Indicators of Success

The Task Force recognizes that restoration must be based on the best science available and that this will require use of adaptive management principles to continually incorporate new knowledge and tools. The Task Force created the SCG in December 2003 to support its efforts to coordinate the scientific aspects of policies, strategies, plans, programs, projects, activities, and priorities and to respond to Congressional directives to improve science coordination based on GAO's recommendations. In August 2004 the Task Force assigned this group the task of developing a proposed integrated suite of System-wide Indicators for helping assess the direction and success of the restoration efforts. This suite of System-wide Indicators replaces the indicators reported in the 2002 *Strategy* and *Biennial Report*.

Strategic Plan Table 2 – Task Force System-wide Indicators for 2006
Ecological Indicators
• Fish and Macroinvertebrates
• Wading Birds (White Ibis, Wood Stork, and Roseate Spoonbill)
• Florida Bay Submerged Aquatic Vegetation
• Florida Bay Algal Blooms
• Crocodilians (American Alligators and Crocodiles)
• American Oysters
• Periphyton and Epiphyton
• Juvenile Pink Shrimp
• Lake Okeechobee Littoral Zone
• Invasive Exotic Species
Compatibility Indicators
• Water Volume
• Biscayne Aquifer Saltwater Intrusion
• Flood Protection – C-111 Basin

Over the past three reporting periods (1998-2000, 2000-2002, and 2002-2004), a great deal of modeling and analysis has generated new information providing the technical and scientific basis for developing a more integrated and rigorous set of indicators than was originally included in the 2002 report. After examination of comments from an Independent Scientific Review and public comments, the SCG developed a suite of proposed System-wide Indicators for 2006 and identified additional indicator gaps they hope to have developed by the 2008 reporting timeframe. There are general desired restoration trends identified for each indicator, but they are not yet well developed or refined enough to set performance targets or end points. The SCG is working on refining these restoration targets and expects to report their findings to the Task Force in 2008 when the first assessment of the entire suite of indicators is anticipated. The SCG will use the feedback from public input and an independent scientific review process to complete the indicators, targets, performance measures, and timelines used to measure success[1].

Ecological Indicators

Fish and Macroinvertebrates

Significance and background. Marsh and estuarine aquatic fauna, including small fishes and crustaceans, are critical in the food web as primary and secondary consumers and as prey for focal Everglades predators such as wading birds. This indicator uses the density (number of animals per unit area) and community composition (how many of each species per unit area) of a suite of native fishes (e.g., eastern mosquito fish, bluefin killifish, sheepshead minnows, sailfin molly) and crustaceans (slough and Everglades crayfish, riverine grass shrimp) to describe trends in their populations related to hydrology.

[1] See Appendix C Additional View of the Miccosukee Tribe "Putting the Everglades back into Everglades Restoration." Section II.B.5.

Fish and macroinvertebrate responses are directly related to the suitability of environmental conditions. Correlations between biological responses and environmental conditions contribute to an understanding of the species' status and trends over time. The positive or negative trends of this indicator relative to hydrological changes permit an assessment of positive or negative trends in restoration.

Factors affecting success. The most important factors affecting fish abundances regionally are the loss of habitat, hydroperiod, and water depth and frequency of drying events. Because of relatively dry hydrological conditions in the Everglades Ecosystem resulting from water management over the past several decades, and a loss of habitat to agricultural and urban uses, fish and macroinvertebrate densities have decreased and community structure has changed.

Toward restoration. The broad restoration goals for this indicator are to enhance population density and community composition of fish and macroinvertebrates through hydrologic restoration and improved water management.

Wading Birds (White Ibis, Wood Stork, and Roseate Spoonbill)

Significance and background. Extremely large numbers of wading birds were one of the defining characteristics of the pre-drainage wetlands of south Florida. Of particular relevance in understanding the population dynamics of wading birds in the pre-drainage system are the combined features of large spatial extent and highly variable hydrological conditions that created and maintained a mosaic of wetland habitats. This combination is what made it possible for the region to support large nesting colonies of wading birds with quite different foraging strategies and prey requirements.

Factors affecting success. The drainage of extensive areas of short-hydroperiod wetlands, large-scaled alterations in water depth and distribution patterns due to compartmentalization of wetlands in the central Everglades, and the reduction of freshwater flows into the formerly more productive estuaries are the human induced stressors that have substantially impacted ibis, storks, spoonbills, and other wading birds in south Florida. The number of ibis nesting in south Florida has declined from an estimated 100,000 – 200,000 birds in the 1930s and 1940s to 20,000 – 60,000 birds since the late 1990s. The number of nesting storks has declined from 14,000 – 20,000 birds prior to 1960 to about 2,000 – 5,000 birds since the late 1990s.

Toward restoration. The broad restoration goals for this indicator are recovering the kind of ecosystem with the spatial and temporal variability to support large numbers of these wading birds. This will include specific restoration goals for these species with targets defined for numbers of nesting pairs, location of colonies, timing of nesting, and an increase in the size and frequency of the larger nesting assemblages referred to as "super colonies."

Florida Bay Submerged Aquatic Vegetation

Significance and background. Florida Bay and adjacent areas of the Florida Keys and southwest Florida coastal zone contain one of the largest contiguous seagrass beds in world. Within Florida Bay, seagrasses are the dominant biological community, covering 90% of the 180,000 hectares of the bay's subtidal mudbanks and basins. Submerged aquatic vegetation (SAV) is well documented as a community that serves many critical functions within estuarine and coastal ecosystems, including habitat for higher trophic level species, a base of primary production for the food web, and a beneficial influence on water quality through sediment stabilization and nutrient retention. A conceptual ecological model of Florida Bay, developed for the Restoration Coordination and Verification Team (RECOVER), identifies the SAV community and its structure

and dynamics as being central to the health of the entire Florida Bay ecosystem – the condition of this community is an essential indicator for South Florida Ecosystem restoration.

*Factors affecting success***.** The SAV indicator for the southern estuaries focuses only on Florida Bay as it currently has the best models available for this indicator. Changes in the seagrass community of Florida Bay have been one of the primary drivers behind a public call for Everglades restoration. Starting in 1987, a mass-mortality event or "die-off" of SAV through much of central and western Florida Bay devastated the once lush seagrass beds. This die-off initiated a cycle of changes in the Florida Bay ecosystem, likely due to increased sediment suspension, turbidity, nutrient mobilization, and phytoplankton blooms resulting in decreased light that caused additional seagrass mortality. The extent to which fish and birds will recover following a sustained recovery of these plants remains to be seen and is a major focus of ongoing research.

Toward restoration. The broad restoration goal for this indicator is an increase in two species, *Halodule wrightii* and *Ruppia maritima*, that are associated with relatively lower salinities and are far less common than the dominant species, *Thalassia testudinum*, and greater species richness and density through a greater proportion of the bay. Another restoration goal is widespread SAV coverage that includes increases in species diversity and richness with moderate density with overall vegetation coverage similar to those found prior to the 1987 "die-off."

Florida Bay Algal Blooms

Significance and background. Algal blooms are a major concern regarding the current and future health of Florida Bay, as well as of waters near the Florida Keys and the southwest Florida coastal zone. The initiation of algal blooms in Florida Bay in 1991, following the seagrass mass-mortality event of the late 1980s, has been a major element of ecological change. Algal blooms decrease light penetration through the water column and can lead to seagrass mortality, which in turn can release nutrients and stimulate more algal blooms.

Factors affecting success. The role of nutrient inputs from the Everglades as a cause of Florida Bay algal blooms is not clear, but it has been hypothesized that these inputs are an important factor and increased freshwater flow with restoration could increase such blooms. The algal bloom indicator reflects overall water quality and is based on the assessment and evaluation of chlorophyll-a concentrations in the water column. The indicator has three components: bloom magnitude, frequency, and spatial extent.

Toward restoration. The broad restoration goal for this indicator is to reduce or eliminate the number and extent of algal blooms in the watershed.

Crocodilians (American Alligators and Crocodiles)

Significance and background. Crocodilians are important in south Florida wetlands and play a major role in influencing the overall health and ecological patterns of the region. Alligators and crocodiles are critical in the food web as top predators, influencing abundance and composition of prey. The American alligator's behavior creates variations in physical conditions that otherwise would not exist in the Everglades landscape such as the holes they dig that become habitat for other species. The American crocodile is an endangered species representing the importance of freshwater inflow to estuarine health and productivity.

Factors affecting success. Reproduction, growth, and survival of crocodilians are dependent on food availability—birds, mammals, fish, and macroinvertebrates—that, in turn, are entirely dependent on hydrologic conditions. Loss of flow and relatively dry hydrologic conditions,

resulting from water management over the past several decades and a loss of habitat in the Everglades, have adversely affected alligators and crocodiles. Loss of habitat in southern marl prairies and rocky glades and reduction in depth and period of inundation of remaining areas have reduced abundance of alligators and alligator holes in these habitats. Reduced prey availability throughout the system as a result of hydrologic alterations corresponds with lower growth rates, survival, and reproduction of alligators.

In estuaries, crocodilians of all species orient towards areas of low salinity and sources of freshwater. In mangrove estuaries, alteration of location and quantity of freshwater flow has lowered the relative density of crocodiles where freshwater has been diverted and decreased growth and survival of juvenile crocodiles throughout the estuary in areas of higher salinities. Reduced freshwater flow into the mangrove estuaries also has resulted in succession of former freshwater mangrove areas to saltwater systems, reducing American alligator populations in tidal rivers and tributaries.

Finally, a large portion of the adult alligator population in the Everglades exists in canals but does not contribute to population growth due to the combination of increased nest flooding and decreased hatchling and juvenile survival during low water periods (predation and cannibalism).

Toward restoration. The broad restoration goal for this indicator is based on recovery of more natural hydropatterns regionally, which in turn will promote increased habitat quantity and improved habitat quality that will support healthy populations of these species. The alligator indicator uses relative density (reported as an encounter rate), body condition, nesting effort and success, and occupancy rates of alligator holes, while the crocodile indicator uses relative density, growth, and survival to describe trends in their populations related to hydrology.

For example, alligators are now largely absent from over-drained rocky glades and marl prairies, and hence are no longer creating alligator holes. As restoration proceeds the occupancy rate of alligator holes should increase, providing ecosystem services for other species. With the resumption of natural patterns of volume, timing, and distribution of flow to the Everglades, the American alligator is expected to repopulate and resume nesting in the rocky glades and the freshwater reaches of tidal rivers in the mangrove estuaries and will increase in population size and body condition throughout most of the Everglades wetlands.

American Oysters

Significance and background. Oysters are indicative of ecosystem health as a whole. They are natural components of estuaries along the eastern seaboard of the United States as well as the Gulf of Mexico and were documented to once be abundant in the South Florida Ecosystem. The American oyster is the dominant species in these oyster reef communities. Oyster bars provide important habitat and food for numerous estuarine species including mollusks, worms, crustaceans, sponges, fish, and birds. Oysters are also an important commercial and recreational resource. The American oyster improves water quality by filtering particles from the water, serves as prey and habitat for numerous other organisms, and plays an important role in the estuarine food chain. Salinity conditions suitable for oysters also produce optimal conditions suitable for a suite of other desirable estuarine organisms. In the Caloosahatchee, Loxahatchee, and St. Lucie Estuaries, oysters have been identified as a valued ecosystem component.

Factors affecting success. Historically, rainfall on the watershed was detained in natural wetland systems and gradually percolated into the groundwater, evaporated, and/or flowed overland into tributaries. As south Florida developed, the canal network built as a result of the C&SF Project drastically altered the quantity, quality, timing, and distribution of freshwater entering

the system. Resultant rapid changes in salinity resulted in degradation of biological integrity of the system and introduced contaminants from urban and agricultural development, including excess suspended solids, nutrients, pesticides, and other harmful pollutants. Inflows became extremely variable and tended to be too great in the wet season and too little in the dry season to support a healthy estuary. The inflow extremes and degraded water quality (particularly suspended solids and nutrients) severely compromise the development of healthy, sustainable oyster and related estuarine communities.

Toward restoration. The broad restoration goal for this indicator in the northern estuaries is the restoration of oyster beds within the St. Lucie, Caloosahatchee, Loxahatchee, and Lake Worth Lagoon Estuaries, including the restoration of habitat function and oyster health in areas that become suitable habitat. Acre increases are identified in the 2005 RECOVER *Interim Goals and Targets Report* but these need to be further refined as to locations and definition of what an acre of oysters means (i.e. how many oysters per meter square, what quality, reproductive capacity, etc.).

Periphyton and Epiphyton

Significance and background. Periphyton communities, comprised of algae, floating plants, and associated animals, are a common feature of Everglades marshes and respond strongly to alterations in hydrologic conditions and water quality, especially phosphorus. Epiphyton communities are also comprised of algae and associated animals, but instead of floating are attached to other plants and underwater surfaces. Both periphyton and epiphyton are important both as a food source and a refuge for aquatic invertebrates that are consumed by small fish, crayfish, and grass shrimp. Periphyton has been studied extensively in the Everglades because of its utility as an early warning indicator of impending ecosystem change and the significant consequences of altered periphyton communities on the rest of the food web. Epiphyton serves much the same role as periphyton but is primarily associated with estuarine and coastal ecosystems, particularly seagrass beds.

Factors affecting success. Increased nutrient delivery to natural Everglades marshes causes periphyton mats to disintegrate and collapse, resulting in a major alteration in food availability at the base of the food web. Research shows periphyton losses are initiated upon exposure to even very low nutrient enhancements. Models have been developed to determine the extent of periphyton losses throughout the South Florida Ecosystem because of nutrient enrichment. Further, hydrologic changes have strong functional and structural consequences in the periphyton community. Studies have shown that sites that are dry for a majority of the year have minimal production values, while sites that are flooded for less than six months are most productive. The timing of reflooding of previously dried periphyton mats is also important as dried periphyton releases large quantities of nutrients into the water column upon reflooding that subsequently may negatively affect downstream systems. Periphyton cover, biomass, productivity, and composition are affected by the duration and frequency of droughts. The reduction of hydroperiod resulting from long-term water and land management practices has limited the period of production for periphyton in Everglades wetlands for many decades. Recovery of this indicator will depend on hydrological restoration to improve habitat for periphyton production in both long and short hydroperiod wetlands.

Toward restoration. The broad restoration goal for this indicator is to increase the periphyton mat cover, structure, and composition to periphyton communities that were characteristic of the spatially distinct hydroperiods and low nutrient conditions that were present in the greater Everglades wetland communities historically.

Juvenile Pink Shrimp

Significance and background. Pink shrimp are important both economically and ecologically in south Florida and are a core component of the ecologic food chain. Juvenile pink shrimp are present in coastal waters throughout south Florida and densities are highest in western Florida Bay. Biscayne Bay supports small local fisheries for food shrimp and bait shrimp. The growth and survival of young pink shrimp is influenced by salinity.

Factors affecting success. Historically, water management practices have changed the quantity, timing, and distribution of freshwater inflow to estuaries, which have affected the frequency and rate of salinity change. Both Florida Bay and parts of Biscayne Bay have been subjected to prolonged hypersaline conditions. Eastern Florida Bay, Whitewater Bay, and Biscayne Bay experience large, rapid changes in salinity.

Restoration of flows more similar to rainfall-driven flows should benefit the Tortugas pink shrimp fishery. The potential for improving shrimp nursery habitat in Florida Bay may be greatest in the north-central bay, where water management changes associated with the CERP could potentially reduce the frequency, spatial extent, and duration of hypersaline conditions.

Toward restoration. The broad restoration goal for this indicator is increased juvenile pink shrimp density at peak abundance during the August-October period in optimal habitat (seagrass) in three regions of Florida Bay, in Ponce de Leon Bay on the lower southwestern mangrove coast, and in western nearshore southern Biscayne Bay.

Lake Okeechobee Littoral Zone

Significance and background. The SAV in Lake Okeechobee provides nesting habitat and food resources for economically important sport fish populations, wading birds, migratory waterfowl, alligators, and the federally-listed endangered Everglades snail kite. In addition, the SAV community stabilizes shoreline sediments and supports attached algae that help to remove phosphorus from the water. The littoral zone emergent vegetation community in the lake covers an area larger than 400 square kilometers.

Factors affecting success. Florida has an annual rainfall cycle that can lead to prolonged or extreme high or low lake levels that in turn can stress the ecosystem. The spatial extent of the SAV in the lake has fluctuated significantly over the years according to wet and dry years and management schedules. Just after a period of low water levels in 1989 to 1991, between 43,000 and 51,000 total SAV acres were found. In 1998, after many years of high lake levels, a rough estimate indicated that only 3,000 acres of total SAV remained in the lake. In July 2002, the spatial extent of SAV was back up to 43,000 acres, though not all desirable species. In the most recent sampling, conducted in August 2004, the total acres had increased to nearly 55,000.

Toward restoration. The broad restoration goals for this indicator include lowering average water levels in the lake, reducing frequency of extreme high water levels, and decreasing phosphorus inputs. Under those conditions, the distribution and abundance of bulrush and submerged plants are expected to increase. In addition, reducing phosphorus loads from agricultural and urban activities to 40 parts per billion in the pelagic zone (open-water area) will result in the following changes: a decrease in algal blooms; an increase in water clarity; an increase in the spatial extent and biomass of native SAV; and a decrease in the rate of nuisance and exotic plant species expansion along the edge of the littoral zone.

Invasive Exotic Species

Significance and background. Florida is noted, along with Hawaii, California, and Louisiana, as one of the states with the greatest number of invasive non-indigenous species. Approximately one-third of the plant species in south Florida are exotic, and south Florida has more introduced animals than any other region in the United States. An estimated 26 percent of all mammals, birds, reptiles, amphibians, and fish are exotic. While invasive exotic plants may result in changes in ecological function and structure, they do not provide a measure that relates to the ecosystem's ecological condition except as it pertains to their level of invasion and adverse impacts on the ecosystem and biota. This is an indicator of the status of the spread, spatial distribution, and dominance of invasive exotic species and an indicator of progress (or lack thereof) in the control and management of invasive exotic species. The indications provided by monitoring and assessments of invasive exotic species are an evaluation of the integrity of the natural system and native vegetation.

Factors affecting success. During the past 400 years, Florida has been inundated with many predominantly tropical non-indigenous plants and animals. These waves of introductions accelerated during the twentieth century principally through importations by the ornamental plant and exotic pet industries. Exotic species compete with indigenous species for limited water, prey, and habitat; too often the exotics species outcompete the native. Since exotic species often drive ecological changes that may be irreversible, prevention, early detection, and removal are key to control and management. Monitoring and regular assessment of the spread of existing exotic species and the detection of new potentially invasive species is critical to effective control and management. Trends in the spread and density of invasive exotic plants, as well as the impacts that control and management activities have on their spread and density, will be important to the assessment of management success to control and eradicate invasive species in the Everglades.

Toward restoration. Broad restoration goals for this indicator are a reduction in spatial extent of invasive exotic plant species and populations of invasive exotic animal species in the South Florida Ecosystem. In addition, development of a comprehensive management program would address prevention, maintenance, and management of this condition.

Restoration Compatibility Indicators

Water Volume

Significance and background. A regional volume of water can be evaluated on how well it meets reasonable and beneficial urban and agricultural demands even in drought years. In 1997 Florida established a water supply planning goal to provide water to all existing users during droughts up to the level of severity of a one-in-ten-year frequency of occurrence. This goal has been interpreted to mean at least a 90 percent probability that during any given year all of the needs of reasonable, beneficial water uses will be met while also not causing harm to the water resources and related natural environment.

The C&SF Project was originally designed to provide flood control and deliver water for municipal, industrial, and agricultural uses. Later this was modified to include prevention of saltwater intrusion and provision of adequate water to ENP. The system put in place was an attempt to meet the estimated water needs for a projected population of approximately two million residents by 2000. This population projection was significantly low as the actual population in 2000 was over six million and continues to grow rapidly.

Factors affecting success. As south Florida's population increased, so did the demand for water and land, and the subsequent conversion of natural lands to urban and agricultural uses. The result of this conversion was:

- A reduction in the extent of the natural system
- A reduction in water available for the natural system
- Reduced water resources and recharge capability for the aquifer
- Loss of water from the natural and human systems
- Increased needs for flood protection in urban and agricultural areas
- Less water available for the human population
- Conflicts for water between the natural system and people

Under current conditions, canals and levees associated with the C&SF Project have altered the timing and distribution of water across the landscape while the regional flood control and water supply constraints create unnatural surface and groundwater stages (altered volumes) in many areas. The CERP is expected to improve the timing, volume, and distribution of water throughout the system primarily by increasing regional storage capacity, removing barriers to flow, and through a careful redistribution of water within the system that more closely matches natural cycles. The CERP's cumulative objective is to significantly reduce the release of millions of acre-feet of water for flood control by increasing storage capacity and thus increasing the amount of freshwater available to all water users—people as well as the environment—and to meet anticipated water supply needs for the 50 year CERP planning horizon. This retained and stored water is referred to as "new" water.

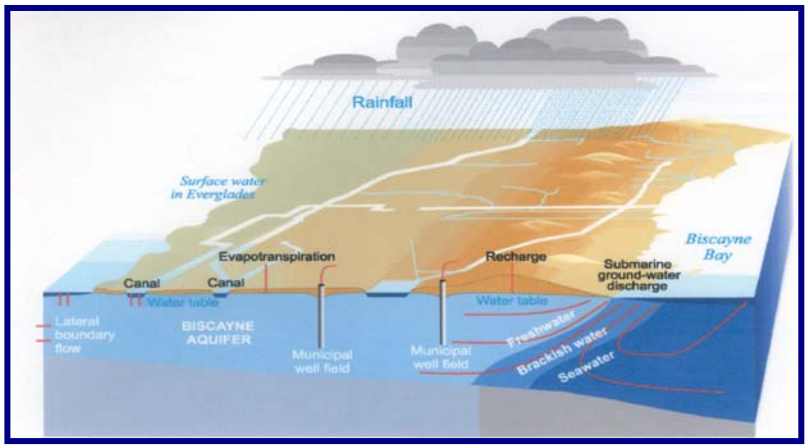
Toward restoration. Broad restoration goals for this indicator are to distribute water across the ecosystem in a manner that reflects natural conditions while providing for the other water-related needs of the region. In addition the water supply planning goal that will support achieving this condition is to provide water to all existing users during droughts up to the level of severity of a one-in-ten-year frequency of occurrence. Though specific targets are being refined the general target is to meet predicted "new" water volume targets (in acre-feet) identified through the C&SF Restudy. Current projections for new water are outlined below.

Targets for "new" water volume		
By 2010	–	931,000 acre-feet of new water
By 2015	–	1,060,000 acre-feet of new water
Full Restoration	–	1,620,000 acre-feet of new water

Biscayne Aquifer Saltwater Intrusion

Significance and background. The Biscayne aquifer underlying southeast Florida provides freshwater resources to both the ecosystem and most of south Florida's human population. Saltwater intrusion poses a continuing threat to the Biscayne aquifer. In order to restrict the inland migration of the saline interface, a sufficient freshwater head must be consistently maintained within the aquifer. Both the volume and water quality in the aquifer are affected by human activities, including extractions for public and private water services, and pumping and diversion of the freshwater to restoration projects or to sea.

Factors affecting success. Harm to the Biscayne aquifer in terms of saltwater intrusion is considered to be movement of the saltwater interface to a greater distance inland than has occurred historically as a consequence of seasonal water level fluctuations up to and including a one-in-ten-year drought event. Groundwater levels within the Biscayne aquifer are controlled by local rainfall and by the canals and structures that are regionally operated by the SFWMD. The SFWMD implements two programs, canal operations and consumptive use permitting, to prevent increases in movement of saltwater within the Biscayne aquifer.



Conceptual diagram of hydrologic system of south Florida (from Langevin, 2000).

The CERP intends to increase the storage capacity of water in the regional system for delivery to the Lower East Coast Service Area. The increase in regional storage capacity provided by the CERP will supplement regional and local sources used to prevent saltwater intrusion. CERP's water projects that may directly or indirectly affect Biscayne aquifer dynamics include surface and water storage, aquifer storage and recovery (ASR), and modifications to impediments of sheetflow (decompartmentalization).

Toward restoration. The broad restoration goal for this indicator is for the Biscayne aquifer to achieve a level of protection where the movement of the saltwater interface is maintained at no greater distance inland than has occurred historically as a consequence of seasonal water level fluctuations up to and including a one-in-ten-year drought event.

Flood Protection – C-111 Basin

Significance and background. The 1948 C&SF Project was intended to help protect the public living in south Florida from flooding. As population increased the land uses changed, agricultural areas were developed for housing and natural wetlands were developed for agriculture, with increasing pressure to continue this pattern toward the Everglades. As agricultural and residential areas eventually abutted the Everglades a direct conflict related to water levels occurred.

Factors affecting success. The water levels required for the health of Everglades wetlands and aquifer recharge are often not the same as needed for agricultural and developed areas. In south Miami-Dade County, the draining of the developed side of the levy also caused the loss by seepage of water needed for sustenance of natural wetlands and ENP. During dry seasons the C&SF Project moved water into south Miami-Dade County for agriculture and the Everglades, but constant pumping drained even more water from the Everglades, exacerbating the dry conditions. This scenario particularly describes the evolution of flooding challenges in the C-111 Basin that covers approximately 100 square miles in the southernmost portion of Miami-Dade County adjacent to the ENP. The predominant land use in this basin is agricultural, although portions of Florida City and Homestead lie within the basin.

Toward restoration. A goal of Everglades restoration and the CERP is to enhance economic values and social well being by maintaining or enhancing the current level of flood protection while

restoring appropriate water levels and hydroperiods in the natural system. By avoiding increased flood damages or mitigating for flood encroachment, increases to project and societal costs can be minimized.

Broad restoration goals for this indicator are to reduce conflict in the water management operations in the C-111 Basin where agricultural lands abut ENP and to achieve a one-in-ten-year level of flood protection for the C-111 Basin.