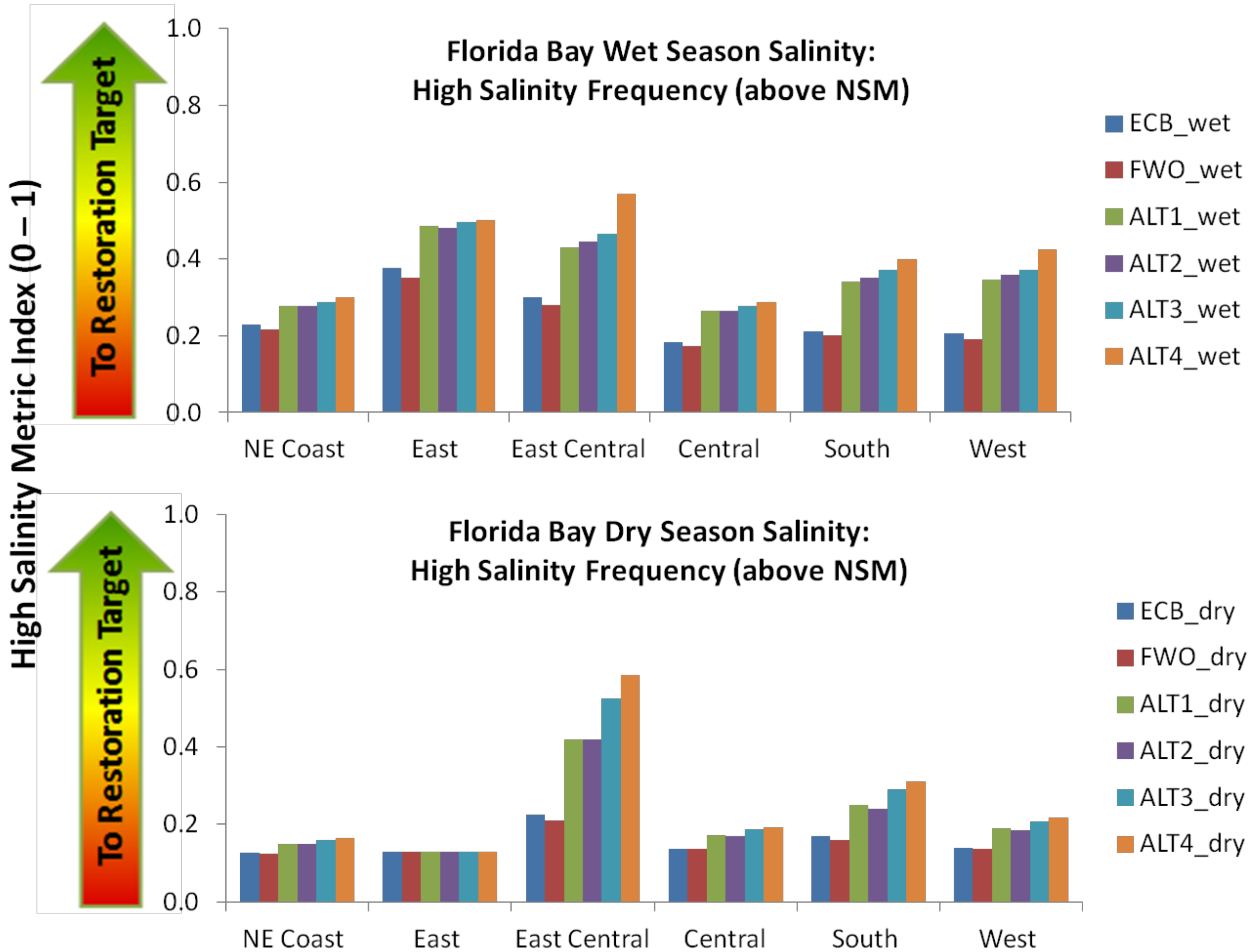


Figure G-27. High Salinity Performance Measure for Florida Bay for Alternatives 1-4

Table G-18 provides the percentage of target HUs resulting from the performance measure scores for each zone in Florida Bay. Alternative 4 is consistently the best performer, followed by Alternatives 3, 1 and 2. This pattern is consistent with alternative performance in ENP. While the mean salinities for all alternatives are still higher than target conditions, implementation of Alternatives 1-4 brings salinities in Florida Bay closer to target conditions CEPP does not reconnect SRS to Taylor Slough or Florida Bay as it was historically, but it does allow additional surface water to flow southeastward around Mahogany Hammock towards West Lake, the Lungs, and Garfield Bight helping to negate the harmful buildup of hypersalinity. Similarly, the improved timing and volume of water flowing southwest out of the Shark River, plumes into the coastal zone water and bends southeastward to enter Florida Bay from the west, causing a slight, but perceptual decline in central basin salinities, especially around Whipray Basin, where hypersaline conditions can be extreme. Given the large area of Florida Bay, even a small decrease in salinity can translate into a substantial increase in improved Habitat Units. Habitat quantity and quality (in this case, seagrass habitat) are expected to improve with improvements in salinity. Likewise, animal populations (particularly fish) that depend on this habitat are expected to improve because of improved habitat and decreased salinity stress. Additional freshwater flows of 500,000 to 700,000 ac-ft per year, annual average, may be necessary to bring Florida Bay to full restoration.

Table G-18. Percentage of Target HU (HSI x 100) for Florida Bay for Alternatives 1-4

Florida Bay Zone	ECB	FWO	ALT1	ALT2	ALT3	ALT4
Florida Bay West	15	13	27	27	30	33
Florida Bay Central	10	10	19	18	21	21
Florida Bay South	17	15	31	30	34	36
Florida Bay East Central	25	23	42	42	48	53
Florida Bay North Bay	17	16	21	21	22	23
Florida Bay East	25	23	28	28	29	29

G.2.4 Conclusions (Alternatives 1-4)

Alternatives 1-4 provided improvements in hydrology relative to the FWO in each region of the project area. **Table G-19** displays HU lift for Alternatives 1-4. Alternative performance in the Northern Estuaries was equivalent between Alternatives 1-4 as project components did not differ between alternatives within that region of the project area. Alternative 4 provided the greatest project benefits relative to the FWO project condition for WCA 3, ENP, and Florida Bay while Alternative 2 provided the least. Alternatives 3 and 1 provided more project benefits than Alternative 2. Alternative 3 provided more project benefits than Alternative 1.

Table G-19. Habitat Unit Lift Results for Alternatives 1-4

Project Region (Zone)	ALT1*	ALT2*	ALT3*	ALT4*
Caloosahatchee Estuary (CE-1)	4,968	4,968	4,968	4,968
St Lucie Estuary (SE-1)	2,399	2,399	2,399	2,399
Total Northern Estuaries	**7,367**	**7,367**	**7,367**	**7,367**
WCA 3A Northeast (3A-NE)	66,677	66,677	66,677	66,677
WCA 3A Miami Canal (3A-MC)	30,501	29,719	28,937	29,719
WCA 3A Northwest (3A-NW)	24,636	23,228	23,228	23,228
WCA 3A Central (3A-C)	4,117	4,117	4,117	4,117
WCA 3A South (3A-S)	0	-825	-825	0
WCA 3B (3B)	9,426	10,283	8,569	5,998
ENP North (ENP-N)	47,547	46,296	48,798	47,547
ENP South (ENP-S)	42,946	42,946	50,104	62,034
ENP South East (ENP-SE)	1,351	1,351	1,351	2,702
Total WCA 3 and ENP	**227,201**	**223,792**	**230,956**	**242,022**
Florida Bay West (FB-W)	22,113	22,113	26,852	31,590
Florida Bay Central (FB-C)	7,384	6,564	9,025	9,025
Florida Bay South (FB-S)	15,637	14,659	18,569	20,523
Florida Bay East Central (FB-EC)	16,708	16,708	21,984	26,381
Florida Bay North Bay (FB-NB)	633	633	760	887
Florida Bay East (FB-E)	1,888	1,888	2,265	2,265
Total Florida Bay	**64,363**	**62,565**	**79,455**	**90,671**
Total All Regions	**298,931**	**293,724**	**317,778**	**340,060**

* HU lift values for ALT 1 through ALT 4 represent those calculated in the year 2072.

G.2.5 Northern Estuaries (Alternatives 4R and 4R2)

Modeling results of Alternatives 4R and 4R2 indicate a reduction in the number of high discharge events from Lake Okeechobee to the Northern Estuaries (**Table G-20** and **Table G-21**). Within the Caloosahatchee Estuary, the number of times mean monthly flows greater than 2,800 cfs were not met decreased from 81 in the FWO to 70 with implementation of Alternatives 4R and 4R2 (**Figure G-28**). 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 65 in the FWO to 37 for Alternative 4R and 36 for Alternative 4R2 (**Figure G-29**). Alternatives 4R and 4R2 decreased the number of low discharge events to the Caloosahatchee Estuary in comparison to the FWO. The number of low discharge events to the Caloosahatchee Estuary decreased from 27 in the FWO to 24 and 23 for Alternatives 4R and 4R2 respectively. Alternatives 4R and 4R2 also decreased the number of low discharge events to the St. Lucie Estuary relative to the FWO. Alternative 4R improved the number of low discharge events to 90 and Alternative 4R2 to 65 (**Figure G-29**). Improvements in performance within the St. Lucie Estuary between Alternatives 4R and 4R2 can be attributed to operational refinements of the Indian River Lagoon-South Project. Operational refinements emphasized base flow through Ten Mile Creek. Better utilization of local basin water improved low flow conditions to the St. Lucie Estuary and allowed more water to be retained in Lake Okeechobee by back flowing water from the C-44 Reservoir to the Lake. Implementation of Alternatives 4R and 4R2 would achieve 55% of the target HUs for the Caloosahatchee Estuary and 34-55% of the target HUs for the St. Lucie Estuary (**Table G-20** and **Table G-21**). The FWO would achieve 48% of the target HUs for the Caloosahatchee Estuary and 16% for the St. Lucie Estuary (**Table G-20** and **Table G-21**). Implementation of the recommended plan provides an increment of the benefits envisioned in CERP and builds upon those achieved in the Northern Estuaries with implementation of other CERP projects (i.e. C-43 West Basin Storage Reservoir and Indian River Lagoon South Project).

Table G-20. Rescaled Performance Measure Scores (Zero to 100 Scale) for Caloosahatchee Estuary (Zone CE-1) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
6.1	Low Flow (< 450 cfs)	4	78	80	81
6.2	High Flow (>2800 cfs)	4	17	29	29
	Percentage of Target HU (HSI x 100)	**4**	**48**	**55**	**55**

Table G-21. Rescaled Performance Measure Scores (Zero-100 Scale) for St. Lucie Estuary (Zone SE-1) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
7.1	Low Flow (< 350 cfs)	14	9	12	52
7.2	High Flow (>2000 cfs)	14	22	56	57
	Percentage of Target HU (HSI x 100)	**14**	**16**	**34**	**55**

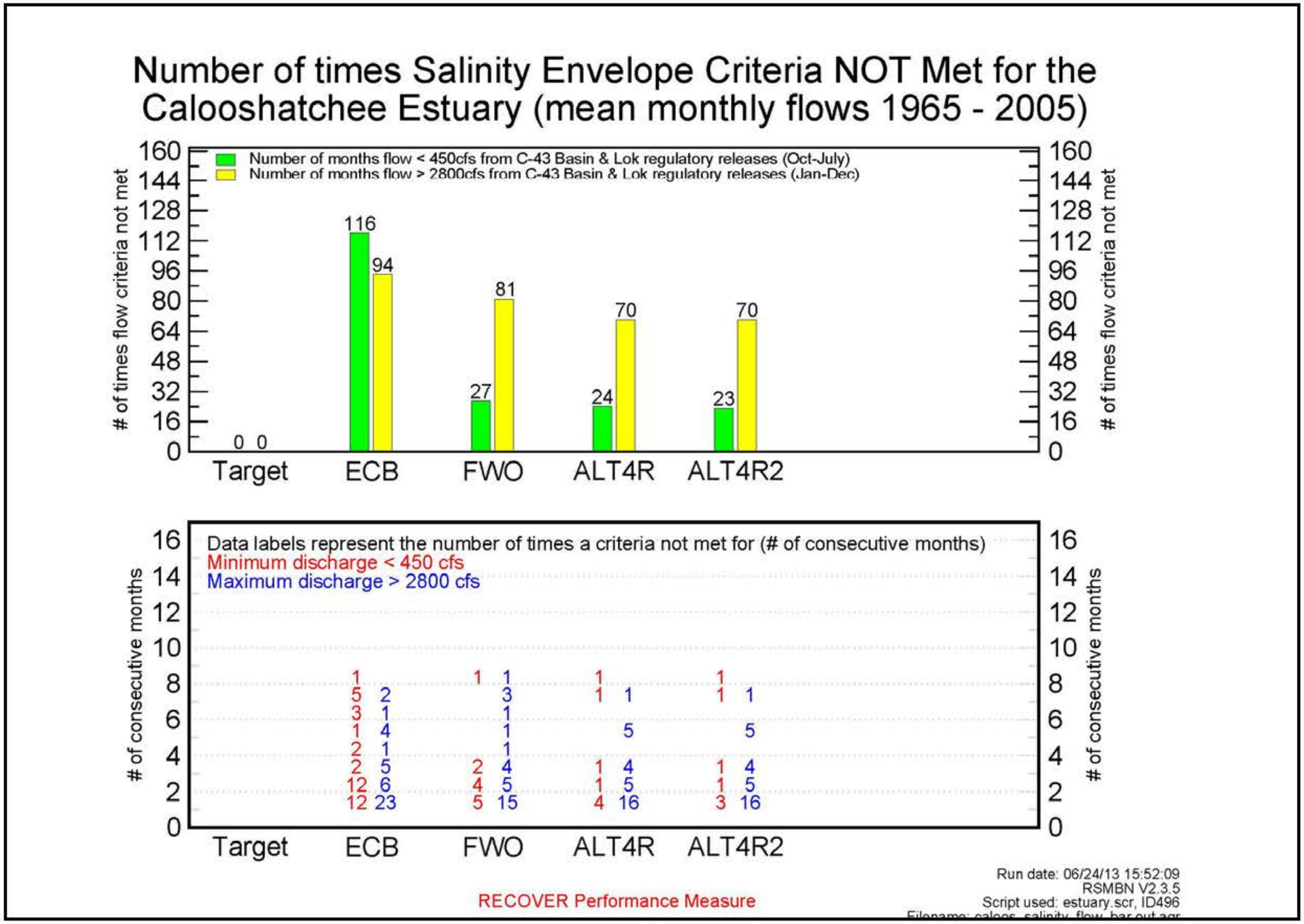


Figure G-28. Number of Times Salinity Criteria Not Met for the Caloosahatchee Estuary for Alternatives 4R and 4R2

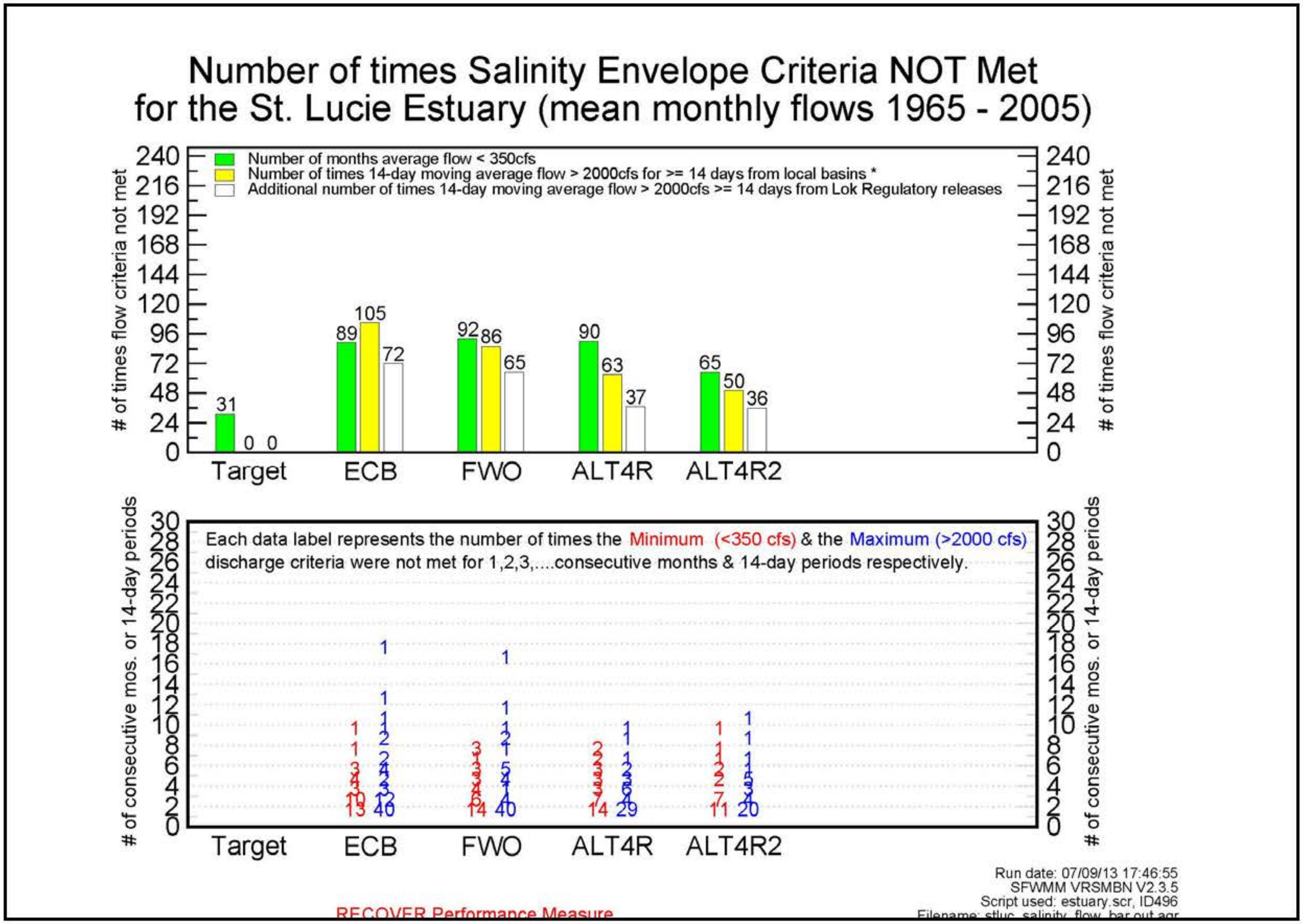


Figure G-29. Number of Times Salinity Criteria Not Met for the St. Lucie Estuary for Alternatives 4R and 4R2

G.2.6 WCA 3 and ENP (Alternatives 4R and 4R2)

G.2.6.1 Northern WCA 3A (Zones 3A-NW, 3A-MC, 3A-NE) (Alternatives 4R and 4R2)

Alternatives 4R and 4R2 improved hydrologic conditions in northern WCA 3A in comparison to the FWO by increasing depths and resulting hydroperiods within the area. Alternatives 4R and 4R2 scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability (**Table G-22**, **Table G-23**, and **Table G-24**). Pertaining to slough vegetation suitability, greater performance was noted with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events below 0.7 ft. Scores for these performance measures ranged from 66 to 97. Alternatives 4R and 4R2 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing and distribution of sheetflow. Scores for these performance measures ranged from 30 to 68.

Table G-22. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northwestern WCA 3A (Zone 3A NW) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	63	61	94	95
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	20	19	34	34
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	4	4	62	61
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	24	18	67	68
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	63	63	96	97
5.1	Slough Vegetation Suitability -- Hydroperiod	46	46	79	79
5.2	Slough Vegetation Suitability -- Dry down	51	48	85	85
5.3	Slough Vegetation Suitability -- Dry Season Depth	22	19	38	38
5.4	Slough Vegetation Suitability -- Wet Season Depth	22	20	46	46
	Percentage of Target HU (HSI x 100)	**44**	**43**	**77**	**77**

Table G-23. Rescaled Performance Measure Scores (Zero to 100 Scale) for Miami Canal (Zone 3A MC) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	55	45	89	88
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	18	17	32	32
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	4	4	62	61
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	28	23	62	62
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	52	44	75	75
5.1	Slough Vegetation Suitability -- Hydroperiod	42	35	73	73
5.2	Slough Vegetation Suitability -- Dry down	63	50	86	85
5.3	Slough Vegetation Suitability -- Dry Season Depth	37	32	50	49
5.4	Slough Vegetation Suitability -- Wet Season Depth	40	32	51	50
	Percentage of Target HU (HSI x 100)	**42**	**35**	**70**	**70**

Table G-24. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northeastern WCA 3A (Zone 3A NE) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	40	25	95	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	16	15	30	30
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	6	4	59	59
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	18	17	58	57
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	50	26	94	93
5.1	Slough Vegetation Suitability -- Hydroperiod	38	27	68	66
5.2	Slough Vegetation Suitability -- Dry down	58	51	84	82
5.3	Slough Vegetation Suitability -- Dry Season Depth	35	30	46	45
5.4	Slough Vegetation Suitability -- Wet Season Depth	30	26	42	41
	Percentage of Target HU (HSI x 100)	**36**	**24**	**75**	**74**

Slight differences occurred between zones within northern WCA 3A. Alternatives 4R and 4R2 scored the highest in terms of meeting the desired performance measure targets in northwestern WCA 3A (Zone 3A-NW) in comparison to northeastern WCA 3A (Zone 3A-NE) and in areas adjacent to the Miami Canal (Zone 3A-MC). Differences in hydrologic improvements within northern WCA 3A may be a direct consequence of the location at which inflows into northern WCA 3A are delivered. Alternatives 4R and 4R2 includes removal of the L-4 levee approximately 3 miles west of S-8. Inundation duration for Alternatives 4R and 4R2 ranged from 91% of the period of record to 96% of the period of record in northwestern WCA 3A (Zone 3A-NW) (**Table G-24**). Inundation duration for the FWO within this same region varied from 73% to 93% of the period of record (1965-2005) (**Table G-9**). Alternatives 4R and 4R2 generally produced higher depths within northwestern WCA 3A relative to the FWO as depicted by the normalized weekly stage duration curve for IR 114 (**Figure G-30**); an example IR for Zone 3A-NW. Depths were significantly increased on average by 0.6 to 0.8 ft relative to the FWO at this location. Improvements in depth of water below ground surface were also significant. Drought intensity for Alternatives 4R and 4R2 ranged from -450 ft-days below ground to -145 ft-days over the period of record (**Table G-25**) for Zone 3A-NW. Drought intensity for the FWO within this same region varied from -1431 ft days to -256 ft-days over the period of record (**Table G-10**). Improved inundation patterns in northwestern WCA 3A resulted in better suitability for slough vegetation for Alternatives 4R and 4R2 (**Figure G-31**). Ranges of inundation duration and drought intensity for northeastern WCA 3A (Zone 3A-NE) and in areas adjacent to the Miami Canal (Zone 3A-MC) are also shown in **Table G-25**. Slight reductions in performance within Zone 3A-NE between Alternatives 4R and 4R2 can be attributed to a change in the distribution of flows within northern WCA 3A from the L-6 diversion east to S-7 to address potential impacts to water depths in WCA 2B and Service Area 2 of the LEC. Alternative 4R2 produced slightly lower depths within northeastern WCA 3A (Zone 3A-NE) relative to Alternative 4R. Hydrology in all of northern WCA 3A would be significantly affected by the implementation of Alternatives 4R and 4R2. Implementation of Alternatives 4R and 4R2 would achieve 77% of the target HUs for Zone 3A-NW (**Table G-22**), 70% of the target HUs for Zone 3A-MC (**Table G-23**), and 74-75% of the target HUs for Zone 3A-NE (**Table G-24**).

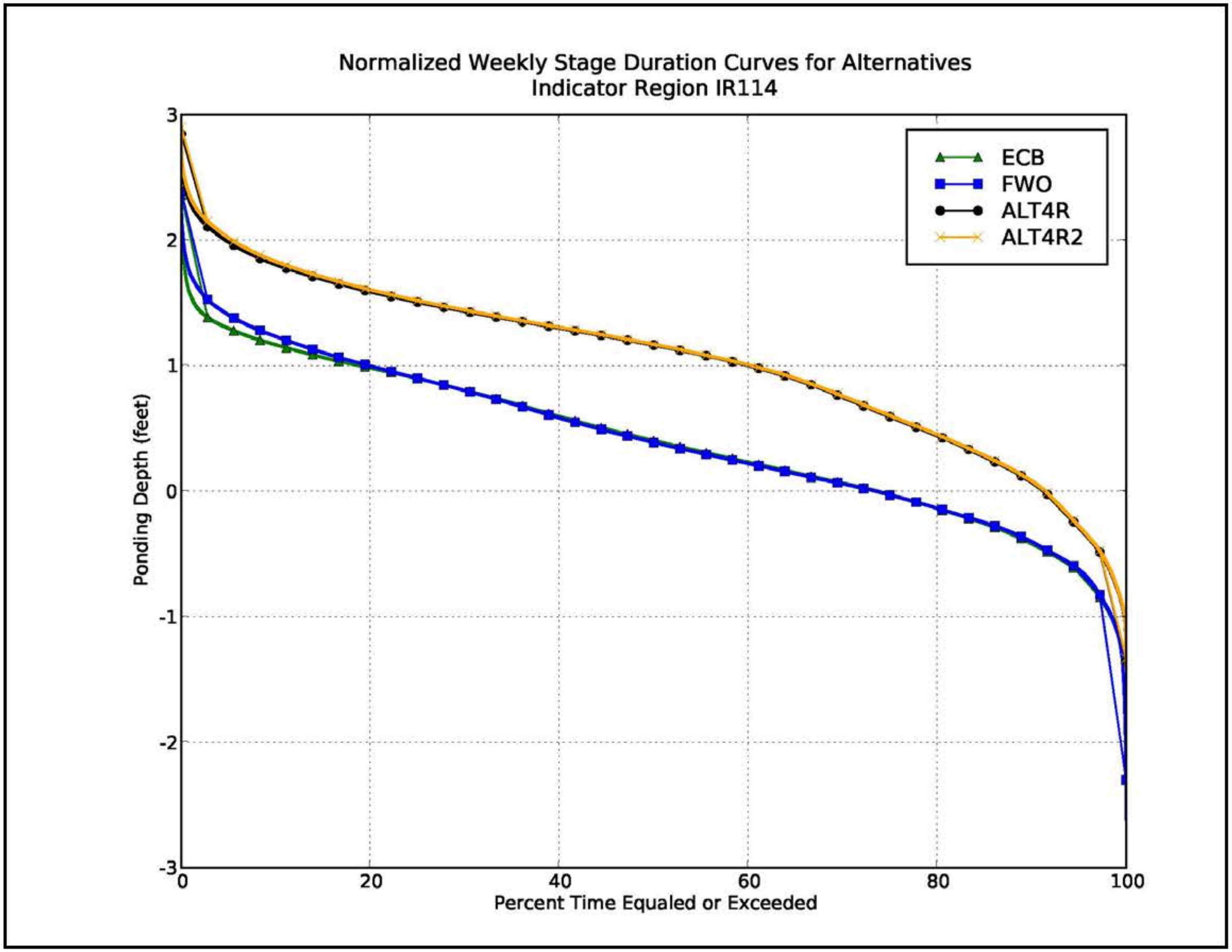
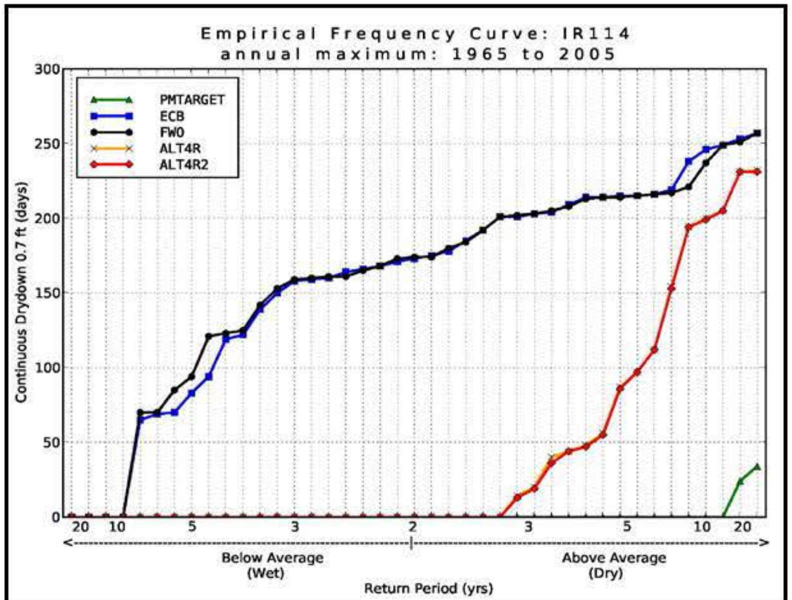
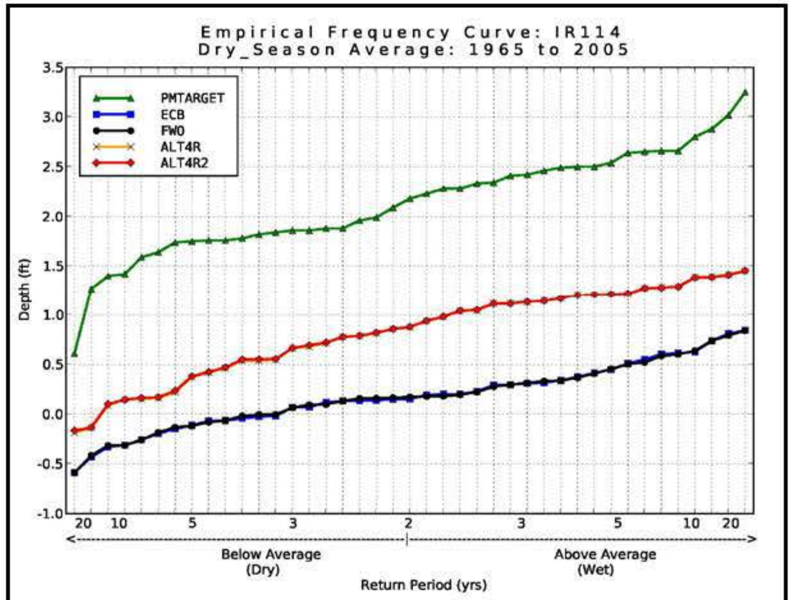
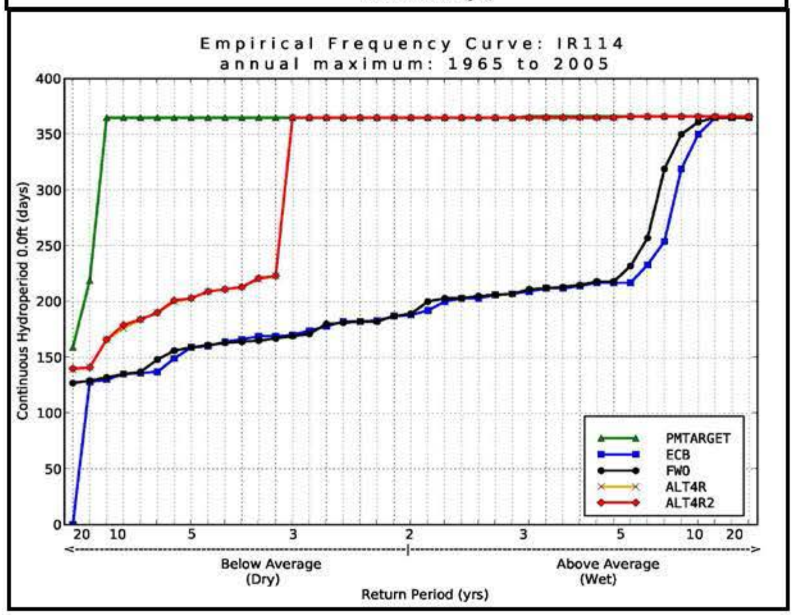


Figure G-30. Normalized Weekly Stage Duration Curve for Indicator Region 114 for Alternatives 4R and 4R2


Empirical Frequency Curve: IR114
annual maximum: 1965 to 2005
PMTARGET
ECB
FWO
ALT4R
ALT4R2
Continuous Drydown 0.7 ft (days)
Below Average (Wet)
Above Average (Dry)
Return Period (yrs)


Empirical Frequency Curve: IR114
Dry_Season Average: 1965 to 2005
PMTARGET
ECB
FWO
ALT4R
ALT4R2
Depth (ft)
Below Average (Dry)
Above Average (Wet)
Return Period (yrs)


Empirical Frequency Curve: IR114
annual maximum: 1965 to 2005
Continuous Hydroperiod 0.0ft (days)
PMTARGET
ECB
FWO
ALT4R
ALT4R2
Below Average (Dry)
Above Average (Wet)
Return Period (yrs)

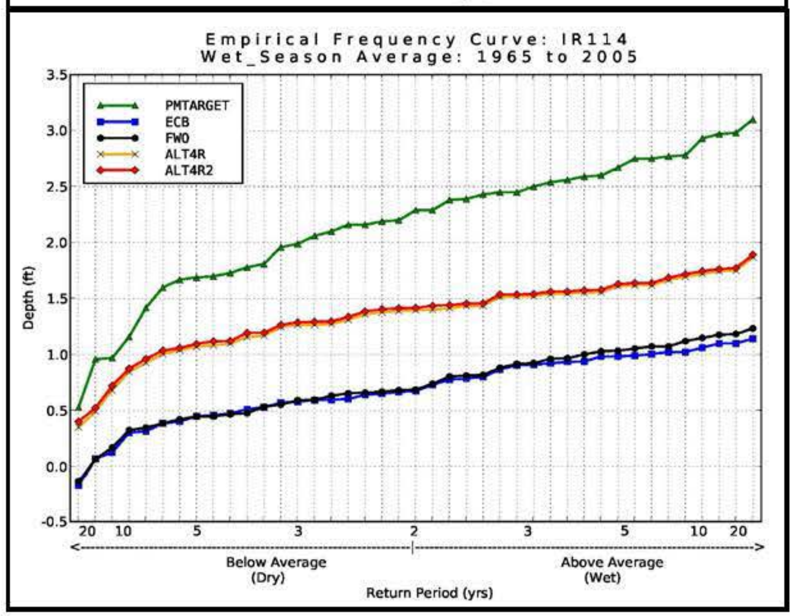

Empirical Frequency Curve: IR114
Wet_Season Average: 1965 to 2005
PMTARGET
ECB
FWO
ALT4R
ALT4R2
Depth (ft)
Below Average (Dry)
Above Average (Wet)
Return Period (yrs)

Figure G-31. Slough Vegetation Empirical Frequency Curves Indicator Region 114 for Alternatives 4R and 4R2

Table G-25. Percent Period of Record of Inundation Duration and Hydrologic Surrogate for Soil Oxidation (Water Depth Relative to Land Surface Elevation Ft-Days Below Ground) for Alternatives 4R and 4R2 (Raw Performance Measure Scores)

Zone	Indicator Region	PPOR of Inundation ALT4R	PPOR of Inundation ALT4R2	Cumulative Drought Intensity (ft-days) ALT4R	Cumulative Drought Intensity (ft-days) ALT4R2
Zone 3A-NW	IR 114	91	91	-450	-438
	IR 117	95	95	-248	-247
	IR 121	96	96	-147	-145
Zone 3A-MC	MC NE 1	93	93	-317	-360
	MC NE 2	95	95	-198	-227
	MC NW 1	93	93	-335	-380
	MC NW 2	90	90	-596	-624
	MC CE 1	92	92	-415	-443
	MC CE 2	87	87	-1530	-1525
	MC CW 1	92	92	-566	-578
	MC CW 2	94	94	-277	-276
	MC SE 1	91	91	-584	-570
	MC SE 2	88	88	-1490	-1430
	MC SW 1	91	91	-675	-657
	MC SW 2	93	93	-359	-355
Zone 3A-NE	IR 115	92	92	-370	-432
	IR 116	88	88	-633	-681
	IR118	88	87	-789	-819
	IR 119	92	92	-403	-384
	IR 190	90	89	-515	-552

G.2.6.2 Central and Southern WCA 3A (Zone 3A-C, 3A-S) (Alternatives 4R and 4R2)

In central WCA 3A, Alternatives 4R and 4R2 provided slight improvements in hydrologic conditions in comparison to the FWO (**Table G-26**). Alternatives 4R and 4R2 produced slightly higher depths than the FWO as depicted by the normalized weekly stage duration curve for IR 122 (**Figure G-32**); an example IR for Zone 3A-C. Increases in depth within central WCA 3A were not as significant as increases in observed depths relative to the FWO in northern WCA 3A. Depths were generally increased by 0.1 to 0.2 ft during average to dry conditions, with a slight depth reduction during the wettest 10% of conditions, and no significant change during extreme dry conditions. Inundation duration for Alternatives 4R and 4R2 ranged from 92% of the period of record to 98% of the period of record in central WCA 3A. Inundation duration for the FWO was similar, ranging from 92% to 96% of the period of record. Drought intensity for Alternatives 4R and 4R2 ranged from -331 ft-days below ground to -72 ft-days over the period of record. Drought intensity for the FWO within this same region varied from -308 ft days to -142 ft-days over the period of record. Improved inundation patterns in central WCA 3A resulted in better suitability for slough vegetation for Alternatives 4R and 4R2. As previously stated, maintenance of existing conditions within this region of the project area is desirable as ridge and slough habitat is well conserved. Alternatives 4R and 4R2 would achieve 80-81% of the target HUs for Zone 3A-C; a difference of 3-4% from the FWO (**Table G-26**).

Table G-26. Rescaled Performance Measure Scores (Zero to 100 Scale) for Central WCA 3A (Zone 3A C) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	42	43	47	47
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	63	60	65	66
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	74	72	80	81
5.2	Slough Vegetation Suitability -- Dry down	88	85	90	91
5.3	Slough Vegetation Suitability -- Dry Season Depth	42	37	43	43
5.4	Slough Vegetation Suitability -- Wet Season Depth	42	38	47	47
	Percentage of Target HU (HSI x 100)	**79**	**77**	**80**	**81**

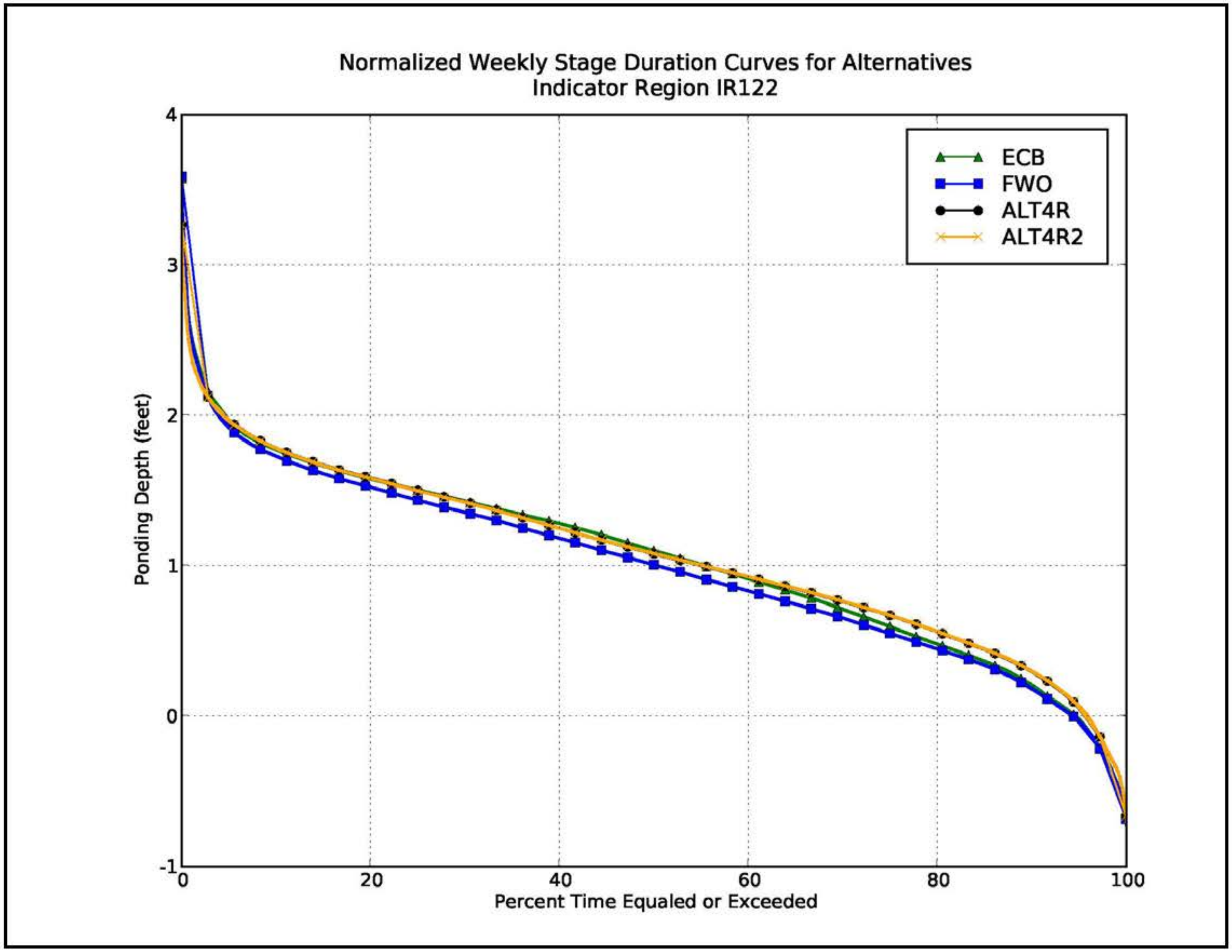


Figure G-32. Normalized Weekly Stage Duration Curve for Indicator Region 122 for Alternatives 4R and 4R2

Alternatives 4R and 4R2 produced the same performance within southern WCA 3A (Zone 3A-S). Within southern WCA 3A, Alternatives 4R and 4R2 scored similarly to the FWO in terms of meeting the desired targets for each of the performance measures (**Table G-27**). Alternatives 4R and 4R2 produced similar depths to the FWO as depicted by the normalized weekly stage duration curve for IR 124 (**Figure G-33**); an example IR for Zone 3A-S. Depths are slightly decreased by 0.1 to 0.2 ft during the wettest 5% of conditions and slightly decreased during normal to dry conditions. It should be noted that Alternatives 4R and 4R2 performed slightly worse for measures of slough vegetation suitability relative to the FWO (**Figure G-34**). As previously stated, performance with respect to this metric can best be explained by the operational targets that were used during plan formulation. Southern WCA 3A would remain largely unaffected by the implementation of Alternatives 4R and 4R2 due to the extended ponding of deep water which would continue to occur. See **Section G.2.2.2** [(**Central and Southern WCA 3A** (**Alternatives 1-4**)].

Table G-27. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern WCA 3A (Zone 3A S) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	45	47	50	50
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	60	59	61	61
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	84	82	81	81
5.2	Slough Vegetation Suitability -- Dry down	100	95	93	93
5.3	Slough Vegetation Suitability -- Dry Season Depth	82	73	72	72
5.4	Slough Vegetation Suitability -- Wet Season Depth	71	64	61	61
	Percentage of Target HU (HSI x 100)	**84**	**83**	**83**	**83**

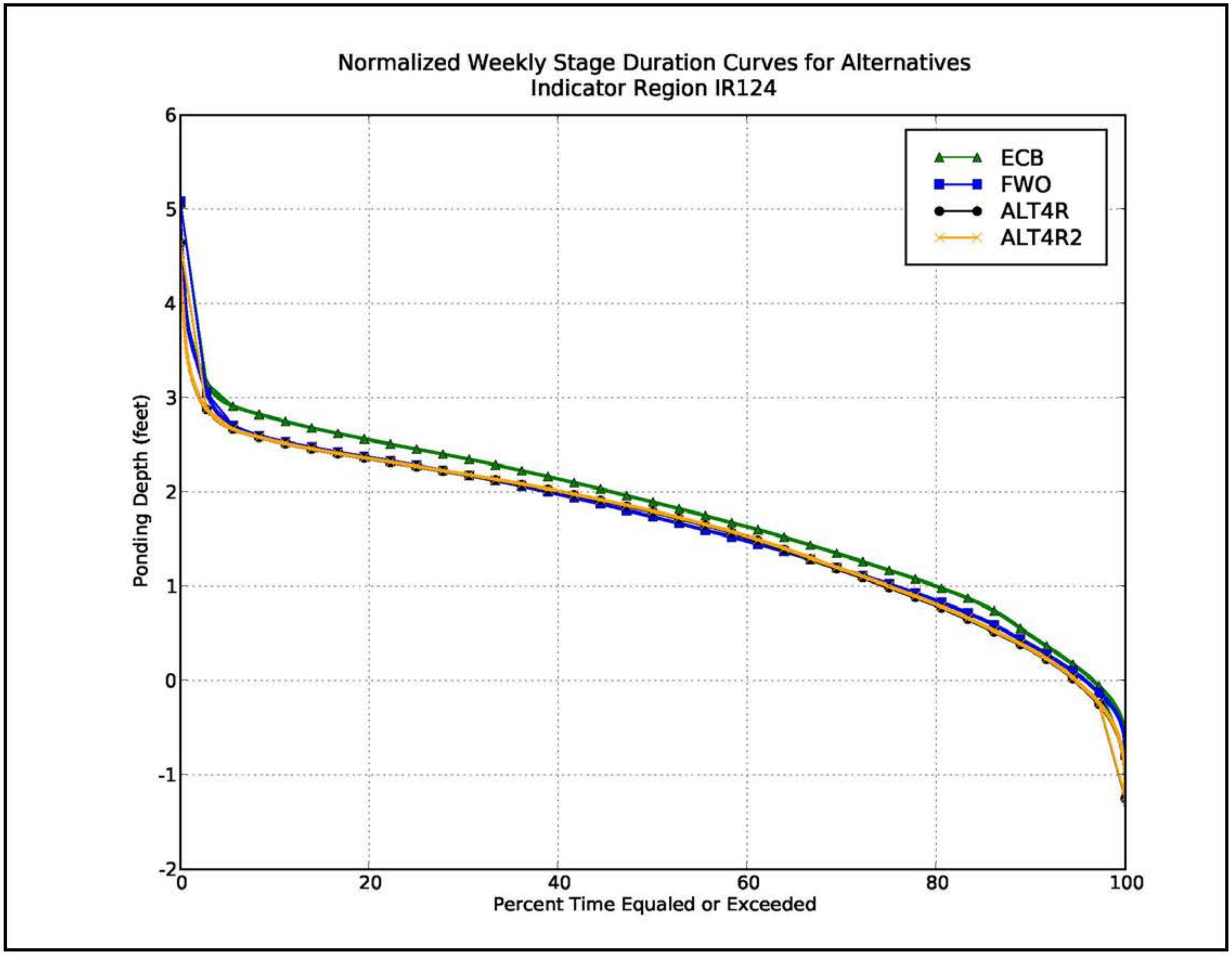


Figure G-33. Normalized Weekly Stage Duration Curve for Indicator Region 124 for Alternatives 4R and 4R2

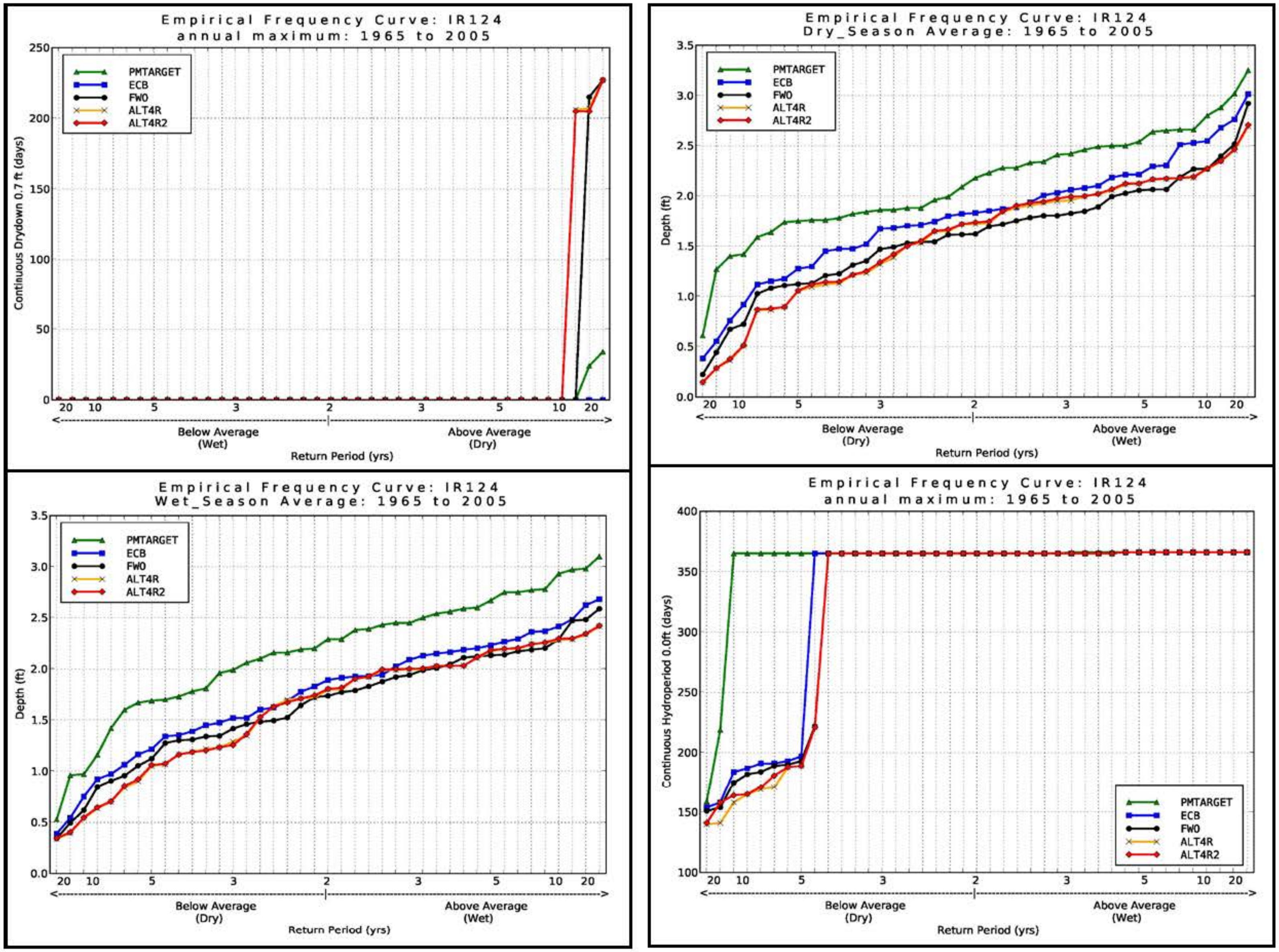


Figure G-34. Slough Vegetation Empirical Frequency Curves Indicator Region 124 for Alternative 4R and 4R2

G.2.6.3 WCA 3B (Zone 3B) (Alternatives 4R and 4R2)

Alternatives 4R and 4R2 improved hydrologic conditions in WCA 3B in comparison to the FWO by increasing depths and resulting hydroperiods within the area. Alternatives 4R and 4R2 scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability (**Table G-28**). Pertaining to slough vegetation suitability, greater performance was noted with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events below 0.7 ft. Scores for these performance measures ranged from 76 to 94. Alternatives 4R and 4R2 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing and distribution of sheetflow. Scores for these performance measures ranged from 0 to 46. Poor performance was especially noted for measures of sheetflow.

Table G-28. Rescaled Performance Measure Scores (Zero to 100 Scale) for WCA 3B (Zone 3B) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	86	76	92	93
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	0	0	0	0
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	35	39	40
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	56	58	45	46
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	84	71	93	94
5.1	Slough Vegetation Suitability -- Hydroperiod	72	63	75	76
5.2	Slough Vegetation Suitability -- Dry down	86	80	89	89
5.3	Slough Vegetation Suitability -- Dry Season Depth	45	38	42	43
5.4	Slough Vegetation Suitability -- Wet Season Depth	28	23	32	33
	Percentage of Target HU (HSI x 100)	**65**	**57**	**68**	**69**

Overland flow directionality generally showed poor alignment with landscape patterning. Alternatives 4R and 4R2 maintained the directionality of overland flow seen in the FWO shown in (**Figure G-17**) which is oriented to the southeast corner of WCA 3B. Overland flow directionality was improved west of the Blue Shanty levee where vectors were more aligned in a north to south direction. Sheetflow plays an essential role in maintaining the directionality, and spatial extent of ridges and sloughs. Poor alignment of overland flow with landscape patterning would have potential effects on what ridge and slough landscape currently remains within WCA 3B. .Implementation of Alternatives 4R and 4R2 would reestablish the connection through WCA 3B and ENP, providing the longest uninterrupted flow-way by removal of a portion of the L-67 C and L-29 levees.

Inundation duration for Alternatives 4R and 4R2 ranged from 91% of the period of record to 96% of the period of record in WCA 3B. Inundation duration for the FWO within this same region varied from 84% to 93% of the period of record. Alternatives 4R and 4R2 generally produced higher depths within WCA 3B relative to the FWO under all hydrologic conditions as depicted by the normalized weekly stage duration curve for IR 128 (**Figure G-35**); an example IR for WCA 3B. Alternative 4R2 produced slightly higher depths within WCA 3B. Depths are increased by 0.1 ft during the upper 20% of the duration curve and increased by 0.2 to 0.5 ft for normal to dry conditions (**Figure G-35**). Increases in depth within WCA 3B were not as significant as increases in observed depths relative to the FWO in northern WCA 3A. Construction of the L-29 levee divides WCA 3B into two separate compartments allowing restoration of sheetflow to the maximum extent practicable while preventing undesirably high water depths east of the Blue Shanty levee. Water depths were greater west of the Blue Shanty levee (**Figure G-36**) in comparison to the remainder of WCA 3B (**Figure G-35**).

Alternatives 4R and 4R2 improved the severity of drought intensity. Drought intensity for Alternatives 4R and 4R2 ranged from -463 ft-days below ground to -170 ft-days over the period of record. Drought intensity for the FWO varied from -1101 ft days to -328 ft-days over the period of record. Improved inundation patterns in WCA 3B resulted in better suitability for slough vegetation for both alternatives (**Figure G-36**). Implementation of Alternatives 4R and 4R2 would achieve 68-69%% of the target HUs for Zone 3B (**Table G-28**).

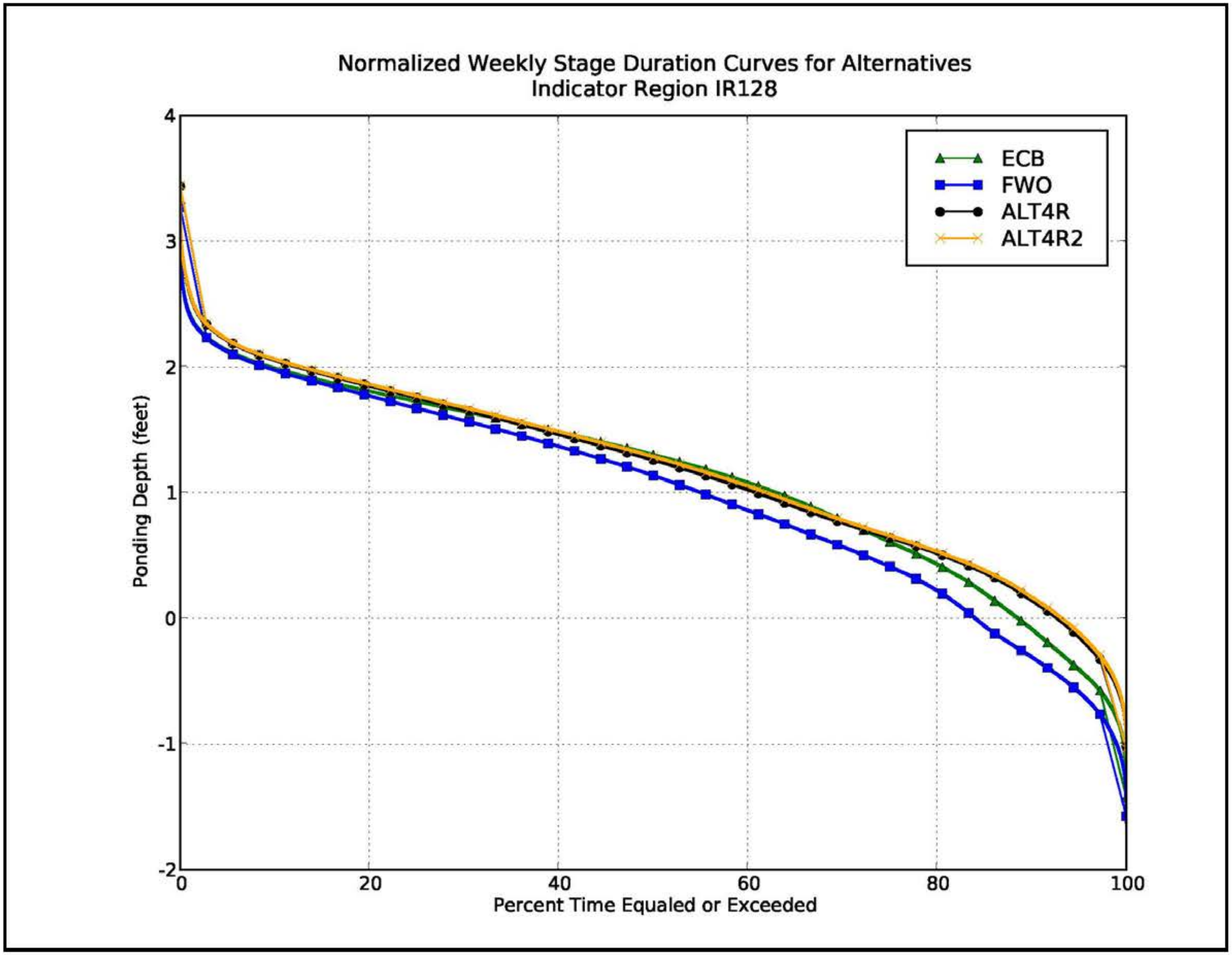


Figure G-35. Normalized Weekly Stage Duration Curve for Indicator Region 128 for Alternatives 4R and 4R2

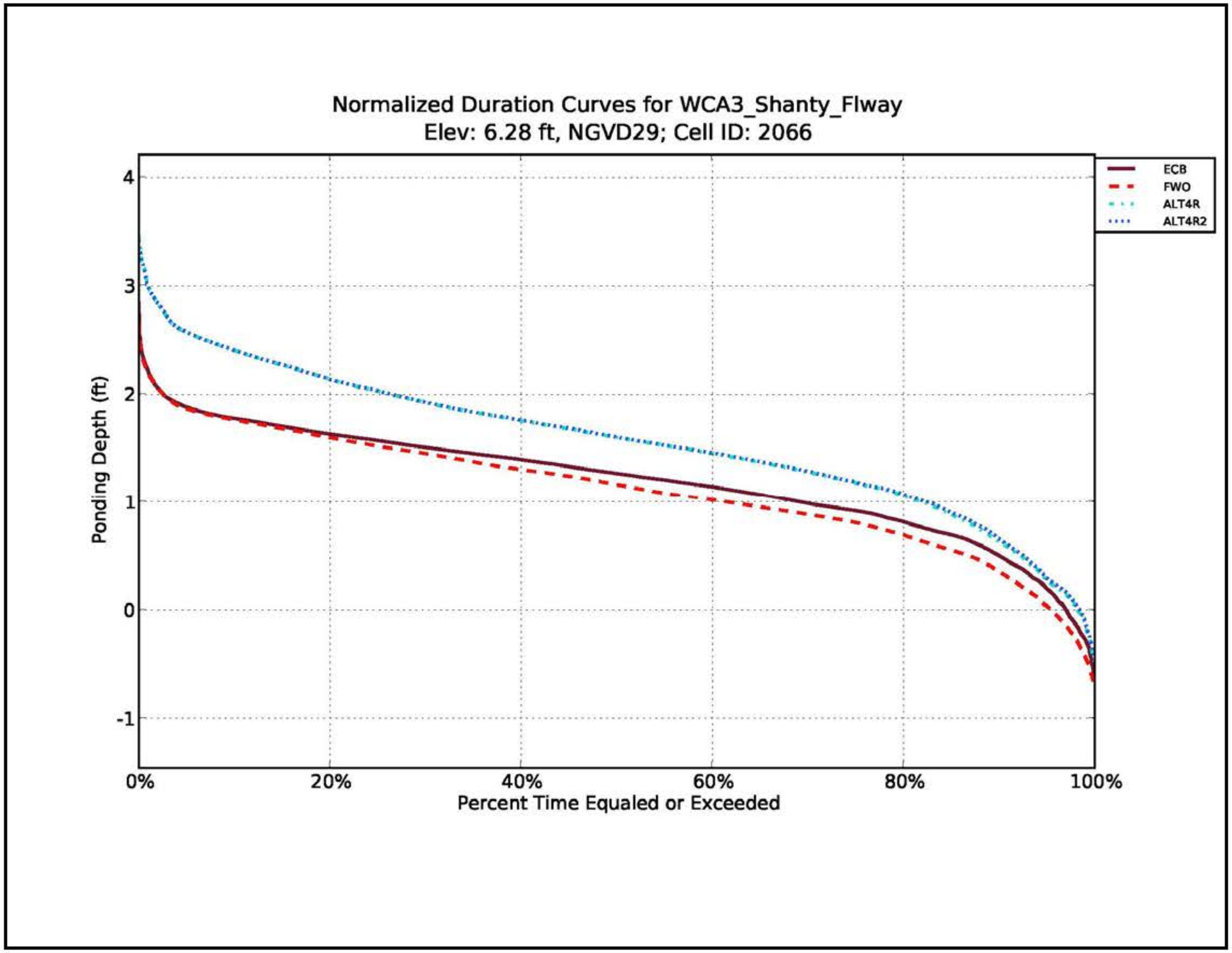


Figure G-36. Normalized Weekly Stage Duration Curve for Gage in Blue Shanty Flow-Way for Alternatives 4R and 4R2

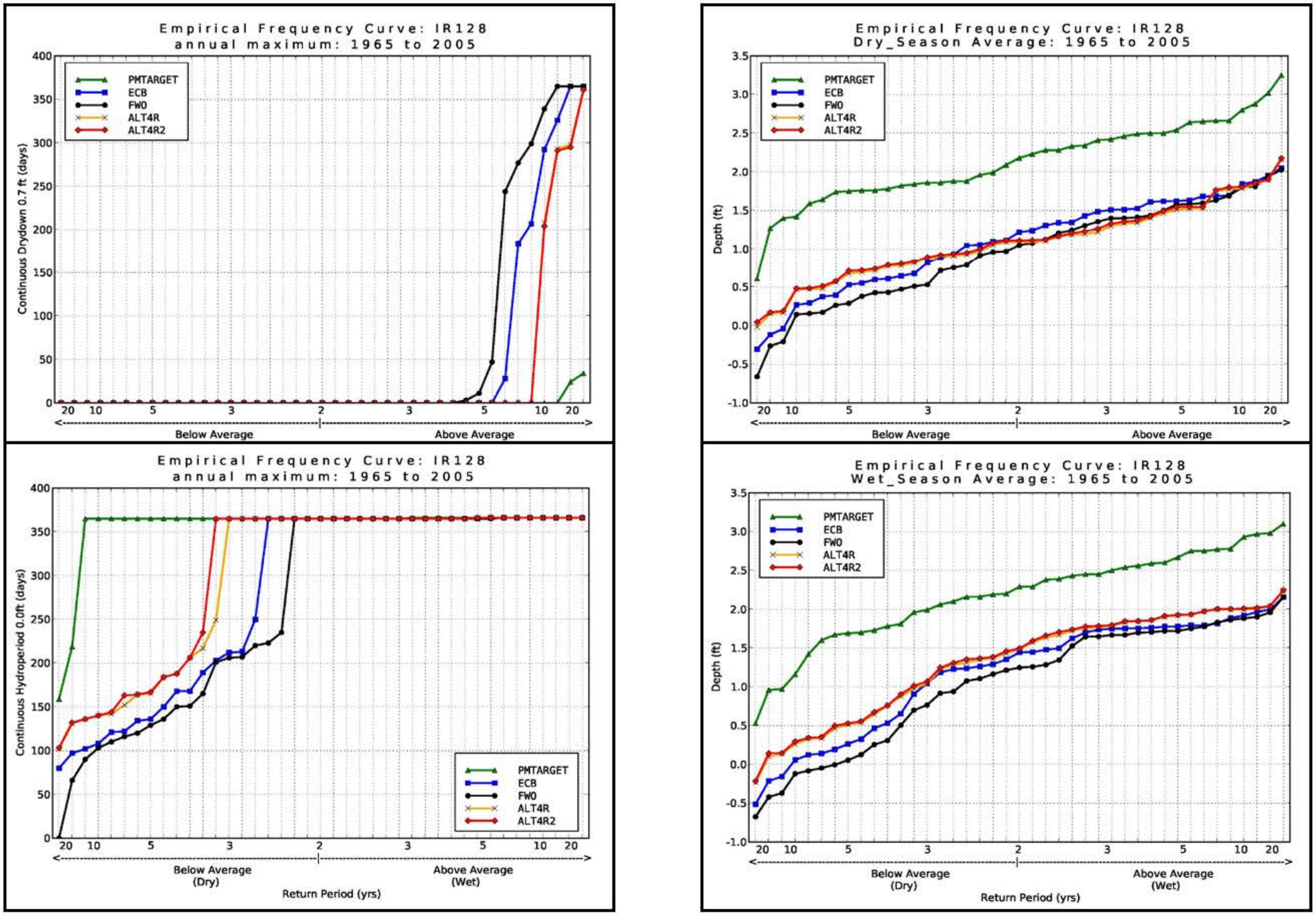


Figure G-37. Slough Vegetation Empirical Frequency Curves Indicator Region 128 for Alternatives 4R and 4R2

G.2.6.4 ENP (Zones ENP-N, ENP-S, ENP-SE) (Alternative 4R and 4R2)

Alternatives 4R and 4R2 improved hydrologic conditions in ENP in comparison to the FWO by significantly increasing depths and resulting hydroperiods in NESRS. Slight differences occurred between zones within ENP. Alternatives 4R and 4R2 scored the highest in terms of meeting the desired performance measure targets relative to the FWO in northern (Zone ENP-N) and southern ENP (Zone ENP-S) in comparison to southeastern ENP (Zone ENP-SE) (**Table G-29**, **Table G-30**, and **Table G-31**). Alternatives 4R and 4R2 scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability. Alternatives 4R and 4R2 also consistently improved the number and duration of dry events in NESRS in comparison to the FWO (**Table G-32**). Scores for these performance measures ranged from 65 to 100 for northern ENP (Zone ENP-N) and southern ENP (ENP-S). Alternatives 4R and 4R2 were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing of sheetflow. Scores for these performance measures ranged from 30 to 63. In southeastern ENP (Zone ENP-SE), Alternatives 4R and 4R2 scored the highest in meeting desired performance measure targets for inundation duration and drought intensity (*i.e.* scores of 100). Other performance measure (slough vegetation suitability, and sheetflow) scored notably low.

Table G-29. Rescaled Performance Measure Scores (Zero to 100 Scale) for Northern ENP (Zone ENP-N) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	70	68	93	94
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	19	21	30	30
2.2	Sheetflow in the Ridge and Slough Landscape -- Continuity	41	35	39	40
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	50	46	53	53
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	52	50	89	89
4.1	Number and Duration of Dry Events -- Number	68	60	85	85
4.2	Number and Duration of Dry Events -- Duration	18	26	100	100
4.3	Number and Duration of Dry Events -- PPOR	1	2	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	59	53	86	86
5.2	Slough Vegetation Suitability -- Dry down	69	69	95	98
5.3	Slough Vegetation Suitability -- Dry Season Depth	24	23	56	56
5.4	Slough Vegetation Suitability -- Wet Season Depth	15	12	63	63
	Percentage of Target HU (HSI x 100)	**46**	**44**	**79**	**79**

Table G-30. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southern ENP (Zone ENP-S) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	66	65	82	82
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	30	35	52	53
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	53	51	75	75
4.1	Number and Duration of Dry Events -- Number	61	62	69	70
4.2	Number and Duration of Dry Events -- Duration	74	75	98	95
4.3	Number and Duration of Dry Events -- PPOR	51	52	95	92
5.1	Slough Vegetation Suitability -- Hydroperiod	58	58	65	66
5.2	Slough Vegetation Suitability -- Dry down	82	86	96	96
5.3	Slough Vegetation Suitability -- Dry Season Depth	31	32	39	39
5.4	Slough Vegetation Suitability -- Wet Season Depth	26	24	35	35
	Percentage of Target HU (HSI x 100)	**52**	**53**	**71**	**71**

Table G-31. Rescaled Performance Measure Scores (Zero to 100 Scale) for Southeastern ENP (Zone ENP-SE) for Alternatives 4R and 4R2

Metric #	Performance Measure Metric	ECB	FWO	ALT4R	ALT4R2
1.1	Inundation Duration in the Ridge and Slough Landscape	100	100	100	100
2.1	Sheetflow in the Ridge and Slough Landscape -- Timing	13	20	25	25
2.3	Sheetflow in the Ridge and Slough Landscape -- Distribution	48	48	49	49
3.1	Hydrologic Surrogate for Soil Oxidation -- Drought Intensity Index	100	100	100	100
5.1	Slough Vegetation Suitability -- Hydroperiod	14	11	19	18
5.2	Slough Vegetation Suitability -- Dry down	5	4	28	25
5.3	Slough Vegetation Suitability -- Dry Season Depth	1	0	3	3
5.4	Slough Vegetation Suitability -- Wet Season Depth	4	4	6	5
	Percentage of Target HU (HSI x 100)	**59**	**60**	**63**	**62**

Table G-32. Number and Duration of Dry Events in Northeast Shark River Slough for Alternatives 4R and 4R2 (Raw Performance Measure Scores)

Zone	Indicator Region	Metric	FWO	ALT4R	ALT4R2
Zone ENP-N	129	Number	18	8	8
		Average Duration (Weeks)	20	10	9
Zone ENP-S	130	Number	16	13	12
		Average Duration (Weeks)	17	12	13
	131	Number	20	17	17
		Average Duration (Weeks)	16	13	13
	132	Number	22	20	20
		Average Duration (Weeks)	12	12	12

Inundation duration for Alternatives 4R and 4R2 ranged from 76% of the period of record to 96% of the period of record in northern ENP (Zone ENP-N) and from 91% to 93% in southern ENP (ENP-S). Inundation duration for the FWO within this same region varied from 78% to 83% of the period of record in northern ENP (Zone ENP-N) and from 86% to 91% in southern ENP (ENP-S). Alternatives 4R and 4R2 produced significantly higher depths than the FWO as depicted by the normalized weekly stage duration curve for IRs 129 (**Figure G-38**) and IR 130 (**Figure G-39**); example IRs for northern (Zone ENP-N) and southern (Zone ENP-S) ENP. Depths are significantly increased by 0.5 to 0.9 ft under all hydrologic conditions at IR 129 and by 0.1 to 03 ft at IR 130. Alternatives 4R and 4R2 improved the severity of drought intensity. Drought intensity for the Alternatives 4R and 4R2 varied from -3841 ft days to -350 ft-days over the period of record in northern ENP (Zone ENP-N) and from -750 ft-days to -395 ft-days in southern ENP (ENP-S). Drought intensity for the FWO varied from -3341 ft days to -1562 ft-days over the period of record in northern ENP (Zone ENP-N) and from -917 ft-days to -801 ft-days in southern ENP (ENP-S). Improved inundation patterns resulted in better suitability for slough vegetation for Alternatives 4R and 4R2 in both locations of ENP. Implementation of Alternatives 4R and 4R2 would achieve 79% of the target HUs for Zone ENP-N (**Table G-29**), 71% of the target HUs for Zone ENP-S (**Table G-30**), and 63-62% of the target HUs for Zone ENP-SE (**Table G-31**).

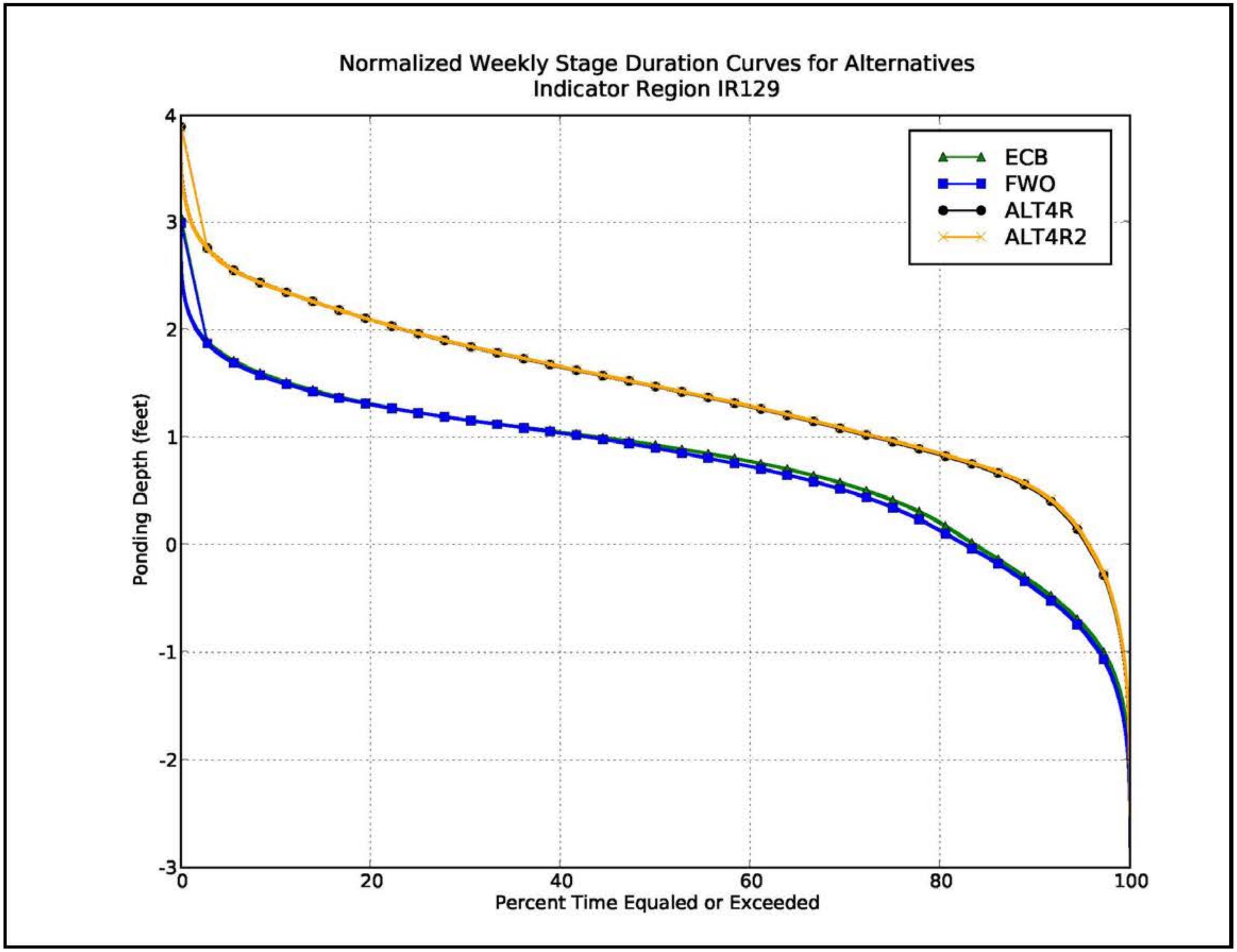


Figure G-38. Normalized Weekly Stage Duration Curve for Indicator Region 129 for Alternatives 4R and 4R2

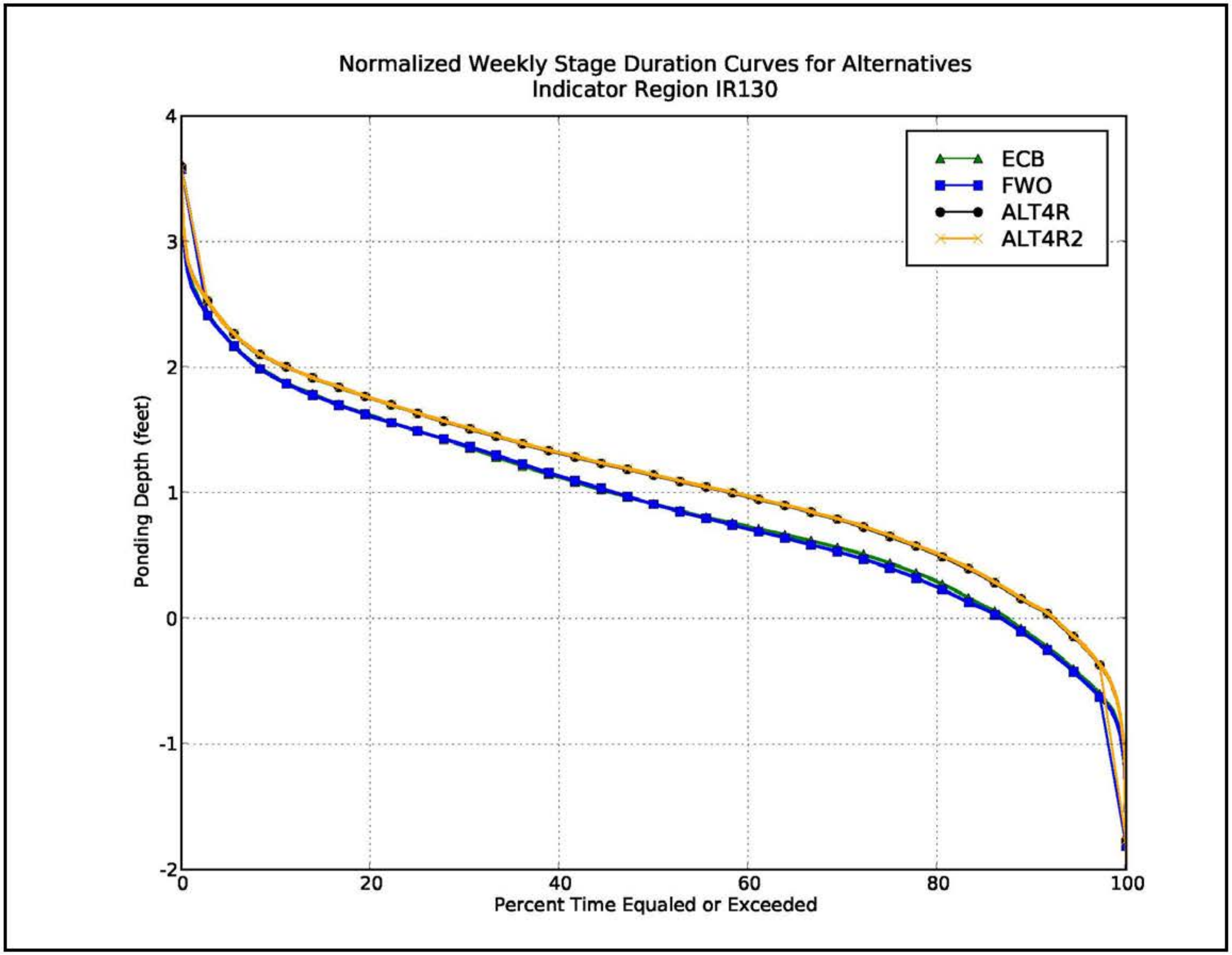


Figure G-39. Normalized Weekly Stage Duration Curve for Indicator Region 130 for Alternatives 4R and 4R2

G.2.7 Florida Bay (Alternatives 4R and 4R2)

Performance between Alternative 4R and 4R2 was similar. Alternatives 4R and 4R2 improved hydrologic conditions in Florida Bay in comparison to the FWO by increasing overland flows. Alternatives 4R and 4R2 provided increased flows within SRS in comparison to the FWO with annual flow increases above the FWO of 164,000 to 168,000 ac-ft on average per year (**Figure G-40**). Alternatives 4R and 4R2 provided increased flows within Taylor Slough in comparison to the FWO; however, increases in flow were not as significant as increases in observed flows in SRS. Alternative 4R provided annual flow increases of 27,000 ac-ft on average per year; Alternative 4R2 provided increases of 23,000 ac-ft per year. Improved hydrologic conditions in central SRS directly resulted in improved salinity conditions in Florida Bay. **Figure G-41** and **Figure G-42** depict results for the regime overlap and high salinity performance measures for the wet season and dry season. Alternatives 4R and 4R2 scored the highest in terms of meeting the desired targets during the wet season for each of the metrics. Improvements in salinity conditions relative to the FWO were of greater magnitude in the east central, central, south, and west Florida Bay zones.

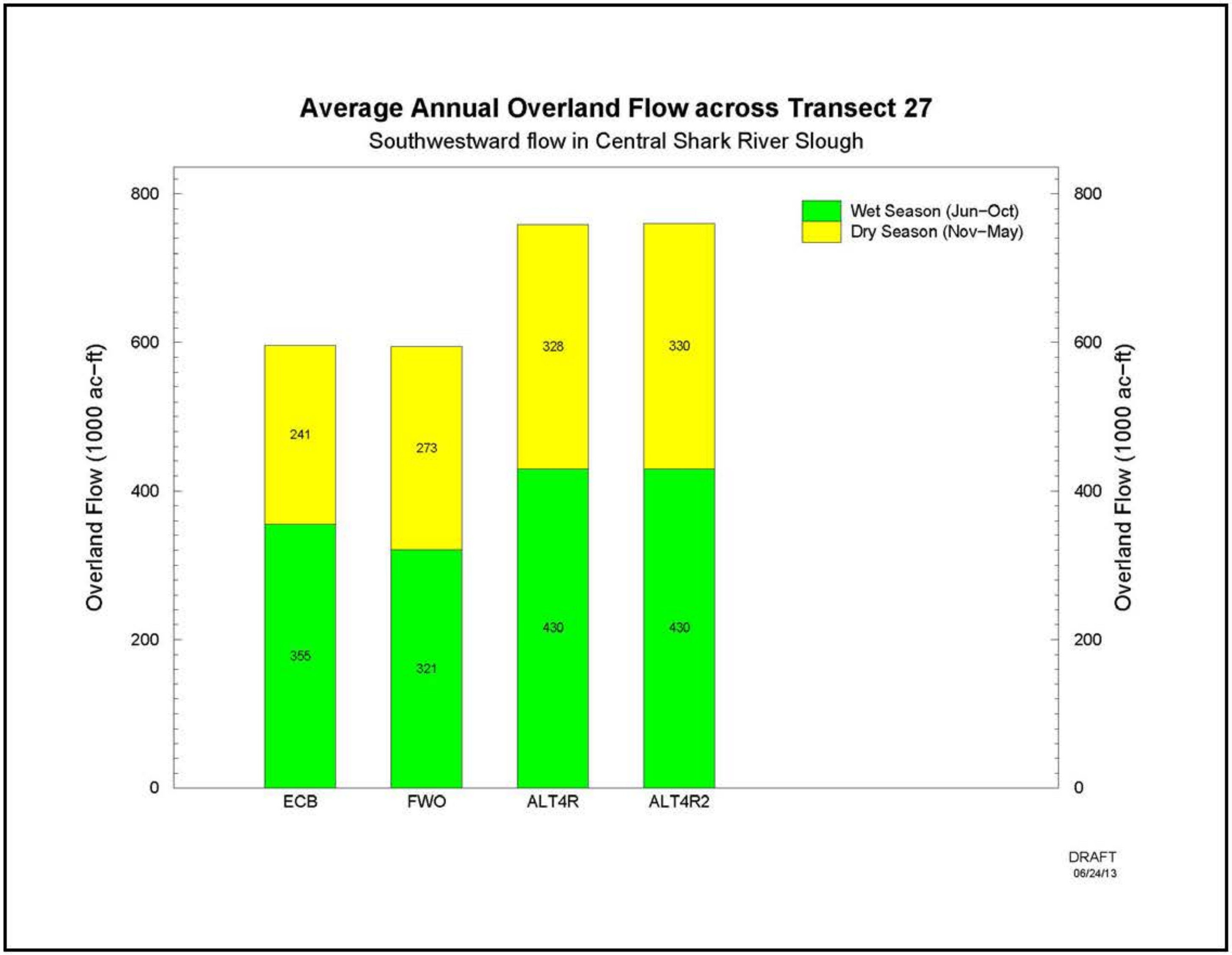


Figure G-40. Average Annual Overland Flow (1000 ac-ft) Across Transect 27 for Alternatives 4R and 4R2

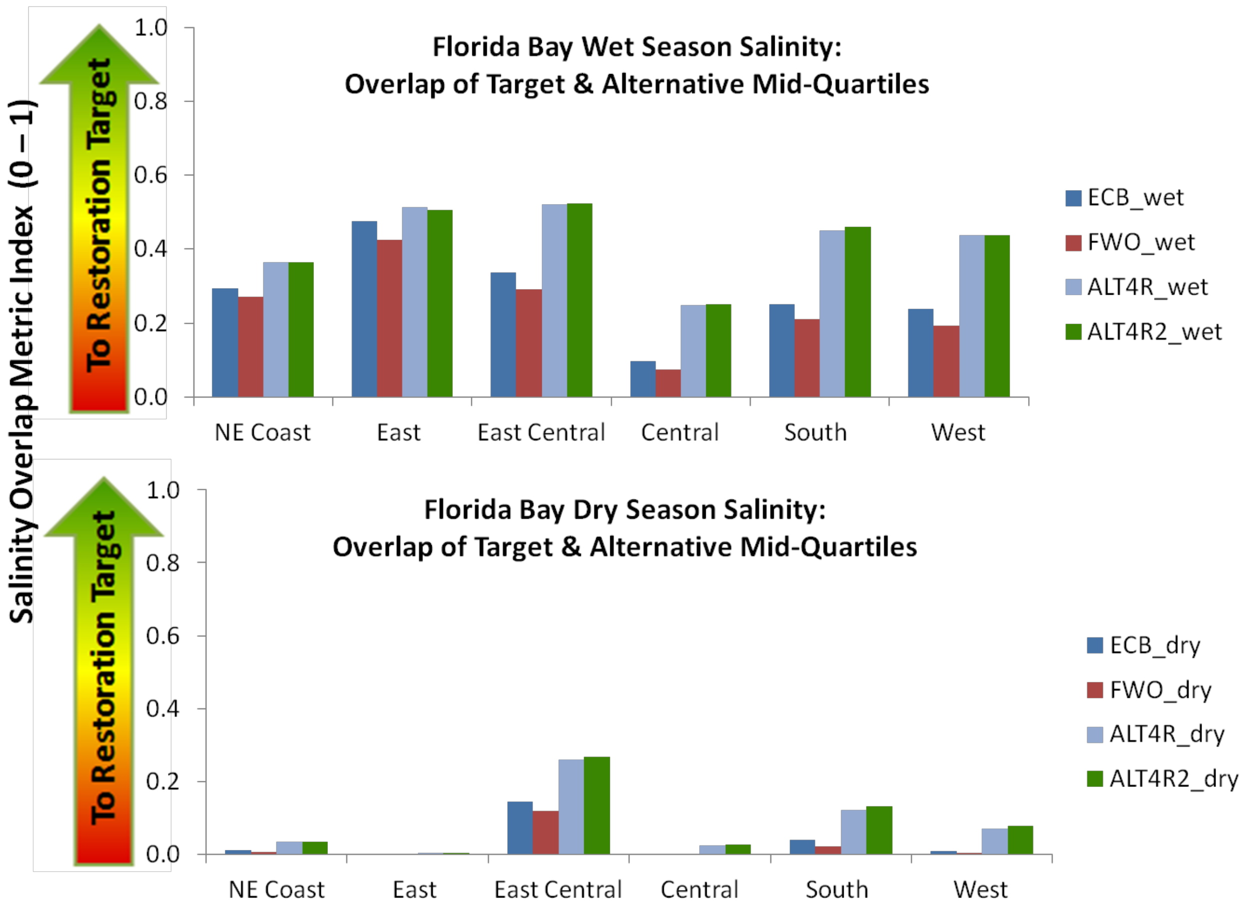


Figure G-41. Wet Season and Dry Season Regime Overlap Performance Measure for Florida Bay for Alternatives 4R and 4R2. Salinity Overlap Index (Dry Season) Equivalent to Zero for East Florida Bay.

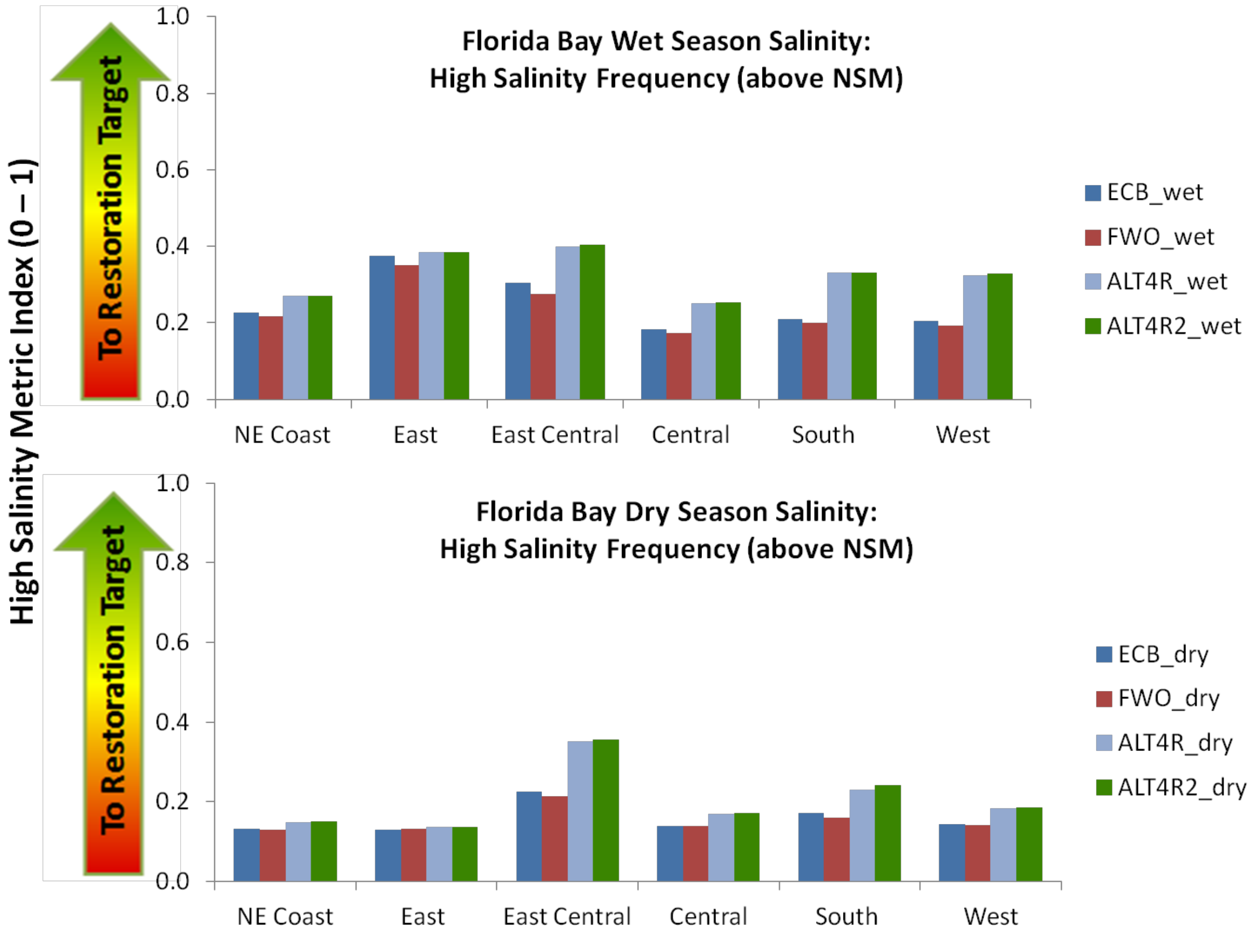


Figure G-42. High Salinity Performance Measure for Florida Bay for Alternatives 4R and 4R2

Table G-33 provides the percentage of target HUs resulting from the performance measure scores for each zone in Florida Bay. While the mean salinities for all alternatives are still higher than target conditions, implementation of CEPP brings salinities in Florida Bay closer to target conditions. Implementation of Alternatives 4R and 4R2 would achieve 17 to 39% of the target HUs for Florida Bay. The FWO would achieve 10% to 23% of the target HUs.

Table G-33. Percentage of Target HU (HSI x 100) for Florida Bay for Alternatives 4R and 4R2

Florida Bay	ECB	FWO	ALT4R	ALT4R2
Florida Bay West (Zone FB-W)	15	13	25	26
Florida Bay Central (Zone FB-C)	10	10	17	18
Florida Bay South (Zone FB-S)	17	15	28	29
Florida Bay East Central (Zone FB-EC)	25	23	38	39
Florida Bay North Bay (Zone FB-NB)	17	16	20	21
Florida Bay East (Zone FB-E)	25	23	26	26

G.2.8 Conclusions (Alternatives 4R and 4R2)

Alternatives 4R and 4R2 provided improvements in hydrology relative to the FWO in each region of the project area. **Table G-34** displays HU lift for Alternatives 4R and 4R2. Alternative 4R2 has been identified as the recommended plan. Alternative 4R2 provides for other water related needs to the LOSA and LEC while maintaining ecosystem benefits identified in Alternative 4R. See **Section 4**(**Evaluation and Comparison of Alternative Plans**) of the main report.

Alternative 4R2 addresses the need to restore ecosystem function in the Caloosahatchee and St. Lucie Estuaries by reducing the number and severity of events where harmful amounts of freshwater from Lake Okeechobee are discharged into the estuaries. Unnatural surges of freshwater have reduced estuarine salinity levels triggering die offs of sea grasses and oysters, species that are indicators of the estuary's overall health. A reduction in the number of high volume freshwater discharges to the estuaries would help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities.

Within the Greater Everglades, altered hydroperiods have led to declines in prey bases for numerous macrofauna including migratory birds. Untimely marsh dry outs deplete populations of fish and amphibians that are necessary to sustain the massive colonies of birds that used to inhabit the area. Fires that once would have contributed to the maintenance of the ecosystem now serve only to burn off layers of organic material and detritus that are imperative to maintaining proper nutrient levels. The resulting soil subsidence severely alters the composition of plant species in the natural communities, increasing the likelihood of invasion by aggressive, exotic vegetation. Results of the evaluation of Alternative 4R2 indicate that hydrology in WCA 3A, 3B and ENP would be significantly improved by the implementation of Alternative 4R2. Due to changes in the quantity, quality, distribution, and timing of water entering the Greater Everglades ecosystem, beneficial effects on wetland hydrology and vegetation would occur. The delivery of additional flow to the Everglades would return many of the currently dehydrated areas to a level of hydration which moves toward the pre-drainage, natural system condition. Improvements in the volume and distribution of flows to the Greater Everglades are a step towards restoring natural landscape patterns and native flora and fauna.

Changes in the hydrology of the freshwater systems have led to effects on the estuarine and marine environments of Florida Bay. Implementation of Alternative 4R2 is expected to improve the volume of overland flow to Florida Bay. The increase in overland flow to Florida Bay is a step toward reducing the intensity, frequency, duration, and spatial extent of hypersaline events in Florida Bay that have negatively impacted native bay flora and fauna.

Table G-34. Habitat Unit Lift Results for Alternatives 4R and 4R2

Project Region (Zone)	ALT4R*	ALT4R2*
Caloosahatchee Estuary (CE-1)	4,968	4,968
St Lucie Estuary (SE-1)	2,699	5,848
Total Northern Estuaries	**7,667**	**10,816**
Northeast WCA 3A (3A-NE)	62,972	61,738
WCA 3A Miami Canal (3A-MC)	27,373	27,373
Northwest WCA 3A (3A-NW)	23,932	23,932
Central WCA 3A (3A-C)	4,117	5,490
Southern WCA 3A (3A-S)	0	0
WCA 3B (3B)	9,426	10,283
Northern ENP (ENP-N)	43,793	43,793
Southern ENP (ENP-S)	42,946	42,946
Southeast ENP (ENP-SE)	4,054	2,702
Total WCA 3 and ENP	**218,613**	**218,257**
Florida Bay West (FB-W)	18,954	20,534
Florida Bay Central (FB-C)	5,743	6,564
Florida Bay South (FB-S)	12,705	13,682
Florida Bay East Central (FB-EC)	13,191	14,070
Florida Bay North Bay (FB-NB)	506	633
Florida Bay East (FB-E)	1,133	1,133
Total Florida Bay	**52,232**	**56,616**
Total All Regions	**278,512**	**285,689**

* HU lift values for ALT 4R and 4R2 represent those calculated in the year 2072.

G.3 TECHNICAL QUALITY OF THE CEPP PLANNING MODEL

The CEPP is 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 2005a, 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 Corps 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.4 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 our current 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 have 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.

1. Are there performance measures that do not differentiate between alternatives and should these performance measures be removed from the CEPP planning model?

All performance measures were realistically sensitive to differences between modeled alternatives. Differences in the magnitude of performance between alternatives varied by approximately ± 5 points on a zero to 100 scale. This was not a result of intrinsic insensitivity of the performance measures because the alternatives showed as much as a 74 point difference relative to the FWO for several regions of the project area. Similarity in the range of performance measure scores between alternatives is more likely a consequence of plan formulation efforts. During plan formulation efforts, the CEPP project team optimized operations within WCA 3A, 3B and ENP to best achieve targets throughout the system. Similar performance in northern WCA 3A was expected as alternative configurations were similar in structure. Alternative configurations differed with respect to the L-67 A/C and L-29 levees in WCA 3B; stage constraints in WCA 3B dictated the amount of available water that could be delivered to this area, forcing hydrologic improvements in this area to be similar among alternatives even though the number and size of operational structures differed.

2. Are there performance measures that could be influencing the overall benefits score?

No one performance measure was identified as disproportionately influencing the overall benefits score within a given zone. 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 were outlined under the RECOVER salinity performance measure. Performance measures for the Northern Estuaries showed differences between alternatives in their ability to meet the desired high and low flow targets. 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. Alternatives scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation. Pertaining to slough vegetation suitability, greater performance was noted with regard to maximizing continuous hydroperiods (days with depth ≥ 0.0 ft) and minimizing dry down events below 0.7 ft. Alternatives were not as effective in maintaining appropriate dry and wet season depths for slough vegetation or in maintaining the timing and distribution of sheetflow however improvements in these performance measures were apparent over the FWO for many regions of the project area. Alternative performance in Florida Bay was measured by evaluating the magnitude of salinities in Florida Bay in response to inflows from ENP. Performance measures for Florida Bay showed differences between alternatives in their ability to meet the desired salinity targets.

3. Are there indicator regions and/or transects within each zone that could be influencing the overall benefits score?

Performance measures within WCA 3 and ENP were generated from hydrologic output from the RSM-GL using indicator regions (IRs) and/ or flow transects. No one IR and/or transect was identified as disproportionately influencing the overall benefits score within a given zone. Generally speaking, observed differences in alternative performance were similar across IRs and/or transects within a given zone; the ranking of alternatives did not change. The magnitude of the difference in alternative performance did change based on the relative distance of the IR and/or transect from the location at which additional flow was introduced. For example, within northern WCA 3A significant differences in alternative performance in comparison to the FWO primarily occurred at IRs and transects located near the L-4/L-5 boundary where additional flow was introduced into WCA 3A (*i.e.* IRs 114, 115, 116, 117, 118, 190, MC NE1, MC NE2, MC NW1, MC NW2, MC CE1, MC CE2, MC CW1, MC CW2, Transect 5, Transect 6, Transect MC 1, MC 2, MC 3). Hydrologic improvements over the FWO were less significant as the distance from the L-4/L-5 boundary increased (*i.e.* IRs 119, 121, MC SE1, MC SE2, MC SW1, MC SW2, Transect 7, Transect 8, Transect MC 4, MC 5). Similar patterns were apparent in IRs and/or transects in ENP as the distance from introduction of additional flow at Tamiami Trail (L-29) increased.

4. Is there the potential for trade-offs within the project area? (*i.e.* Do benefits to northern WCA 3A come at the expense to southern WCA 3A?).

The CEPP planning model reported the partition of HU into contributions from each zone within the Northern Estuaries, WCA 3, ENP, and Florida Bay. 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. Benefits were observed in each zone of the project area. Alternative 4 provided the greatest project benefits for WCA 3, ENP, and Florida Bay while Alternative 2 provided the least. Alternatives 3 and 1 provided more project benefits than Alternative 2. Results of the CE/ICA identified Alternative 4M as providing the greatest overall benefits with the least cost per habitat unit. See **Section 4** (**Evaluation and Comparison of Alternative Plans**). However, within WCA 3B, this alternative was consistently the worst performer. Operational refinements were subsequently proposed to Alternative 4 to address project constraints and provide improved water depths to WCA 3B.

5. How does error within the regional hydrologic models influence performance measure output?

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 assumed that each of the performance measures used within the project area could be extrapolated from the point locations modeled by the regional hydrologic models to the larger areas they represent. This approach assumed that the results of the hydrologic models were similar across spatial scales within these geographic regions. Due to differences in each hydrologic model's accuracy and precision (within and among regions of each model's domain), and differences in sensitivities of each performance measure to changes in hydrologic conditions, an assumption that all performance measure results are of equal credibility may be viewed as faulty. To address this concern, the CEPP project team consulted individuals involved in the development, calibration, and application of the hydrologic models being used to conduct alternative analyses to verify that observed differences between alternatives were not the results of differential exploitation of hydrologic model error/bias. Results of the calibration and validation of RSM-GL were reviewed to address how error in the hydrologic model could influence alternative results within WCA 3 and ENP. A brief summary of the pertinent results of the calibration and validation report (SFWMD 2010) are provided below as well as an overview of RSM-GL and its suitability for CEPP application. Analyses conducted to evaluate how error in RSM-GL could influence alternative performance within the CEPP planning model is described below.

Overview of the RSM-GL and Suitability for CEPP Application

The RSM-GL provides daily, detailed estimates of hydrology across the 41 year period of record. The regional hydrologic model encompasses an area of 5,825 square miles. The model simulates all major water budget components that are relevant to South Florida. These include evaporation, transpiration, overland and groundwater flows, levee seepage, and canal flows. The area of the model-domain includes Everglades National Park, Water Conservation Areas, Big Cypress National Preserve, and the Lower East Coast Service Areas south of the C-51 canal in Palm Beach County. The southern, eastern and southwestern boundaries of the model comprise Florida Bay, the Atlantic Ocean/Biscayne Bay and the Gulf of Mexico.

The RSM-GL application of the RSM was developed by the SFWMD and the RSM-GL was specifically calibrated to support the evaluation of proposed project features for the CERP WCA-3 Decompartmentalization and Sheetflow Enhancement project (Decomp). Prior to initiation of the CEPP project, the RSM-GL model was previously first applied by the SFWMD/USACE to support base condition modeling and evaluations of the final array of alternatives for the Decomp Project Implementation Report 1 (PIR 1) during 2010-2011. Both the Decomp and CEPP projects are components of the CERP and the features of the prior Decomp project are central components to the CEPP. Following the CEPP announcement in October 2011, the USACE SAJ and the SFWMD decided to integrate the previous Decomp planning effort into the CEPP.

Since the Decomp project represented the inaugural USACE project application of the RSM-GL, the Decomp project team had planned to submit the RSM-GL for USACE Engineering software validation evaluation following the completion of the RSM-GL model calibration and validation report and the completed simulations/documentation for the initial suite of alternatives with the RSM-GL, when sufficient model documentation could be readily provided to facilitate the review. Since the requisite documentation was not available until December 2011, the RSM-GL request for USACE Engineering software validation evaluation was deferred to the CEPP.

The USACE model certification process distinguishes between “Engineering” and “Planning” models. One of the goals of the Scientific and Engineering Technology (SET) initiative is to inventory and evaluate the software used by the Corps’ scientific and engineering community, to ultimately achieve a manageable and cost-effective USACE corporate tool set. Each piece of software is inventoried, reviewed, and ultimately listed in one of five categories: Enterprise Tools, Community of Practice (CoP) Preferred, Allowed for Use, Retired, and Not Allowed for Use. It is expected that the lists will continue to evolve as new software is introduced.

Current USACE guidance (ES-0801: June 2011) regarding software validation for the Hydrology, Hydraulics, and Coastal Community of Practice (HH&C CoP) indicate that both the District and Division need to recommend the software for evaluation for inclusion within the inventory. The recommendation should state whether the software will be used nationally, regionally, or locally, and should include why the software is needed, an explanation as to what it does and how it does it, why any of the other corporate software already on the list doesn't meet the needs, who within the Corps has knowledge of this software, what type of peer review has it received, what Area of Expertise (AoE) software list should it be included with, and what documentation, training and support can be found. The goal of the SET program is to manage the number of pieces of software so the Corps doesn't have to support multiple pieces of software that do roughly the same thing. The USACE should use “well-known and proven” software unless a new piece of software does something one of the “validated” pieces of software does not.

Based on ES-0801 guidance and coordination between SAJ and SAD, the following comprehensive suite of information (items 1 through 9) is typically requested to support a request for USACE "Engineering" model validation evaluation:

1) Model Classification (Area of Expertise);
2) Requested Model Application Area;
3) General model documentation/description of model capabilities (include web site links or documentation reports);
4) Why the model software is needed? (consider other approved corporate software);
5) External peer review (requested by?; Conducted by?; Model version and date?; final reports should be provided);
6) Internal technical review by Interagency Modeling Center (model version and date?; final report should be provided);
7) Previous applications of the model (specific projects and sponsor agency);
8) Additional applicable reports or documentation, if any (other agency peer reviews, project specific applications of model, model users' guide, etc.);

9) USACE knowledge base for this software.

The request for RSM software validation included significant reliance on the USACE modeling strategy that was executed for Decomp, which included primary reliance on the RSM-GL. An extensive modeling strategy development and review effort was used by the Decomp project delivery team (PDT) to identify the RSM-GL model as the preferred sub-regional modeling tool to support Decomp PIR 1 alternative evaluations. The comprehensive Decomp modeling strategy was further endorsed by the CERP Interagency Modeling Center (IMC) in June 2008; the IMC, under its responsibility to serve as a central point to coordinate Comprehensive Everglades Restoration Program (CERP) and CERP-related modeling activities, is routinely consulted to implement peer reviews of models and their applications. In addition, IMC peer review of the available sub-regional hydrologic modeling tools for Decomp resulted in an IMC endorsement for the RSM-GL model. The IMC peer review report (May 2008) recognized the RSM-GL as: (1) an improvement over the Regional South Florida Water Management Model (SFWMM) with respect to model methodology (surface flow, canal flow, sub-surface flow, evaporation, evapotranspiration, infiltration and seepage), especially when considered as a sub regional tool for implementation of the hydrologic portion of the Decomp modeling strategy; (2) an improvement over the SFWMM with respect to the model grid density and local grid refinement capabilities, and modeler control of adding, removing, or modifying canals, structures, and structure operation rules; (3) able to distinguish between spatial and temporal differences in water depths/stage (including recession rates), and overland and canal flow adequately for CERP evaluations; and (4) if used with caution and adequate interpretation of the model output, able to show some important differences between the varying degrees of Miami Canal backfill or plugging that may be proposed for Decomp PIR 1 alternatives. Key priority recommendations from the IMC peer review panel for enhancements to the RSM-GL model and the calibration/validation report content, as agreed upon following a May 2008 meeting with SFWMD, USACE, IMC managers, and the IMC peer review panel, were implemented for the final version of the RSM-GL that was applied for Decomp and, ultimately, CEPP.

For the CEPP project, the previously-listed USACE software validation evaluation information was compiled and submitted through SAD to the HH&C CoP for evaluation in June 2012. In August 2012, SAJ received notification that the RSM model (including the RSM-BN and RSM-GL sub-regional applications of RSM, which are both utilized for CEPP) was added to the SET inventory of approved engineering software as “Allowed for Use” for South Florida applications.

Summary of Performance for RSM-GL (Review of Calibration/Validation Results)

Two goodness-of-fit statistics, bias and root mean square error (RMSE), were utilized for the calibration of the RSM-GL. These two goodness-of-fit statistics are commonly used in the calibration of surface water models. The model was calibrated until the following two criteria were met: 1) a bias value of ± 1.0 feet (ft) for all stage stations; and 2) an RMSE value smaller than 2.0 ft for all stage stations. These threshold values are well within the data error and uncertainty tolerances for the modeled area. These targets were used to determine the minimum acceptable threshold value requirements for an acceptable calibration.

A total of 336 and 321 measured stage time-series data sets were used for the calibration and validation of RSM-GL, respectively. The model is calibrated using historical stage data from 1/1/1984 to 12/31/1995. Out of the 336 gages used for stage calibration, 100% of the gages meet the acceptability criterion for both bias (1.0 ft) and RMSE (2.0 ft). None of the gages violated the pre-set bias and RMSE threshold considerations. Overall, the mean and the standard deviation of absolute bias for the calibration period were 0.21 ft and 0.18 ft, respectively. Similarly, the mean and standard deviation values of RMSE for the calibration period were 0.54 ft and 0.25 ft, respectively.

Historical stage data from 1/1/1981 to 12/31/1983, and 1/1/1996 to 12/31/2000 are used for model validation. In general, the model performed extremely well during the two validation periods. For the two validation periods, these percentages changed to 98.4% and 99.4 %, respectively. Overall, the mean and the standard deviation of absolute bias for the validation period were 0.26 ft and 0.29 ft, respectively. Similarly, the mean and standard deviation values of RMSE for the validation period were 0.59 ft and 0.35 ft respectively. For the validation period, five gages exceeded the bias threshold value of ± 1.0 feet. Two gages exceeded the RMSE threshold value of 2.0 ft. Two of the gages exceeded both criteria. The actual reasons that contributed to these deviations are not easy to identify and isolate. However, it is very likely that errors in the measured historical data may have contributed to these deviations.

Additional Analyses to Address Performance of CEPP Alternatives

The calibration/validation results mentioned above show that output from RSM-GL provides the best data available to predict the most-likely hydrologic changes as a result of the project. These above calibration/validation results show that the RSM-GL is capable of simulating with an acceptable error tolerance, the stage and other stage dependent variables such as flow, flow vectors, ponding depth and hydroperiods within the model-domain. However, it is recognized that the RSM-GL calibration results (in terms of RMSE) vary spatially across the model domain, potentially giving a rise to a concern of model performance consistency. Areas with high RMSE scores may be deemed less reliable than those with low RMSE scores. Although this is an inherent problem in all models, users of regional hydrologic models often wish to utilize a measure of model relative performance to reflect such calibration variability within the study area. Ideally, uncertainty measures should be developed as a standalone metric for model reliability. Given the inherent complexity of the subject matter, the CEPP project team proposed a simple approach that reflects the model's relative performance based on the RMSE scores.

To specifically evaluate how error in the hydrologic model could reflect alternative results' reliability (henceforth called importance), results of the RMSE utilized for the calibration of RSM-GL were used to calculate a relative importance score for each IR within the CEPP planning model. Indicator regions with a higher RMSE were generally given a lower importance score. The RMSE was noted for those gages that were located either within or directly adjacent to each of the IRs used in the CEPP planning model. Of the 33 IRs used, RMSE scores were available for 17 out of the 33 IRs, ranging from 0.29 to 0.95 ft. Best professional judgment was used to interpolate RMSE scores for the remaining 16 IRs. Using the RMSE scores at all 33 IR locations, the following equation was used to calculate the relative importance score (RIS) for each IR. **Table G-35** presents the RMSE used for each IR and the IRs relative importance score.

$$RIS_i = \frac{\left(1/_{RMSE}\right)^{\alpha}}{\sum_{i=1}^{n}\left(1/_{RMSE}\right)^{\alpha}} * n$$

Where *RMSE is the root mean square error for each IR, α is a power constant and n is the number of IRs used in the CEPP planning model. α is a measure of the performance variability steepness across the RMSE values (2 is recommended).*

Table G-35. Root mean square error statistics and relative importance scores for each Indicator Region used in the CEPP Planning Model

Indicator Region	Root Mean Square Error (RMSE)	Relative Importance Score
IR 114	0.58	0.53
IR 115	0.65	0.43
IR 116	0.84	0.25
IR 117	0.47	0.81
IR 118	0.52	0.66
IR 119	0.43	0.99
IR 120	0.37	1.34
IR 121	0.33	1.64
IR 122	0.29	2.13
IR 123	0.37	1.31
IR 124	0.30	1.99
IR 125	0.38	1.24
IR 126	0.39	1.21
IR 128	0.39	1.18
IR 129	0.32	1.81
IR 130	0.40	1.15
IR 131	0.42	1.02
IR 132	0.42	1.02
IR 133	0.47	0.81
IR 140	0.54	0.61
IR 190	0.95	0.20
MC_NE1	0.65	0.43
MC_NE2	0.65	0.43
MC_NW1	0.34	1.55
NC_NW2	0.57	0.55
MC_CE1	0.53	0.64
MC_CE2	0.53	0.64
MC_CW1	0.53	0.64
MC_CW2	0.50	0.72
MC_SE1	0.41	1.09
MC_SE2	0.39	1.20
MC_SW1	0.37	1.32
MC_SW2	0.35	1.47

Performance measure scores were based on the hydrologic conditions in IRs and flow transects, however, only one of the five Greater Everglades performance measures was based on transect flow metrics. The RSM-GL was calibrated to stage, but not transect flows. Although flow is a stage dependent variable and transect flow weighting could potentially be estimated from the relative importance scores for each IR, the decision was made to not assign importance values to transects in the CEPP planning model. Transect scores which were also included in the CEPP planning model were not assigned a relative importance factor.

Habitat unit results for Alternatives 1-4 are displayed in **Table G-36**. Scores denoted with an asterisk include the addition of the relative importance score within the CEPP planning model. Inclusion of a relative importance score did not influence the overall rank of alternative performance. **Table G-36** indicates that in both instances (weighted versus un-weighted) Alternative 4 provides the greatest lift for WCA 3 and ENP while Alternative 2 provides the least lift relative to the FWO. Alternatives 3 and 1 provide more lift in comparison to Alternative 2. Differences in HU scores between the weighted and un-weighted scores occurred primarily in northern WCA 3A with the ECB and FWO project condition. Overall, a 5% change occurred between the weighted versus un-weighted total HU scores for the ECB. A 7% change occurred between the weighted versus un-weighted total HU scores for the FWO. A 1% or less percent change occurred between weighted versus un-weighted total HU scores for the alternatives. Some locations where the FWO scored poorly and the alternatives received high scores were down-weighted the most when the importance weighting was applied, resulting in a greater change in the FWO scores. An alternative score will increase if poor scores are down-weighted and higher scores within a zone are not. The process of deciding appropriate weights raises challenging questions about methods for assigning those weights. Given this result, the CEPP project team decided to use the current default weight of 100% for all IRs within each zone. The results of this additional analysis to address the performance of CEPP alternatives indicate that the developed methodology is robust.

For Florida Bay, simulated hydrology produced by the RSM-GL at marsh gages in ENP is post-processed using multiple linear regression statistical models to predict salinities at all MMN stations in Florida Bay. Given that alternative performance in Florida Bay is dependent on upstream hydrology, and the overall rank of alternatives in WCA 3 and ENP did not change with inclusion of a relative importance score, weighting of the Florida Bay performance measure was not pursued.

An additional analysis similar to the one above was not performed for performance measures within the Northern Estuaries. Alternatives 1-4 were the same within the Northern Estuaries.

Table G-36. Habitat Unit Results for Project Alternatives 1-4

Project Region (Zone)	ECB*	ECB#*	FWO**	FWO#**	ALT 1***	ALT 1#***	ALT 2***	ALT 2#***	ALT 3***	ALT 3#***	ALT 4***	Alt 4#***
Northeast WCA 3A (3A-NE)	44,451	56,799	29,634	45,686	96,311	97,545	96,311	97,545	96,311	97,545	96,311	98,780
WCA 3A Miami Canal (3A-MC)	32,847	39,886	27,373	34,412	57,874	59,438	57,092	58,656	56,310	57,874	57,092	58,656
Northwest WCA 3A (3A-NW)	30,970	38,713	30,266	38,009	54,902	55,606	53,494	54,902	53,494	54,902	53,494	54,902
Central WCA 3A (3A-C)	108,414	107,042	105,669	105,669	109,786	109,786	109,786	109,786	109,786	109,786	109,786	109,786
Southern WCA 3A (3A-S)	69,247	69,247	68,423	68,423	68,423	68,423	67,598	67,598	67,598	67,598	68,423	68,423
WCA 3B (3B)	55,697	55,697	48,842	49,699	58,268	58,268	59,125	59,125	57,411	57,411	54,840	55,697
Northern ENP (ENP-N)	57,557	67,566	55,054	65,064	102,601	102,601	101,350	102,601	103,852	105,103	102,601	103,852

Project Region (Zone)	ECB*	ECB#*	FWO**	FWO#**	ALT 1***	ALT 1#***	ALT 2***	ALT 2#***	ALT 3***	ALT 3#***	ALT 4***	Alt 4#***
Southern ENP (ENP-S)	124,068	124,068	126,454	124,068	169,400	169,400	169,400	169,400	176,558	176,558	188,488	188,488
Southeast ENP (ENP-SE)	79,711	79,711	81,062	81,062	82,413	82,413	82,413	82,413	82,413	8,2413	83,764	83,764
Total HU WCA 3 and ENP	602,962	638,729	572,777	612,092	799,978	803,480	796,569	802,026	803,733	809,190	814,799	822,348

* Denotes instances in which indicator regions were assigned a relative importance weight.
** HU values for the ECB represent those calculated in the year 2010.
*** HU values for the FWO and ALT 1 through ALT 4 represent those calculated in the year 2072.

G.5 ASSUMPTIONS OF THE CEPP PLANNING MODEL

There is no standardized methodology for predicting ecosystem benefits that result from habitat restoration projects. For the Corps 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. Assumptions used in the CEPP planning model that may influence the accuracy of its results are described below.

1. **Equal Weighting:** Metrics may contribute equally or unequally to a final evaluation. The process of deciding appropriate weights raises challenging questions about methods for assigning those weights. The CEPP planning model assumed that each project performance measure would carry equal weight in the overall benefits calculation. One performance measure was not assumed to be more "important" than another. In addition, all project objectives were considered equally important restoration targets and were assumed to carry equal weight in the overall benefits calculation.

   The CEPP planning model was developed during prior plan formulation efforts under CERP. The model was developed during planning efforts for the Decompartmentalization (Decomp) and Sheet flow Enhancement of WCA 3 (Project Implementation Report I). This component of the CERP is now a part of CEPP. A number of weighting options were used in alternative evaluations for Decomp PIR 1; however the weights chosen by that planning team did not influence the overall ranking of project alternatives. The planning effort for Decomp used several of the same performance measures, had similar project objectives and was located within the CEPP project domain. Because of the similarity between planning efforts, the CEPP project team chose not to use similar weighting options.

2. **Spatial Extrapolation:** The CEPP planning model assumed that each of the performance measures used within the Northern Estuaries, WCA 3, ENP, and Florida Bay could be extrapolated from the point locations modeled by RSM-BN and RSM-GL to the larger areas they represent. This approach assumed that the results of the RSM-BN and RSM-GL performance measures were similar across spatial scales within these geographic regions.

   It is acknowledged that performance may vary across the hydrologic model domain; however, the CEPP project team considers the current approach to be acceptable for the purposes of evaluating relative performance between alternatives. Indicator regions and transects were used within WCA 3 and ENP in part because there is greater confidence in the hydrologic model results at these locations than at other locations within the model domain. Furthermore, while extrapolation of performance measures from IRs and/or transects to larger zones can potentially impact model accuracy; a sufficient number of IRs and transects have been used within each zone to address this concern.

3. **Reference Degraded Areas:** For those performance measures used within WCA 3 and ENP, reference areas within the existing system were used to set the minimum value from which each project performance measure was re-scaled. The environmental conditions in northern WCA 3A were assumed to be an accurate measure of the current degraded ecologic condition of WCA 3A. Indicator regions and transects (under existing conditions) within northwest WCA 3A consistently produced the lowest performance measure scores as a result of the modeled water

depths and hydroperiods. The results showed this to be the most degraded location within WCA 3 and ENP and are consistent with field observations.

It is recognized that this computation may be viewed as a limitation of the CEPP planning model to mask trade-offs by embedding an assumption that conditions can be made no worse than the values used to set the minimum score (ECB); however the CEPP project team considers the current approach to be acceptable for the purposes of evaluating relative performance between alternatives. Increasing the range between the minimum and the target to include conditions worse than “fully degraded” artificially compresses the range in scores and makes it difficult to distinguish the relative differences between alternatives. It should also be noted that improperly decreasing the range between the minimum and target artificially expands the relative differences between alternative scores. Inconsistent re-scaling between performance measures indirectly alters the weight given to each performance measure when the scores are aggregated. Scores that are compressed by improper re-scaling will have less influence over the final aggregated scores and the computed lift. The intent of this scoring method is to provide consistent re-scaling analogous to habitat suitability indices (HSIs), in that the scores are scaled between the points of zero suitability (for the given metric) and target conditions.

The CEPP planning model provides scores which show increasingly degraded conditions up to the point that the location is considered “fully degraded”. In this instance, the term “fully degraded” references a habitat type that has degraded so poorly that it has converted to a different type of habitat. For example, a ridge and slough type habitat may degrade to a habitat type similar in elevation with a significantly different hydroperiod and species composition. At this point, the habitat suitability score would fall to zero as it is no longer a ridge and slough type habitat. A score of zero does not imply that the area is in the worst possible condition according to any scale, it means that the area no longer ranks as a ridge and slough type habitat. Again, this is consistent with the concept used by habitat suitability indices; indices are not intended to drop below zero.

A review of the CEPP planning model was conducted to evaluate instances in which the methodology used to rescale performance measure sub-metric scores potentially masked cases when the un-scaled sub-metric score is higher than the target or the un-scaled sub-metric score is lower than the score used to set the minimum value for purposes of rescaling. **Table G-37** and **Table G-38** illustrate instances in which the un-scaled sub-metric score for a given performance measure, achieved less than 95% of the score used to set the minimum value for the ECB, FWO and alternatives. Instances in which this occurred were few in comparison to the amount of data that is produced for each of the performance measure sub-metrics and occurred primarily with the ECB or FWO in northern WCA 3A. In total there are 267 scores per alternative, of which (for the alternatives) 13 or fewer were scores below the ECB score at the reference degraded site. In other words, only about 1% of the alternative scores were set to zero when the score could be considered negative relative to the base (reference) condition.

Resetting values less than zero to zero with the FWO provided a more conservative calculation of habitat unit lift calculations (*i.e.* HU Alternative – HU FWO) by reducing the magnitude of lift calculated between the alternatives and the FWO for instances in which project alternatives scored higher than the score used to set the minimum value. The influence of this calculation would affect all alternatives similarly.

Instances in which an alternative contributed to further departure from sought hydrologic conditions below what is considered a “fully degraded” ridge and slough habitat occurred primarily in WCA 3B at Transect T 15 for *PM. 2.1 Timing of Sheetflow* and at Transect T18N for PM 2.3 *Distribution of Sheetflow*.

Table G-37. Instances in which the un-scaled sub-metric score achieve less than 95% of the score used to set the minimum value for the ECB and FWO.

Performance Measure Metric	Zone	Location	Baseline	Raw Score	Score Used to Set 0 Value
1.1	Zone 3A-NE	115	FWO	68	73
1.1	Zone 3A-MC	MCNE1	FWO	64	73
1.1	Zone 3A-MC	MCNE2	FWO	60	73
2.1	Zone 3A-NW	T5	FWO	0.26	0.30
2.1	Zone 3B	T15	ECB	0.22	0.30
2.1	Zone 3B	T15	FWO	0.26	0.30
2.1	Zone ENP-N	ENP3	ECB	0.08	0.30
2.1	Zone ENP-N	ENP3	FWO	0.10	0.30
3.1	Zone 3A-NE	115	FWO	-1861.11	-1478.60
3.1	Zone 3A-NE	116	FWO	-1705.22	-1478.60
3.1	Zone 3A-MC	MCCE2	ECB	-1901.56	-1478.60
3.1	Zone 3A-MC	MCNE1	ECB	-1643.56	-1478.60
3.1	Zone 3A-MC	MCNE1	FWO	-2172.00	-1478.60
3.1	Zone 3A-MC	MCNE2	ECB	-4206.67	-1478.60
3.1	Zone 3A-MC	MCNE2	FWO	-6218.08	-1478.60
3.1	Zone 3A-MC	MCNW1	ECB	-1625.22	-1478.60
3.1	Zone 3A-MC	MCNW2	FWO	-1752.06	-1478.60
3.1	Zone 3A-MC	MCCE2	FWO	-2911.12	-1478.60
5.1	Zone 3A-MC	MCNE1	ECB	5.77	7.32
5.1	Zone 3A-MC	MCNE1	FWO	0	7.32
5.1	Zone 3A-MC	MCNE2	ECB	1.03	7.32
5.1	Zone 3A-MC	MCNE2	FWO	0.77	7.32
5.1	Zone 3A-MC	MCCE2	FWO	3.96	7.32
5.1	Zone 3A-MC	MCNW1	FWO	6.64	7.32
5.2	Zone 3A-MC	MCNW2	ECB	7.45	9.76
5.2	Zone 3A-MC	MCNW2	FWO	7.32	9.76

Table G-38. Instances in which the un-scaled sub-metric score achieve less than 95% of the score used to set the minimum value for each project alternative.

Performance Measure Metric	Zone	Location	ALT	Raw Score	Score Used to Set 0 Value
2.1	Zone 3B	T 15	ALT 1	0.24	0.30
2.1	Zone 3B	T 15	ALT 2	0.01	0.30
2.1	Zone 3B	T 15	ALT 3	0.16	0.30
2.1	Zone 3B	T 15	ALT 4R	0.27	0.30
2.1	Zone 3B	T 15	ALT 4R2	0.22	0.30
2.3	Zone 3B	T18N	ALT 2	2.29	1.93
2.3	Zone 3B	T18N	ALT3	2.14	1.93
3.1	Zone 3A-MC	MCCE2	ALT 4R	-1529.56	-1478.60
3.1	Zone 3A-MC	MCSE2	ALT 4R	-1489.22	-1478.60
7.1	SE-1	Associated water control structures	ALT 1	37.80	31.15
7.1	SE-1	Associated water control structures	ALT 2	37.80	31.15
7.1	SE-1	Associated water control structures	ALT 3	37.80	31.15
7.1	SE-1	Associated water control structures	ALT 4	37.80	31.15

Instances in which the un-scaled sub-metric score exceeded target conditions occurred primarily with three Greater Everglades performance measures; *PM 1.1 Percent Period of Record of Inundation, PM 3.1 Drought Intensity Index,* and *PM 4.1-4.3 Number and Duration of Dry Events in Shark River Slough.* These performance measures are intended to measure the occurrence of undesirable dry hydrologic conditions. For these performance measures there is no penalty for exceeding the target. Exceeding the target would not increase the severity of dry downs and result in potential for further unnatural loss of organic soils.

4. **<u>Inferring Ecosystem Response from Hydrologic Change:</u>** The CEPP planning model also assumed that ecosystem health can be assessed with hydrologic conditions only. The quantification of benefits for a restoration project essentially measures desired hydrologic changes which act as a surrogate for ecological suitability or habitat units. The restoration of natural landscape patterns and native flora and fauna within the project area may be affected by a multitude of other parameters and the interactions of such factors including water quality, fire patterns, disturbance and meteorological conditions including climate change among others. The basic premise of the CERP is to restore the quantity, quality, timing, and distribution of water within the south Florida ecosystem. The fundamental role and importance of

hydrology in Everglades restoration is expressed in the CEMs developed early in CERP. Even though uncertainty is recognized, ecological benefits derived from hydrologic performance measure metrics, calculated from model output, are useful in making planning-level decisions as they provide a quantitative means for comparing alternatives to determine the best performing alternative. CEPP has addressed other factors critical to ecosystem restoration in the main body of the Final PIR/EIS including assessments of potential effects of alternatives on water quality, invasive and native nuisance species, listed species and other wildlife and their habitat.

5. **Accuracy of the FWO Project Condition:** The FWO project condition is the projection and forecast of what is “most likely” to occur in the study area over the planning horizon. The FWO project condition is used as a baseline in plan formulation and benefits calculations to calculate HU lift. Incorrect assumptions related to the FWO project condition have the potential to have bearing on the amount of ecosystem benefits derived from the project. The project team for CEPP has established consistent assumptions for the FWO project conditions in the study area, including items such as land use, water supply demands, and operations of the C&SF project. First and second generation CERP projects will be included in the FWO project condition.

G.6 PLAN IMPLEMENTATION

Implementation of CEPP will occur over many years and include many actions by USACE and SFWMD. Multiple Project Partnership Agreements (PPAs) will be executed prior to construction. Each PPA will cover a separable element that groups inter-related project features to provide hydrologic and ecological benefits. These PPAs include the construction of logical groupings of plan elements, agreed upon by the USACE and SFWMD, that maximize benefits to the extent practicable consistent with project dependencies and the Adaptive Management and Monitoring Plans (see **Annex D**). The text below is in support of information that appears in **Section 6.7** (**Plan Implementation**) of the main report. Rationale for the percent gain in project benefits for each PPA using both the volume based approach and consensus approach as described in **Section 6.7** (**Plan Implementation**) are provided below.

Table G-39 shows four sets of cost and benefit information, one for each of the proposed three PPAs as stand-alone elements, and one with the costs and benefits gained from implementation of PPA New Water subsequent to the completion of features included in PPA North and PPA South. For additional information see **Section 6.7.1.2** (**Multiple Project Partnership Agreements**) and **6.7.1.3** (**Approach Taken to Estimating Phased Benefits**) in the main report.

Table G-39. Benefits Achieved with Implementation of PPAs.

PPA First Cost $Million	Benefits of the Recommended Plan	Relationship to CEM	Acres Improved	Benefits: Volume Based	Benefits: Consensus Based					Non-CEPP Dependencies	CEPP Internal Dependencies
					NE	WCA 3A	WCA 3B	ENP	Florida Bay		
PPA North Only $567	The Miami Canal functions as unnatural source of drainage for WCA 3A; effectively overdraining area. Benefits gained from construction of features that re-distribute inflows into northern WCA 3A include localized improvements in ●water depths and durations ● suitability for slough vegetation ● patterns of sheetflow ● reductions in the risk of peat fires ● beneficial shifts in habitat for wildlife species Southern WCA 3A would continue to be impounded by the L-67 A/C, and L-29 canal until outlet capacity is improved.	*Stressors:* Improved hydroperiods Increased Sheetflow *Ecological* Effects: Reduced fire risk and soil oxidation Peat Accretion *Attributes:* Improved fish, alligator, wading bird conditions, Maintain sawgrass Restore ridge and slough	Northern WCA 3A 272,070	Maximum Potential Hydrologic Benefits 41% of Alt 4R2*	0%	3A-NE: 25-50% 3A-NW: 40-70% 3A-MC: 40-70% 3A-C: 0% 3A-S: 0%	0%	ENP-N: 0% ENP-S: 0% ENP-SE: 0%	0%	A-1 FEB & Restoration Strategies (WQBEL) Appendix A Water Quality Compliance 8.5 SMA and Existing S-356 C-111 South Dade MWD 1-Mile Bridge & Road Raising	L-4 levee degrade and L-5 canal improvements generate primary source of fill for backfilling Miami Canal. Implementation of PPA North is not dependent on PPA South.
PPA South Only $454	WCA 3B has become a rain-fed compartment dominated by sawgrass. Remaining tree islands have been reduced in elevation. Flows through NESRS are reduced resulting in lower wet season depths and more frequent and severe dry downs. Over-drainage along the eastern flanks of NESRS has resulted in shifts in vegetative community structure and invasion by exotic woody species. Increased capacity of S-356 and S-333, degradation of the L-29 levee, and construction of the Blue Shanty Levee would increase flows to NESRS and provide minor benefits to Florida Bay. Florida Bay is the main receiving waterbody of the Greater Everglades and is heavily influenced by changes in the timing, distribution, and quantity of freshwater flows upstream. Benefits gained from construction of features that re-introduce flows in WCA 3B, NESRS and Florida Bay include improvements in ● water depths and durations ● suitability for slough vegetation ● patterns of sheetflow ● reductions in the risk of peat fires ● reductions in the intensity, frequency, and duration of hypersaline events ● beneficial shifts in habitat for wildlife species Construction of these features will ready the system for additional inflows from Lake Okeechobee, providing outlet capacity for WCA 3.	*Stressors:* Improved hydroperiods Increased sheetflow *Ecological Effects:* Reduced fire risk and soil oxidation Peat accretion Improved salinities *Attributes:* Improved fish, alligator, wading bird conditions Maintain sawgrass Restore ridge and slough, Increased seagrass	WCA 3A C 173,233 WCA 3A S 82,437 WCA 3B 85,688 ENP 498,819 Florida Bay 476,096	Minimum Potential Hydrologic Benefits 12% of Alt 4R2 WCA 3B** Maximum Potential Hydrologic Benefits 45% of Alt 4R2 NESRS and Florida Bay***	0%	3A-NE: 0% 3A-NW: 0% 3A-MC: 0% 3AC: 70-90% 3AS: 70-90%	70-90%	ENP-N: 40-70% ENP-S: 10-20% ENP-SE: 10-20%	10-20%	BCWPA C-11 Impoundment TTNS Bridging & Road Raising	Evaluation of results from introducing flows into WCA 3B through L-67 A Structure 1 would determine whether additional L-67 A inflow structures could be implemented prior to construction of Blue Shanty levee. (**Annex D**) L-67 C, L-67 Ext and L-29 levee removals generate source of fill for Blue Shanty levee. Old Tamiami Trail can be completed at any time during implementation, but must precede backfilling of L-67 Extension Canal. Construction of Blue Shanty levee would occur after increase in capacity of S-356. Implementation of PPA South is not dependent on PPA North.

PPA First Cost $Million	Benefits of the Recommended Plan	Relationship to CEM	Acres Improved	Benefits: Volume Based	Benefits: Consensus Based					Non-CEPP Dependencies	CEPP Internal Dependencies
					NE	WCA 3A	WCA 3B	ENP	Florida Bay		
PPA New Water Only $879	The A-2 FEB decreases high volume freshwater discharges from Lake Okeechobee to the Northern Estuaries. Additional water sent south from the Northern Estuaries to the A-2 FEB would provide limited benefits to northern WCA 3A as the Miami Canal would continue to function as a source of drainage for WCA 3A. Limited benefits will be provided to ENP due to construction of the seepage barrier wall. Florida Bay may benefit as it is largely influenced by changes in freshwater flows upstream. Benefits gained from construction of the A-2 FEB and seepage barrier wall include ● improvements water depths and durations ●improvements in optimal salinity ranges for estuarine communities ● decreased turbidity and sedimentation in the estuaries ● maintain level of service for flooding Without additional outlet capacity provided by PPA South, only limited water could be introduced to WCA 3A. The A-2 FEB would remain full and reduce the opportunities to divert water away from the Northern Estuaries that the full CEPP plan provides.	*Stressors:* Improved hydroperiods, Increased sheetflow, Reduced high flows *Ecological Effects:* Reduced fire risk and soil oxidation Peat accretion Improved salinities *Attributes:* Improved fish, alligator, wading bird conditions Maintain sawgrass Restore ridge and slough Increased oyster and seagrasses	~ 1.2 Million Acres Northern Estuaries, WCA 3A, ENP, and Florida Bay	Slight increases in freshwater flowing into Everglades	0-5%	0-5%	0%	0-5%	0-5%	IRL-S C-44 Reservoir LO Regulation Schedule Revisions	Seepage Barrier along L-31 N needs to be completed prior to the A-2 FEB. Implementation of PPA New Water is dependent on features in PPA South
PPA New Water (After PPA North and South features are built) $879	The A-2 FEB decreases high volume freshwater discharges from Lake Okeechobee to the Northern Estuaries. New water from Lake Okeechobee is sent south to achieve the full extent of ecological benefits for CEPP. Benefits gained from construction of the A-2 FEB and seepage barrier wall include ● improvements in optimal salinity ranges for estuarine communities ● decreased turbidity and sedimentation in the estuaries ● increases in the amount of water available for municipal and industrial uses in LECSA 2 (Broward County) and LECSA 3 (Miami-Dade County) by ~ 12 and 15 MGD/day. ● maintain level of service for flooding ● landscape improvements (i.e., large-scale connectivity and reduced compartmentalization) associated with the restoration of hydroperiods and sheetflow from the Northern Estuaries to coastal mangroves of ENP.	*Stressors:* Improved hydroperiods Increased sheetflow Reduced high flows *Ecological Effects:* Reduced fire risk and soil oxidation Peat accretion Improved salinities *Attributes:* Improved fish, alligator, wading bird conditions Maintain sawgrass Restore ridge and slough Increased oyster and seagrasses	~ 1.5 Million Acres Northern Estuaries, WCA 3, ENP, and Florida Bay	Significantly increases freshwater flowing into Everglades ~ 210,000 Acre Feet per Year On Average	100%	3A-NE: 50-75% 3A-NW: 30-60% 3A-MC: 30-60% 3A-C: 10-30% 3A-S: 10-30%	3B:10-30%	ENP-N: 30-60% ENP-S: 80-90% ENP-SE: 80-90%	FB: 80-90%	IRL-S C-44 Reservoir LO Regulation Schedule Revisions	Seepage Barrier along L-31 N needs to be completed prior to the A-2 FEB. Implementation of PPA New Water is dependent on features in PPA South.

*Minimum benefits were not determinable for WCA 3A (PPA New Water Only) **Maximum benefits were not determinable for WCA 3B (PPA South Water Only) ***Minimum benefits were not determinable for ENP and Florida Bay (PPA South Water Only).

G.6.1 PPA North Only

See Section 6.7.1.4 (PPA North Only) of the main report.

G.6.1.1 Benefit Calculation – Volume Based Approach

The recommended plan provides a combined average annual increase of 210,000 ac-ft per year in the quantity of freshwater that is redirected south from Lake Okeechobee to the central portion of the Everglades across the Redline to WCA 2A and WCA 3A, based on comparison between the recommended plan and the future without project baseline used for CEPP formulation (FWO). Following identification of the recommended plan in June 2013, the CEPP base condition assumptions were subsequently revisited and updated to represent the most current information for the analysis of Savings Clause requirements and Project-Specific Assurances (refer to **Section 6.8** of the main report, **Appendix A**, and **Annex B** for additional details). Based on comparison between the updated future without project baseline (IORBL1) and the recommended plan the combined average annual increase of freshwater redirected across the Redline from Lake Okeechobee to WCA 2A and WCA 3A is slightly higher at 214,000 ac-ft per year (2% increase). Due to treatment capacity considerations for STA 2 and STA 3/4 and the recommended plan L-6 diversion operations, the net volume flow increases provided with the recommended plan are not uniformly distributed between WCA 2A and WCA 3A. The average annual WCA 3A inflows are significantly increased by 362,000 ac-ft, and average annual WCA 2A inflows (STA 2 and S-7) are correspondingly significantly decreased by 148,000 ac-ft. The IORBL1 provides more water than WCA 2A needs, and the recommended plan utilizes some of this excess IORBL1 water, in addition to the additional flows redirected south from Lake Okeechobee, to increase the hydroperiods and achieve restoration objectives in WCA 3 and ENP through the L-6 diversion operations. The L-6 diversion operations shift an average annual volume of 148,000 ac-ft of water from WCA 2A to WCA 3A.

The benefits provided by the recommended plan to WCA 3A is based on an average annual increase of 362,000 ac-ft per year in the quantity of freshwater flowing across the Redline to WCA 3A, assuming comparison to the updated IORBL base condition. Surface water inflows along the Redline to WCA 3A correspond to the sum of structure inflows from S-8 pump station discharges to the Miami Canal and discharges to the S-8A gated culvert (which diverts water to the L-4 Levee degrade), in addition to S-150 and STA-5/STA-6 outflows to WCA 3A. Based on consideration of average annual structure flows only, the maximum potential hydrologic benefits provided by PPA North (L-6 diversion; no additional flows redirected south from Lake Okeechobee) to WCA 3A are estimated to be 41% of the recommended plan (148,000 ac-ft /362,000 ac-ft per year, on average). This estimate is characterized as a maximum since the recommended plan L-6 diversion quantities cannot be achieved with PPA North only due to the need to maintain preferred hydrology in WCA 2 and the limited storage capacity of the A-1 FEB. This simplified approach does not account for potential hydrologic changes within eastern WCA 3A associated with the reduction of flow volumes from the S-11 structures located adjacent to northeastern WCA 3A along the North New River Canal that would accompany the reductions in inflow to WCA 2 and the L-6 diversion operations; in general, however, reductions in flows through the S-11 structures would be beneficial to WCA 3A since inflows from the S-11 structures currently contribute to undesirable ponding conditions in northeastern WCA 3A east of the Miami Canal and North of the L-67 A Canal.

The maximum 41% gain in potential hydrologic benefits estimated for WCA 3A with PPA North was then multiplied by the proportion of overall CEPP benefits by WCA 3A (WCA 3A produces 41% of overall CEPP benefits), producing a single maximum benefit value of approximately 17% for this approach. Since this preliminary approach could not provide a minimum percent gain for WCA 3A benefits and does not account for the additional portion of overall benefits that are attributable to improved intra-annual timing of flows and the spatial variability across benefit zones, this estimate was recognized as incomplete and considered only as a reference point during the more-detailed consensus method (refer to **Section G.6.1.2**).

G.6.1.2 Benefit Calculation – Consensus Approach

As part of screening alternatives for distribution and conveyance in northern WCA 3A, CEPP considered previously conducted plan formulation, screening and modeling data from the Decompartmentalization and Sheeflow Enhancement of WCA 3 (Decomp) Documentation Report, which helped provide a basis for identification of the initial array of options to be analyzed through the CEPP formulation process (See **Appendix E**). This initial array utilized the existing water budget entering WCA 3A, and provided invaluable insight and information on the performance of different distribution and backfilling options. Although the detailed assumptions for the Decomp modeling effort differ from the recommended plan, several of the alternatives from Decomp are structurally similar to the recommended plan features in PPA North. Furthermore, the CEPP Planning Model used for benefits (habitat unit) computation was developed during prior plan formulation efforts for Decomp. The Decomp model used several of the same performance measures, project zones, had similar project objectives, and was located within the CEPP project domain. Comparisons across models with different assumptions and applicable versions are generally not recommended; however results from the Decomp modeling effort can be used to gain insight into the benefits gained from construction of the distribution and conveyance features in northern WCA 3A under the existing water budget.

Decomp Alternative H included a hydropattern restoration feature and full backfill of the Miami Canal from S-8 to Interstate-75 (I-75). Alternative H is similar to the recommended plan in that the backfill length is the same and the distribution of flow is focused in the northwest corner of WCA 3A. Habitat unit (HU) results for Alternative H indicated that hydrologic improvements were apparent in northern WCA 3A, north of I-75, and were primarily associated with Zones 3A-NE, 3A-NW, and 3A-MC. Alternative H included a hydropattern restoration feature that was longer in length than that identified in the features of the recommended plan and extended east of S-8 to the G-205 structure located south of the Holey Land Wildlife Management Area and west of STA 3/4. Hydrologic improvements were also seen in Zone 3A-C; however the magnitude of improvement was small relative to the benefits gained in the northern WCA 3A zones. The percent of HU lift for Alternative H relative to the CEPP recommended plan was calculated for each zone in northern WCA 3A (Maximum Benefits Zone 3A-NW 71%, Zone 3A-MC 64%, Zone 3A-NE 71%). These percentages were used as a reference to estimate the percent of performance achieved from implementation of PPA North. Performance estimates for northeastern WCA 3A were lowered relative to the remaining portions of northern WCA 3A as Alternative H included a longer hydropattern restoration feature that was able to distribute flow to this area.

Percent of performance estimates using the consensus approach, range from 40% to 70% for northwestern WCA 3A (Zone 3A-NW), 40-70% for areas directly adjacent to the Miami Canal (Zone 3A-MC), and 25-50% for northeastern WCA 3A. The proportion of each zone's (i.e. Zone 3A-NW, 3A-MC, 3A-NE) habitat unit lift within WCA 3A relative to the respective total habitat unit lift for WCA 3A was then determined and multiplied by the minimum and maximum ranges for each zone. These adjusted ranges were then summed to calculate a minimum and maximum range for WCA 3A. Implementation of PPA North would yield an overall performance of approximately 30-56% of WCA 3A benefits based on the consensus approach. The values representing the minimum and maximum range for each region developed using the consensus approach were averaged to determine a midpoint (43%). The midpoint was then multiplied by the proportion of overall CEPP benefits provided in WCA 3A (41%), producing a single value of approximately 18% for this approach. Implementation of PPA North would not benefit the remaining regions of the CEPP study area.

G.6.2 PPA South Only

See Section 6.7.1.5 (PPA South Only) of the main report.

G.6.2.1 Benefit Calculation – Volume Based Approach

Alternative 2 as modeled in the final array of alternatives, was used as a surrogate to estimate the minimum potential hydrologic benefits provided by PPA South for WCA 3B. Alternative 2 considered conveyance features in the L-67A Canal and associated gaps in the L-67C canal similar to the recommended plan. Alternative 2 did not include construction of the Blue Shanty Flow way, but included the construction an additional gravity structure out of WCA 3B, allowing water to flow from WCA 3B to NESRS within the flow way footprint. Both alternatives included an increase in the capacity of the S-333 and S-356 structure. Alternative 2 included a shorter seepage barrier wall than the recommended plan south of Tamiami Trail. It is expected that full recommended plan water level depths within the Blue Shanty Flowway would not be able to be realized under PPA South without the PPA New Water additional seepage management feature and due to the need to maintain preferred hydrology in WCA 3A with existing inflows (prevent increased dry outs). Under PPA South operations, the degraded L-29 segment in the recommended plan was assumed to discharge a similar flow volume as the three total L-29 gravity outlet structures from Alternative 2.

The estimated minimum potential hydrologic benefits to WCA 3B was calculated by dividing the average annual increased volume of outflows along the L-29 Canal for Alternative 2 (~28,000 ac-ft per year on average, as compared to the future without condition (IORBL1)) by that of the recommended plan (~239,000 ac-ft per year on average) to arrive at a minimum project benefit of approximately 12%. This estimate assumed that L-29 outflows provide more applicable comparison criteria than other potential volume-based metrics, such as WCA 3B inflows, WCA 3B net inflows, or WCA 3B total outflows. This estimate does not include or account for inflow volumes to WCA 3B, and similar to the habitat unit calculations, does not separately take into account the hydrology of the Blue Shanty Flowway. The average annual overall flow for WCA 3B was used to inform the consensus approach for WCA 3B east.

The estimated maximum potential hydrologic benefits provided by PPA South for NESRS and Florida Bay were estimated by comparing between the 2008 MWD Tamiami Trail Modifications LRR and the recommended plan. The maximum percent gain in hydrologic benefits (45%) was calculated by dividing the average annual volume of inflows to NESRS along the L-29 Canal demonstrated by the LRR relative to that of the recommended plan (341,000 ac-ft per year /761,000 ac-ft per year). This estimate assumed that the LRR analysis, which was based on an L-29 maximum operating stage of 8.5 feet NGVD and analyzed with a different spreadsheet modeling tool and assumptions, provides a indicative (albeit not equivalent) approximation of NESRS inflows with PPA South.

The minimum percent gain in potential hydrologic benefits estimated for WCA 3B (12%) and the maximum percent gains in hydrologic benefits for ENP (45%) and Florida Bay (45%) were then multiplied by the proportion of overall CEPP benefits by the respective region (WCA 3B produces 4%, ENP produces 31% and Florida Bay produces 20% of overall CEPP benefits). Based on the volume approach, a combined 23% of overall CEPP benefits result from PPA South implementation. Since this preliminary approach could not provide a maximum percent gain for WCA 3B benefits or a minimum percent gain for ENP and Florida Bay benefits, and the approach does not account for the additional portion of overall benefits that are attributable to improved intra-annual timing of flows and the spatial variability across benefit zones, this estimate was recognized as incomplete and considered only as a reference point during the more-detailed consensus method (refer to **Section G.6.2.2**).

G.6.2.2 Benefit Calculation – Consensus Approach

Percent of performance estimates from the implementation of PPA South range from 70% to 90% for central (Zone 3A-C) and southern WCA 3A (Zone 3A-S), and WCA 3B (Zone 3B), 40% to 70% for northern ENP (Zone ENP-N), and 10% to 20% for southern and southeastern ENP and Florida Bay (Zones ENP-S, ENP-SE, and FB-W, C, FB-S, FB-EC, FB-NB, FB-E). A similar approach to calculate the overall performance of CEPP benefits for PPA South was done as described in **Section 6.7.1.4.2**. Implementation PPA South would yield an overall performance of approximately 3-4% of WCA 3A benefits, 70-90% of WCA 3B benefits, 25-44% of ENP and 10-20% of Florida Bay. The values representing the minimum and maximum range for each region developed using the consensus approach were averaged to determine a midpoint (4%, 80%, 34% and 15% respectively). Theses midpoints were then multiplied by the proportion of overall CEPP benefits by region and combined to produce 18% of overall CEPP benefits based on the consensus approach.

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