Appendix E. Draft recommendations for stormwater treatment areas and surface and in-ground water storage reservoirs.

Background

Previous land use including drainage, conversion, and loss of wetland systems has severely impacted the natural storage and cleansing capacity of south Florida ecosystems. Reduced natural flood storage and high nutrient levels, especially phosphorus, threaten the viability of the remaining system. To abate these impacts, Stormwater Treatment Areas (STAs) and reservoirs will be incorporated into the Central and Southern Florida Restudy Project to reduce phosphorus levels and supplant lost natural storage.

The U.S. Fish and Wildlife Service (Service), in coordination with the Florida Fish and Wildlife Conservation Commission (FWC), developed fish and wildlife enhancement recommendations for STAs and reservoirs (Table 1) planned for the Comprehensive Everglades Restoration Plan (CERP). Recommendations focus on compatibility with facilities management and operation for their principal purposes of phosphorus removal and water storage. Indeed, some recommendations may even enhance primary functions. These recommendations were developed through review of existing literature, field visits to STA and reservoir facilities by Service biologists, and interviews and discussions with facility scientists, designers, and managers.

Prior to consideration of recommendations to enhance fish and wildlife use, it is essential that contaminant levels at selected sites do not present a risk to fish and wildlife. Sites with contaminant levels that clearly present a risk in their current condition are not suitable for incorporation of fish and wildlife features. If contaminants become an issue at a particular site following construction, the site should be remediated, or if extreme, abandoned. Measures should be employed to dissuade fish and wildlife use until such time that the contaminants within the facility pose little or no risk. The Service and South Florida Water Management District (District) are using food chain models, bioassays, bioaccumulation studies, and soil desorption studies prior to construction to determine risk to fish and wildlife. Soil concentrations of contaminants are often orders of magnitude higher that those in the water column, and can pose a more relevant indication of risk to fish and wildlife than water column concentrations. In addition, there are questions concerning sediment contamination accumulation in any given reservoir or STA as the facility operates over time. However, information on long-term effects is not available to accurately determine if accumulation of contaminant levels in reservoirs or STAs will pose an unacceptable risk to fish and wildlife. Risk from contaminant accumulation within the entire STA could be reduced by designing initial treatment cells for deposition of suspended particulate-bound contaminants from the water column prior to the water entering the larger portion of the STA. Some reservoirs and STAs must be built and monitored before these questions can be fully answered. We recommend that an interagency group develop a list of research needs associated with STA/R operation and maintenance. Initial interagency research and monitoring recommendations should be reviewed by RECOVER and incorporated into an update of the Monitoring and Assessment Plan.

Why Incorporate Wildlife Features?

The CERP incorporates approximately 158,000 acres of reservoirs and 33,000 acres of STAs for an estimated total of 191,000 acres (300 square miles or a little less than half the size of Lake Okeechobee). This total does not include acres of non-CERP projects such as the Everglades Construction Project which is estimated to be more than 40,000 acres. The sheer physical extent of the acreage involved in these facilities dictates that wildlife features be considered in their design, construction, operation, and maintenance.

Construction and operation of STAs and reservoirs will unavoidably supplant existing fish and wildlife habitat values. In most cases, efforts are being made by PDT's to ensure that natural areas are not targeted for facility siting. However, in some cases, the footprint may unavoidably fragment or include some rare or valued habitats (*e.g.*, wetlands, scrub habitats). Federally listed species use these habitats, and when they do, incidental take [as defined in the Endangered Species Act of 1973, as amended (ESA) (87 Stat. 884; 16 U.S.C. 1531 *et seq*.)] may occur. Well-designed and operated facilities may also benefit federally listed species offsetting potential adverse effects. The Service recognizes that STAs and reservoirs are designed to meet CERP restoration goals, and that will benefit fish and wildlife resources downstream. Although the primary objective of the feature has priority, fish and wildlife enhancement opportunities should be considered for inclusion within the facility design and operation whenever possible.

The loss of original wetland spatial extent and quality in the natural system of South Florida was identified as a key issue of Everglades ecosystem restoration. Natural system attributes degraded by extensive wetland losses include decreases in: (1) genetically viable numbers, distribution, and reproduction of native wildlife, particularly of habitat-specialist and wetland obligate or dependent species; (2) habitat diversity of native flora and fauna; and (3) the ability of a species to recover from disturbance. While STAs and reservoirs assist in improving habitat quality downstream, they will not ameliorate natural everglades wetland spatial extent loss and in some cases can be responsible for increasing this loss. However, fish and wildlife habitat within these facilities can be enhanced with the design, construction, and management for fish and wildlife features compatible with primary storage and treatment functions. While these constructed systems are not meant to replace natural system habitats, they can incorporate features to enhance and supplement them on a local and landscape scale.

Applicable Authorities

The Fish and Wildlife Coordination Act of 1958, as amended (FWCA) (48 Stat. 401; 16 U.S.C. 661 *et seq*.) establishes fish and wildlife conservation as a coequal purpose or objective of federally funded water resource projects. The ESA requires that Federal agencies include programs to aid in the conservation and recovery of endangered species. Incorporation of wildlife features into STAs and reservoirs would address requirements of both Acts.

Approach and Recommendations

The Service conducted a literature search on issues associated with fish and wildlife use of STAs and reservoirs with emphasis on habitat, phosphorus treatment, water quality, contaminants, design, and operation. Staff visited eight active STA and reservoir sites in south Florida and interviewed scientists, designers, and managers to develop a list of design and management options. These options will enhance fish and wildlife habitats while complimenting or minimizing negative impacts on the primary functions of treatment and/or water storage. Each recommendation in Table 1 presents information about fish and wildlife benefits and compatibility or benefit to the primary STA or reservoir function.

Design elements that mimic natural irregular vertical and horizontal landscape spatial features are pivotal to enhancing fish and wildlife function. Irregular shorelines, natural buffers, sloping littoral zones, and microtopographic features are essential to provide and sustain a diversity of habitats during the water level manipulations necessary for treatment and storage. These features also provide ecotones, or transition areas between communities that create an edge effect. For example, wading bird use of ridge and slough habitat is concentrated on the transition between the ridge and adjacent slough. Small fish foraged on by wading birds find cover in the emergent plants along the transition zone between ridge uplands and slough wetlands. Therefore, the birds find the highest concentration of fish in the border. Facilities with microtopographic relief, or bottom surfaces that vary similar to the historic natural landscape rather than laser leveled surfaces, will mimic natural wetland ecotones at a variety of water elevations. Additionally, operational plans designed for primary functions (*e.g.*, seasonal water level manipulations, maintenance techniques and schedules, etc.) can be developed and implemented to minimize negative fish and wildlife impacts.

Not all recommendations presented in Table 1 are practicable or suggested for all sites. However, they are widely applicable and should be considered for incorporation into STA and reservoir design and operation. The Service can help quantify the benefits of including fish and wildlife recommendations in the planning process.

Next Steps

These recommendations should be considered a work in progress which will evolve as additional information becomes available. We recommend the coordination of an interagency workshop to build on this initial effort and further develop and refine STA and reservoir design, operation, monitoring, and adaptive management recommendations and to develop research needs. Recommendations, or sets of categorically similar recommendations, that are valuable and practicable would be detailed, refined, and supported by literature through a white paper approach. Reaching interagency consensus on design and operation measures which benefit fish and wildlife resources while maintaining water storage and cleansing functions is paramount to a successful STA and reservoir CERP component and will enhance overall program restoration goals.

Table 1. Recommendations for wildlife design or operational measures for stormwater treatment areas (STAs) and reservoirs (R).
R[1] - R(litt) = Reservoir littoral zone

	Wildlife/Water Quality Recommendations	**Fish and Wildlife Benefit Rationale**	**Compatibility/Benefit to Reservoir/STA Primary Function**	**Reference**	**STA or R[1]**
	Contaminants				
1	Evaluate and Remediate Contaminants. Evaluate sites prior to acquisition in accordance with protocols developed by the FWS and District. If necessary, remediate site to eliminate concerns for remobilization of contaminants and exposure of wildlife.	Use of former agricultural areas with historic use of persistent pesticides may result in high sediment levels of these contaminants. Remobilization would be harmful to wildlife.	Remobilization of contaminants would limit benefits of water cleansing STA's and utility of stored reservoir water.	St.Johns River Water Management District, 1999	STA R
2	Levee Materials. Evaluate levee construction materials for contaminants prior to utilization. Do not use materials from contaminated areas.	Muck and or sediment from potentially contaminated scrapings or dredging may contain high levels of contaminants. Do not use these materials to construct berms and/or tree islands unless they have been evaluated and remediated if necessary (see #1). Remobilization could be harmful to wildlife.	Remobilization of contaminants would limit benefits of water cleansing STA's and utility of stored reservoir water.		STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
3	Contaminant Monitoring. Design and implement a post-construction monitoring plan for pesticides and other toxicants such as mercury and copper, as set forth in the proposed draft Mercury and Contaminants of Concern CERP Guidance Memorandum (COC/CGM). If necessary, implement the COC/CGM contingencies for fish and wildlife protection.	Contaminants may be toxic and can increase in concentration with trophic level. Large mammals, wading birds, other water birds, fish, and wildlife should be protected from toxic exposures that may result from the operations of reservoirs or STAs.	The operation of facilities which cause detrimental wildlife impacts should not be sustained. This would counter the beneficial functions of these facilities.	St. Johns River Water Management District, 1999 SFWMD/COE, 2003	STA R
	Design and Morphology				
4	Facilities Siting. a) Locate facilities within the watershed where water volumes will optimize water treatment and minimize "dry outs" (water levels below bed surface) to patterns consistent with natural timing, frequency and duration. b) Locate and configure facilities to minimize impacts to biologically and ecologically sensitive areas.	a) Maximizing availability of water supply will allow flexible management of hydrological conditions favorable to fish and wildlife and prevent unscheduled dry outs. b) This will reduce direct (footprint) and indirect (hydrological modifications, fragmentation) impacts to fish and wildlife habitat.	a) Treatment and storage functions would be enhanced by adequate water supply, providing hydrologic flexibility to prevent undesirable dry outs, which could re-mobilize pollutants and contaminants. b) Minimizing direct and indirect impacts in the siting process will facilitate timely authorization and construction.	a) Kadlec and Knight, 1996	STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
5	Microtopography. Leave or create non-short circuiting microtopographic features by avoiding uniform leveling of substrates during construction or any future cell maintenance. Overall topography of large STAs should mimic natural historic topographic patterns or patterns within adjacent undisturbed landscapes.	Wetlands that possess a variety of microtopographic features have the most potential for sustaining a diversity of plants, habitats, animals, and biogeochemical processes over a wide range of water elevations.	Microtopographic relief will result in a diversity of plants and biogeochemical processes. It will also reduce "short-circuiting thereby increasing hydraulic residence time and treatment efficiency. Leaving existing topographic features will also reduce design, construction, and maintenance costs and reduce soil compaction.	Mitch and Gosselink, 2000	STA
6	Littoral Shelves. Incorporate sloping littoral shelves with a gradual transitional depth zone.	Sloping littoral shelves provide mobile zones of appropriate hydroperiods for plant diversity and habitat for fish spawning and wading bird foraging during water level manipulation (see #18).	Plant diversity is important to maintain vegetative stability in facilities. Vegetated sloping banks are less susceptible to erosion and perform water quality treatment functions.		STA R (litt)

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
7	Deep Water Zones. Create deep water zones (some at least 3 feet in depth at lowest water levels) for fish refugia transverse to flow direction. Areal extent of the zone(s) should be in proportion to the size of the facility (approximately 10%).	Deep water zones provide a refugia for fish during low water events.	Deep water zones, perpendicular to flow direction, serve multiple purposes including improving hydraulic mixing, increasing hydraulic residence time, providing a sump for solids storage, and reducing resuspension of sediment bound pollutants.	Kobza, et al. *In review* Kadlec and Knight, 1996 Walker, 1987	STA R
8	Perpendicular Flow Features. Create or utilize existing features (e.g. ditches or vegetated shallows) perpendicular to the flow of STA cells rather than parallel to the flow.	Vegetated shallows constructed perpendicular to flow provide cover for wildlife. Existing ditches may provide habitat diversity and refugia for fish during lower water levels.	Remnant ditches parallel to the flow of STA cells tend to "short-circuit" the STA cell and reduce retention time. Perpendicular ditches may be beneficial for spreading the flow. Vegetated shallows constructed perpendicular to flow increase hydraulic retention time possibly aiding treatment efficiency.	Kadlec and Knight, 1996	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
9	Irregular Shorelines. Design and create irregular shorelines.	Irregular shorelines and "fingers" provide visual cover and greater ecotone (edge) length. Ecotones are characteristically species-rich as ecological communities overlap forming a biologically rich and diverse zone.		Kadlec and Knight, 1996 Mitch and Gosselink, 2000 USEPA, 2000	STA R
10	Vegetated Islands. Create vegetated islands in open water areas. Select endemic plant species suitable for wildlife use and upland hydrology. Plantings should be monitored and remediated through replanting and use of forage guards. Exotic and invasive plants should be controlled (see #15).	Islands provide habitat diversity. Upland/ wetland mosaics are essential to the life stages of certain amphibians, reptiles, and other organisms. These areas will provide a visual buffer for nesting and foraging birds, a noise buffer for wildlife, and wildlife beneficial ecotones.	Properly constructed islands in treatment cells will not cause short-circuiting and may be beneficial in redistributing flow patterns. This can result in enhanced retention time and aid in hydrologic mixing. Placement of islands may enhance this effect. Islands (particularly in reservoirs) also reduce wind fetch and wind driven wave run-up enhancing embankment stability.	White et al., 2002 wind fetch - Brian Files, COE, personal communication, July 1, 2003	STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
11	Vertical Structure. Leave clusters and/or individual trees or snags and/or install platforms for wildlife use.	Vertical structure is an important element of aquatic and terrestrial habitat diversity in STA's and reservoirs. It provides perching, nesting, and roosting structure for birds and habitat for turtles and other reptilian fauna.		Kadlec and Knight, 1996	STA R
12	Underwater Structure. Provide underwater substrate and structure such as gravel, sand, logs, stumps, etc. to be used by fish for spawning and cover.	Fish habitat features will enhance the fish community thereby providing a food base for both wading and migratory birds. Logs and stumps can provide basking and perching sites for birds and reptiles and amphibians.			STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
13	Multiple Cells. Design STAs with multiple cells for enhanced water quality, wildlife use, and management flexibility. Sequence cells in the treatment train such that primary treatment cells are at the intake end, wildlife features are in center cells, and cells proximal to the discharge are polishing cells. Avoid incorporating large open water areas and wildlife features in cells near discharge areas.	The use of multiple cells will promote habitat diversity by increasing habitat heterogeneity (more edge, vertical structure). Sequencing cells will allow concentrating wildlife in appropriate zones of the treatment facility.	The use of multiple cells will enhance flexibility for necessary maintenance and will allow specialized management of treatment waters. The use of cells nearest the intake area settle out sediment, final cells polish water prior to discharge, and other cells are focused on development of habitat and food production for wildlife. Furthermore, the incorporation of large open water areas may have increased suspended solids levels and particulate nutrient forms, and should therefore be avoided near discharge areas.	Kadlec and Knight, 1996 C.E. Swindell, Jr. Ecotech Consultants, Mgr - Vero Beach treatment plant, personal communication, November 12, 2002	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
14	Vegetative Buffers. Create or maintain vegetated buffers (*e.g.*, 100 to 500 meter width) adjacent to STA/reservoir levees and/or seepage collection canals. Design and/or manage buffers to include endemic plant communities and natural structural stratification (trees, shrubs, ground covers).	Buffers adjacent to STA/reservoir levees and/or seepage collection canals serve as natural transition zones. They provide habitat for wildlife, including neotropical migrant songbirds, and essential life support for amphibian and reptile species. They also serve as important wildlife travel corridors.	Buffers create a natural aesthetic and safety barrier between constructed features and developed areas. Buffers provide treatment for stormwater runoff, capture excess seepage, and reduce the area of seepage impact and related flooding.	USEPA, 2000 Tiner, 2002	STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
	Biological Diversity -Vegetation				
15	Plant Diversity. Plant and manage for a diversity of native species in target cells. Design and implement a Desirable Plant Management Plan for operation of STAs. Incorporate native plants with known nutrient removal and wildlife benefits.	Using a variety of plants is beneficial to wildlife by enhancing niche and ecological diversity.	Botanical diversity provides greater resilience to pests and operational variability, reduces complications due to hydrological fluctuations, and maximizes treatment options.	Kadlec and Knight, 1996	STA
16	Shrubs and Trees. Plant shrubs and trees in hydrologically appropriate areas (areas matching the hydrologic requirements of planted species).	Planting shrubs and trees in hydrologically suitable areas will enhance survival of the plantings. Incorporating vertical structure in this manner will provide habitat for feeding, roosting, and nesting wildlife.		Kadlec and Knight, 1996 Mark Sees ,City of Orlando, Public Works Dept, personal communication field visit to the Orlando Easterly Wetlands STA, December 16, 2002	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
17	Submerged Aquatic Vegetation. Utilize Submerged Aquatic Vegetation (SAV) cells. To establish SAVs instead of emergent vegetation, flood area 3-3.5 feet deep and then draw down to 2-2.5 feet deep.	SAV cells offer a large element of habitat diversity. These are highly productive systems typically supporting elevated fish diversity and biomass which in turn supports high utilization by wading birds.	SAV can be highly effective at P removal - epiphytic periphyton contributes to this removal. SAV deposits less sediment than cattail. District STAs are projected to function for 50 to 70 years with a sediment rate of 0.5 to 1.25 cm per year. Sediment accretion may be less if SAV and/or periphyton are the main nutrient removal vehicles. One particular advantage to SAV, is that the mechanisms for P release are organic and inorganic, and therefore the plants do not create very high levels of detritus, which will re-release the nutrients under certain conditions.	Havens and Schelske, 2001 Newman and Pietro, 2001 Nungesser and Chimney, 2001	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
	Biological Diversity - Wildlife				
18	Long-legged wading bird feeding. Through variable microtopography and water management, provide areas where water is drawn down to depths between 5 cm and 35 cm for a minimum 90-day period, during the nesting/breeding cycle (January-May), for long-legged wading birds feeding.	Maintaining these depths will maximize foraging conditions for long-legged wading birds.	Cells can be managed for these purposes while achieving treatment. Maintaining wetted cells will enhance phosphate removal and reduce remobilization of phosphate and other contaminants of possible concern.	USFWS, 1999 ATLSS, 2003	STA
19	Short-legged wading bird feeding. Through variable microtopography and water management, provide areas with depths between 0 cm and 20 cm for a minimum 45-day period, during the nesting/breeding cycle, for short-legged wading bird feeding.	Maintaining these depths will maximize foraging conditions for short-legged wading birds, such as white ibis, snowy egrets, and small herons.	Cells can be managed for these purposes while achieving treatment. Maintaining wetted cells will enhance phosphate removal and reduce remobilization of phosphate and other contaminants of possible concern.	ATLSS, 2003	STA mid-Aug-ust

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
20	Long hydroperiod marsh vegetation. Maintain freshwater emergent plant communities with species such as spikerush, maidencane, and beakrush through variable microtopography and water management. Typical long hydroperiod marshes will be inundated from 3 to 5 years continuously between dry outs.	Long-hydroperiod plant and animal communities provide a balance of ecological functions that maintain marsh stability and minimize the need for costly, intrusive anthropogenic maintenance. Long hydroperiod marshes provide a balance of lower trophic level aquatic organisms such as forage fish, apple snails, and crayfish that support higher Everglades trophic levels.	Ecologically stable, functional STAs will maximize treatment benefits and minimize maintenance costs. Minimizing maintenance time, which takes the facility or cell off-line, will also maximize treatment benefits.	USFWS, 1999	STA
21	Dry out timing. Plan any necessary dry out for STAs after May 15, or as late as possible.	Later dry out allow populations of apple snail and other aquatic organisms to develop a cohort to survive to reproduce in the following wet season.	Late planned dry out allows for maintenance such as cattail control or periphyton health while minimizing effects on aquatic systems and biogeochemical processes.	R. Bennetts, USGS, personal communication, July 23, 2003	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
22	Recession rates and reversals. Manage water levels to gradually recede from January through June. Manage reversals (an increase in water depth during a period of recession) to imitate natural processes.	Controlling recession rates and reversals would concentrate prey items for wading birds in a manner similar to natural water recessions.	Controlling recession rates and reversals may increase retention time and treatment efficiency.	Lorenz et al., 2001 Ogden, 1995 Bancroft et al., 1995 Bjork and Powell, 1996 Bjork and Powell, 1994	STA
23	Recession patterns. On a landscape scale, schedule water recessions (drops in weekly average water depth) to vary to imitate natural recession patterns.	On a landscape scale, significant disruption of wading bird foraging could increase search distance and time effort to find suitable foraging areas, reduce nest success, reduce fledgling survival, and increase adult mortality.		Ogden, 1990	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
24	Wildlife Disturbance. Minimize cell maintenance during nesting season (January through August). Create a 10 to 40 meter shrub zone with native vegetation (*e.g.*, buttonbush, willow, wax myrtle) between cells to minimize disturbance to wading birds while performing cell maintenance and other human activities.	Disturbance (*e.g.*, maintenance by manual labor or heavy equipment) to nesting, foraging, and loafing waterbirds can be reduced by providing a visual screen. These vegetation screens also provide wildlife habitat, and reduce the amount of upland area that requires mowing and maintenance.	Allows necessary cell maintenance while minimizing disturbance to wildlife.	Ikutaa and Blumstein, 2003 Rogers and Smith, 1997	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
	Operations and Water Quality				
25	Hydrological Operating Plan. Develop and implement a water control operations plan based on appropriate hydrological metrics (*e.g.*, max and min criteria for water depths, recession rates, timing and frequency, etc.) to maintain desired vegetative communities, treatment functions, and biotic communities.	Specification of beneficial hydrological protocols through advanced planning will enhance survival and productivity of fish and wildlife by reducing the frequency of habitat limiting hydrological events.	Planned hydrological management will enhance treatment and water storage functions during wet and dry seasons.	Miller et al., 1998	STA R
26	Monitoring Plan. Design and implement a water and sediment quality monitoring plan for each reservoir and STA to trigger the adaptive management process.(see #33)	Monitoring plan implementation will identify unanticipated problems and benefit fish and wildlife and ecosystem health.	The plan would guide monitoring of treatment efficiency and indicate the need for maintenance when treatment efficiency drops below a critical level. It would also document facility efficiency.		STA R
27	Dissolved Oxygen (DO). During the limited set of circumstances when there is a potential for fisheries, maintain regionally appropriate DO concentrations to support fisheries and aquatic habitat.	While some locally abundant species have shown greater tolerance of low DO conditions, most recreational fish and aquatic invertebrates cannot tolerate prolonged low oxygen levels.	Low DO concentrations can cause sub-lethal effects for living resources and allow sequestered nutrients, including phosphorus, to be recycled to overlying water, thereby reducing treatment efficiency. Also, discharge of low DO water counters the water quality enhancement function of the facility.	USEPA, 1986	STA R

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
28	Flow Patterns. Use best available technology (passive if effective) to evenly distribute inflow and aerate water at inflow and outflow points.	Distributing and aerating inflows will increase dissolved oxygen levels and reduce pockets of stagnation, thereby enhancing habitat for fish and wildlife.	This technique will increase dissolved oxygen levels, spread water more evenly, improve hydrologic mixing, improve treatment benefits, and reduce short-circuiting.	Example - City of Titusville, Blue Heron Wetland Treatment System, December 16, 2002	STA R
29	"Dry Outs." During facility operation, minimize dry outs to reduce pollutant (*e.g.*, phosphorus, mercury, etc.) release upon rehydration.	Minimizing dry outs protects aquatic communities in STAs and reservoirs and may protect and enhance downstream ecosystems.	Dry outs may result in release and mobilization of pollutants upon rehydration and reduces treatment efficiency.	Walker, 1995	STA R
30	Holding Water. At facility start up and after dry out, hold water until water quality is acceptable for discharge to receiving water body. Deter wildlife use during this period (see #3).	Water retention after dry out avoids the release of a high nutrient pulse and methylmercury which is toxic and can bioaccumulate in fish and wildlife.	Water retention after dry out improves water quality treatment efficiency	SFWMD/COE, 2003	STA R
31	Chemical treatment. Avoid chemical treatment to reach phosphorus reduction targets.	Chemical treatment is undesirable due to unknown effects on natural areas downstream.	Chemical treatment results in the need for extensive waste removal from the treatment site, and continuous cost of operation.	Everglades Program Team, USDOI, August 2001	STA

	Wildlife/Water Quality Recommendations	Fish and Wildlife Benefit Rationale	Compatibility/Benefit to Reservoir/STA Primary Function	Reference	STA or R[1]
	Public Use				
32	Recreational Use. Provide public use (recreational opportunities) while meeting intended primary functions. Consider compatible recreational opportunities such as hunting, fishing, kayak/canoe launches, visitor centers, walking trails, viewing platforms, and educational exhibits on a case by case basis.	Promotes general fish and wildlife conservation and multi-purpose facilities for public benefit.	Garner public support for projects.	Draft CERP Master Recreation Plan (in progress)	STA R
	Adaptive Assessment and Management				
33	Adaptive assessment and management. Develop and implement an adaptive assessment and management plan to evaluate performance of facilities towards achieving targeted performance measures. Include periodic evaluation of performance and triggers for implementation of project design or operational alternatives.	Adaptive assessment will foster continued improved management for fish and wildlife performance measures.	Adaptive assessment will foster continued improved management for water cleansing and storage functions.		STA R

LITERATURE CITED

ATLSS, 2003. http://www.atlss.org

Bancroft, G.T., A.M. Strong, R.J. Sawicki, W. Hoffman, and S.D. Jewell. 1995. Relationships among wading bird foraging patterns, colony locations, and hydrology in the Everglades. In: Everglades: The Ecosystem and It's Restoration, S.M. Davis and J.C. Ogden (Eds.) 1995. St. Lucie Press, Delray Beach, Fla. Chap. 25.

Bjork, R.D. and G.V.N. Powell. 1994. Relationships between hydrologic conditions and quality and quantity of foraging habitat for roseate spoonbills and other wading birds in the C-111 Basin, final report to the South /Florida Research Center, Everglades National Park, Homestead, FL.

Bjork, R.D. and G.V.N. Powell. 1996. Roseate spoonbill, pp. 295-308, In: Rare and Endangered Biota of Florida. Vol 5: Birds. Rodgers, J.A

Everglades Program Team, U.S. Department of the Interior. 2001. Marsh readiness concept paper.

Havens, K.E. and C.L. Schelske. 2001. The importance of considering biological processes when setting total maximum daily loads (TMDL) for phosphorus in shallow lakes and reservoirs. Environmental Pollution 113: 1-9.

Ikutaa, L.A. and D.T. Blumstein. 2003. Do fences protect birds from human disturbance? Biological Conservation, 112(3): 447-452.

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. CRC Press. Boca Raton, FL

Kobza, R.M., J.C. Trexler, W.F. Loftus, and S.A. Perry. In review. Community structure of fishes inhabiting aquatic refuges in a threatened karst wetland and implications for ecosystem management.

Lorenz, J.J., J.C. Ogden, R.D. Bjork and B.V.N. Powell. 2001. Nesting patterns of roseate spoonbills in Florida Bay 1935-1999: implications of landscape scale anthropogenic impacts. In: J.W. Porter and D.G. Porter, eds. The Everglades, Florida Bay and Coral Reefs of th Florida Keys, an Ecosystem Sourcebook. CRC Press, Boca Raton. FL: 555-598.

Miller, S.J., M.A. Lee and E.F. Lowe. 1998. The Upper St. Johns River Basin Project: Merging flood control with aquatic ecosystem restoration and preservation. Trans.63rd No. Am Wldl. and Natur. Resour. Conf

Mitch, W.J. and J.G. Gosselink. 2000. Wetlands, 3rd ed. John Wiley and Sons, Inc. New York, NY.

Newman, S. and K. Pietro. 2001. Phosphorus storage and release in response to flooding: implications for Everglades stormwater treatment areas. Ecological Engineering 18: 23-38.

Nungesser, M.K. and M.J. Chimney. 2001. Evaluation of phosphorus retention in a South Florida treatment wetland. Water Science and Technology 44: 109-115.

Ogden, J.C. 1990. Habitat management guidelines for the wood stork in the Southeast Region. U.S. Fish & Wildlife Service. 9pp.

Ogden, J.C. 1995. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indicatin of ecosystem conditions in the Southern Everglades. In: Everglades: The Ecosystem and It's Restoration, S.M. Davis and J.C. Ogden (Eds.) 1995. St. Lucie Press, Delray Beach, Fla. Chap. 25.

Rodgers, J and H. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25(1): 139-145

St.Johns River Water Management District. 1999. Lake Apopka Restoration Project: Wildlife Impacts and Progress Toward Remediation. 11pp.

South Florida Water Management District (SFWMD)/U.S. Army Corps of Engineers (COE). 2003. Draft CERP Guidance Memorandum. Toxic substances Screening Process - Mercury and Pesticides.

Tiner, Ralph, W. 2002. Remotely-sensed Natural Habitat Integrity Indices for Assessing the General Ecological Condition of Watersheds. In: R.W. Tiner (compiler) Watershed-based Wetland Planning and Evaluation. A Collection of Papers from the Wetland Millennium Event (August 6-12, 2000; Quebec City, Quebec, Canada). Distributed by the Association of State Wetland Managers, Inc., Berne, NY. pp.125-141.

U.S. Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Dissolved Oxygen. EPA 440/5-86-003.

U.S. Fish and Wildlife Service (USFWS). 1999. South Florida multi-species recovery plan. Atlanta, Georgia. 2172 pp.

U.S. Environmental Protection Agency. 2000. Guiding principles for constructed treatment wetlands: providing for water quality and wildlife habitat. EPA 843-00-003. 41pp.

Walker, W.W. 1995. Design basis for Everglades Stormwater Treatment Areas. Water Resources Bull. 31(4):671-685.

Walker, W.W. 1987. Phosphorus removal by urban runoff detention basins. Lake & Reservoir Management III:314-326.

White,J.R., K.R. Reddy, and W.F. Debusk,W.R. Wise and T. Crisman. 2002. Phosphorus removal capacity of the Orlando Easterly Wetland Treatment System, Final Report Wetland Biogeochemistry Laboratory, Soil and Water Science Department, UF-IFAS and Environmental Engineering Sciences Department, UF, Center for Wetlands, UF.