Chapter 9: Kissimmee River Restoration and Basin Initiatives

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SUMMARY

The South Florida Water Management District (SFWMD or District) continues to coordinate with the United States Army Corps of Engineers (USACE) on the Kissimmee River Restoration Project (KRRP). In addition, the SFWMD is working to integrate the KRRP with management activities throughout the Kissimmee Basin and the Northern Everglades region. The primary goals of these efforts are to (1) restore ecological integrity to the Kissimmee River and its floodplain, (2) enhance and sustain natural resource values in the Kissimmee Chain of Lakes (KCOL), (3) collect ecological data to evaluate river restoration and support management decision making, and (4) retain the flood reduction benefits of the Central and Southern Florida Flood Control Project (C&SF Project) in the Kissimmee Basin. To meet goals beyond those of the KRRP, the SFWMD is working with other agencies to define management objectives and assessment targets for the KCOL, address ecological data deficiencies needed to support management decision making, and develop and apply regional modeling and evaluation tools. Major initiatives include the KCOL Long-Term Management Plan, KCOL and Kissimmee Upper Basin Monitoring and Assessment Project, Kissimmee Basin Modeling and Operations Study, and Three Lakes Wildlife Management Area Hydrologic Restoration Project. Activities associated with these initiatives span ecosystem restoration, ecological data collection and evaluation, hydrologic modeling, and adaptive management of water and land resources.

The KRRP's goal of restoring ecological integrity to approximately one-third of the river and its floodplain depends largely on reestablishing the physical form of the river-floodplain system (i.e., the physical habitat template) and subsequently applying hydrologic conditions similar to those that existed before the river was channelized in the 1960s. Achieving these conditions involves acquiring more than 102,000 acres of land in the river's floodplain and headwaters, backfilling 22 miles of the C-38 flood control canal, reconnecting remnant sections of the original river channel, removing two water control structures, and modifying portions of the river's headwaters to supply continuous flow to the river. The first three phases of restoration, constructed between 1999 and 2009, have reestablished flow to 24 miles of river channel and allowed intermittent inundation of 7,710 acres of floodplain. Construction activities continued in Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) in the headwaters and lower part of the river (Pool D). The next major phase of construction is scheduled to begin in 2012. The KRRP is on schedule for completion in late 2014.

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The KRRP's success is being evaluated through the Kissimmee River Restoration Evaluation Program (KRREP). Evaluation of restoration success was recognized as a crucial aspect of the restoration project in the Final Integrated Feasibility Report and Environmental Impact Statement for the Restoration of the Kissimmee River, Florida (USACE, 1991) and was identified as a SFWMD responsibility in its cost-share agreement with the USACE (Department of the Army and SFWMD, 1994). Success is being tracked, in part, using 25 performance measures to evaluate how well the project meets its ecological integrity goal. Targets for these performance measures, called restoration expectations, are based on reference conditions derived from information on the pre-channelized river or similar systems. A final evaluation of KRRP success will follow completion of all project components. Many of the restoration expectations, particularly those relating to floodplain responses, depend on the removal of water control structure S-65C during upcoming phases of restoration construction and implementation of a new headwaters regulation schedule in 2015 after KRRP construction is complete. This new schedule will allow additional storage capacity in the headwater lakes, thereby allowing more flexible operations that can more closely approximate the pre-channelized river's flow regime, including discharges with more natural timing, magnitude, and rates of change. This year's update on restoration evaluation includes newly available data from studies on hydrology, water quality [i.e., total phosphorus (TP)], river channel fish, wading birds, and waterfowl. This subset of restoration evaluation studies assesses the level of response of critical ecosystem components to physical restoration under the interim hydrologic conditions currently in place. Results from these studies provide information for sound water management decision making as the KRRP progresses and to guide water management after the project is complete. Key WY2011 highlights of this chapter include the following:

- **Hydrologic conditions.** Rainfall in the Kissimmee Basin was below average in WY2011. Consequently, the headwater lakes did not refill by the end of the wet season. Discharge from the headwater lakes, which had increased floodplain inundation in the Phase I restoration area, declined in May and June. July rainfall and an August discharge event allowed the floodplain to remain inundated for most of the wet season even though headwater discharge was usually held at minimal levels. However, low-flow conditions continued through the winter, and the floodplain gradually dried out. Although increased headwater discharge in March and April 2011 raised floodplain stage to some extent, much of the floodplain at upper elevations was still dry as WY2011 ended.

- **River channel hydrology.** Water management operations succeeded in maintaining continuous inflow to the Kissimmee River throughout WY2011. Under the interim regulation schedule, continuous flow has been achieved in seven of the last ten years. However, expectations for seasonal flow patterns and river channel flow velocities were not achieved due to below average rainfall, extended periods of low discharge, and the backwater effect from the S-65C structure.

- **Floodplain hydrology.** Floodplain stage met the fluctuation target, as it has every year since WY2002, in the upper part of the Phase I restoration area. Fluctuation was limited by the S-65C structure in the lower end of the restoration area. Only one monitoring station in the upper part of the restoration area was inundated for at least 180 days; other nearby stations fell short of this target. Although floodplain stage generally declined during WY2011, most monitoring stations recorded multiple recession events that were shorter and faster than the slow, prolonged recession that is desired (less than 0.3 meters per 30 days and greater than 173 days).

- **TP loads and concentrations.** TP loads in the C-38 canal were relatively low in WY2011 due to the drought. Loads have declined since WY2005 due to lower discharges and the diminishing impact of three hurricanes that crossed the headwater lakes in 2004. Loading in the WY2007–WY2011 period was less than 50 percent of the loading in the previous five years. TP concentrations also declined. Because the Kissimmee Basin is a major contributor of TP to Lake Okeechobee, this reduction is significant for Lake Okeechobee phosphorus control efforts. Restoration of the river and floodplain should favor lower TP concentrations as a more natural hydroperiod and a stable wetland ecosystem become established, but such a beneficial effect is not yet apparent from the C-38 data. Further investigation is under way to determine if restoration can significantly enhance TP retention. This work continued in WY2011 with a survey of the nutrient content and phosphorus storage capacity of river channel sediments and floodplain soils.
- **Assemblage structure of fish in the river channel**. The assemblage structure of certain taxa of fish is expected to shift in response to river restoration. Bass and sunfishes (centrarchids) are expected to increase in proportion to bowfin (*Amia calva*), Florida gar (*Lepisosteus platyrhincus*), and other fish species. In the Phase I restoration area, the relative abundances of bowfin and gar, which were predicted by the expectation to decrease in relative abundance, declined from 2004 to 2007 and were below or near their expected levels in 2010. However, the relative abundance of centrarchids, which was expected to increase, was well below the expectation of greater than or equal to 58 percent in 2010, although it exceeded the expectation in 2004 and 2007. The relative abundance of redbreast sunfish (*Lepomis auritus*) remained far below the greater than or equal to 16 percent expectation in all three years of interim sampling. Increases in the abundance of other fish species appear primarily responsible for the decline in the relative abundance of centrarchids. The results of this evaluation are mixed, but may reflect unfavorable conditions (droughts, low flows, and hypoxic events) that prevented centrarchids from maintaining dominance.
- **Wading birds and waterfowl.** River restoration is expected to reproduce conditions necessary to once again support an abundant and diverse assemblage of wading birds and waterfowl. Five nesting colonies of wading birds were observed in 2011 — two in the Kissimmee River survey area and one each in Lake Mary Jane, Lake Kissimmee, and Lake Istokpoga. White ibis (*Eudocimus albus*) nests were fewer than the year before, while nests of other aquatic wading birds were at levels similar to the previous year. The continued small numbers of aquatic wading birds nesting within and adjacent to the restoration area suggest prey availability on the floodplain is not yet sufficient to support successful breeding. Recent droughts and operational constraints under the interim regulation schedule have limited the range and seasonality of floodplain inundation, thereby restricting the abundance and density of prey items for foraging birds during the nesting season. Wading bird and waterfowl abundance is evaluated using a running average of three dry season surveys. Soon after completion of Phase I construction in 2001, the abundance of foraging wading birds was consistently meeting the restoration expectation of 30.6 birds per square kilometer, but under drier conditions, wading bird abundance fell short of this target in 2007–2009 and 2009–2011. Mean waterfowl abundance continued to exceed the restoration expectation of 3.9 ducks per square kilometer during 2009–2011. The restoration target for waterfowl species richness (greater than or equal to 13 species) has not yet been reached.

INTRODUCTION

The Kissimmee Basin encompasses more than two dozen lakes in the Kissimmee Chain of Lakes (KCOL), their tributary streams and associated marshes, and the Kissimmee River and floodplain (**Figures 9-1** and **9-2**). The basin forms the headwaters of Lake Okeechobee and the Everglades; together they comprise the Kissimmee-Okeechobee-Everglades system. In the 1960s, the Central and Southern Florida Flood Control Project (C&SF Project) modified the Kissimmee Basin's water resources extensively by constructing canals and installing water control structures to achieve flood control in the Upper and Lower Kissimmee basins. In the Lower Kissimmee Basin, construction of a 56-mile-long canal through the Kissimmee River resulted in profound ecological consequences caused by elimination of flow in the original river channel and prevention of seasonal floodplain inundation. In the Upper Kissimmee Basin, C&SF Project modifications allowed lake stages to be regulated at reduced ranges of fluctuation, altering or eliminating much of the formerly extensive littoral zones around the lakes and the marshes between them. These and other environmental losses led to legislation authorizing the federal-state Kissimmee River Restoration Project (KRRP). The South Florida Water Management District (SFWMD or District) has been working since the 1990s to coordinate and evaluate the KRRP, which is being done through the Kissimmee River Restoration Evaluation Program (KRREP).

In response to the need for increased integration and coordination of management activities at basin and watershed scales, the SFWMD has worked to integrate the KRRP with various management activities within the Kissimmee Basin and the Northern Everglades region. The primary goals of these efforts are to (1) restore ecological integrity to the Kissimmee River and its floodplain, (2) enhance and sustain natural resource values in the KCOL, (3) collect ecological data to evaluate river restoration and support management decision making, and (4) retain the flood reduction benefits of the C&SF Project in the Kissimmee Basin. To meet goals beyond those of the KRRP, the SFWMD is working with other agencies to define management objectives and assessment targets for the KCOL, address ecological data deficiencies needed to support management decision making, and develop and apply regional modeling and evaluation tools. The SFWMD and these agencies partner in construction, planning, monitoring, evaluation, and modeling projects described in this chapter and in previous South Florida Environmental Reports (SFERs).

In addition to the KRRP (**Figure 9-3a** and **b**), major initiatives include the interagency KCOL Long-term Management Plan and the KCOL and Kissimmee Upper Basin Monitoring and Assessment Project (**Figure 9-3c**), and the Kissimmee Basin Modeling and Operations Study (KBMOS) (**Figure 9-3d**). Activities associated with these initiatives span ecosystem restoration, ecological data collection and evaluation, hydrologic modeling, and adaptive management of water and land resources. Other ongoing activities of regional importance, such as water reservation development, water management operations, nutrient control efforts, and invasive species management, have been discussed in detail in Chapter 11 of the *2010* and *2011 South Florida Environmental Reports* (SFER) – *Volume I.*

This chapter is an update to Chapter 11 of the 2011 SFER – Volume I. It focuses on progress of the KRRP, KRREP, and KBMOS, and status of the KCOL Long-term Management Plan and other projects during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). The chapter also summarizes hydrologic conditions during WY2011 and presents newly available data from the evaluation of the river restoration project.

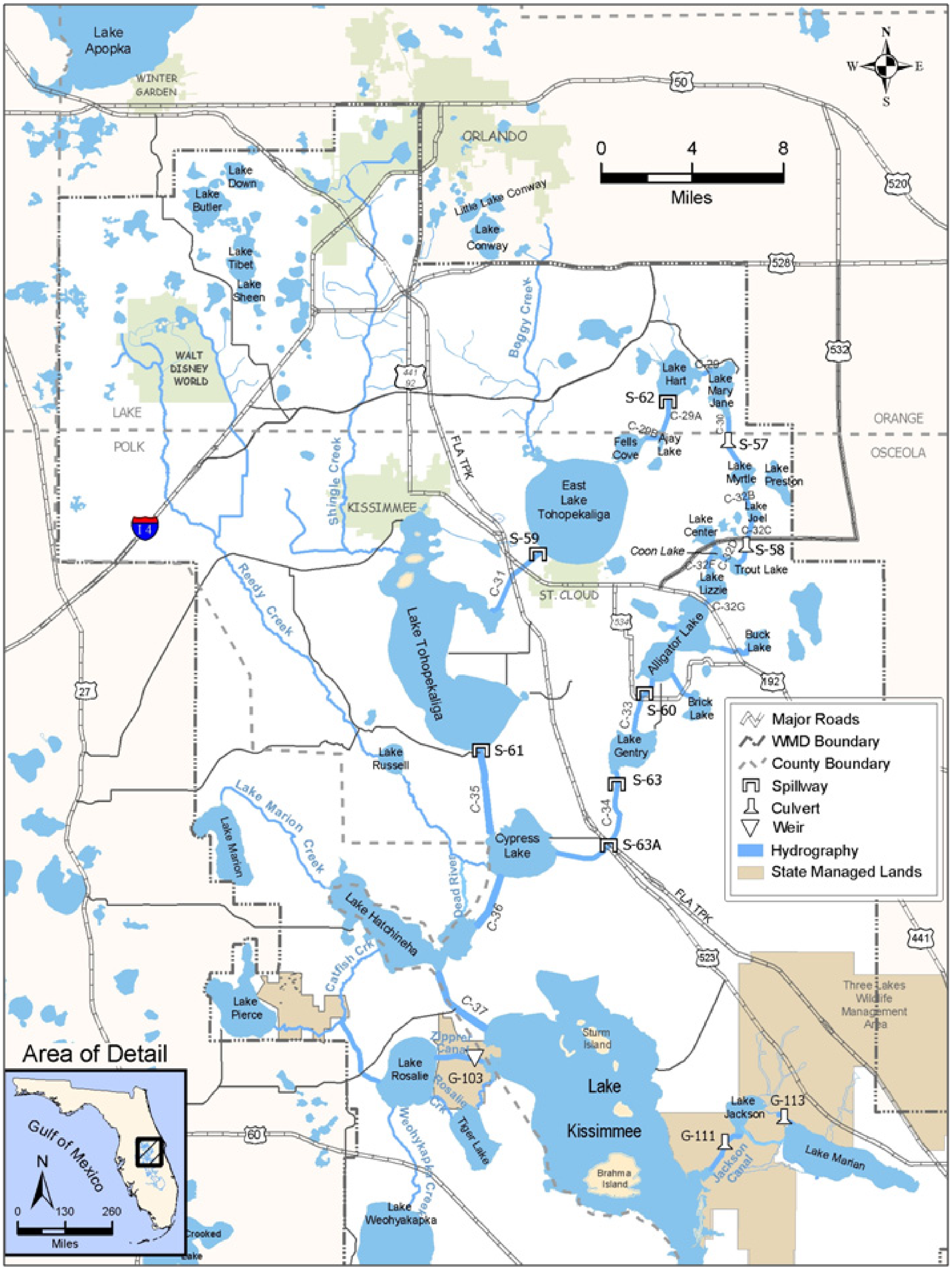

Figure 9-1. Upper Kissimmee Basin.

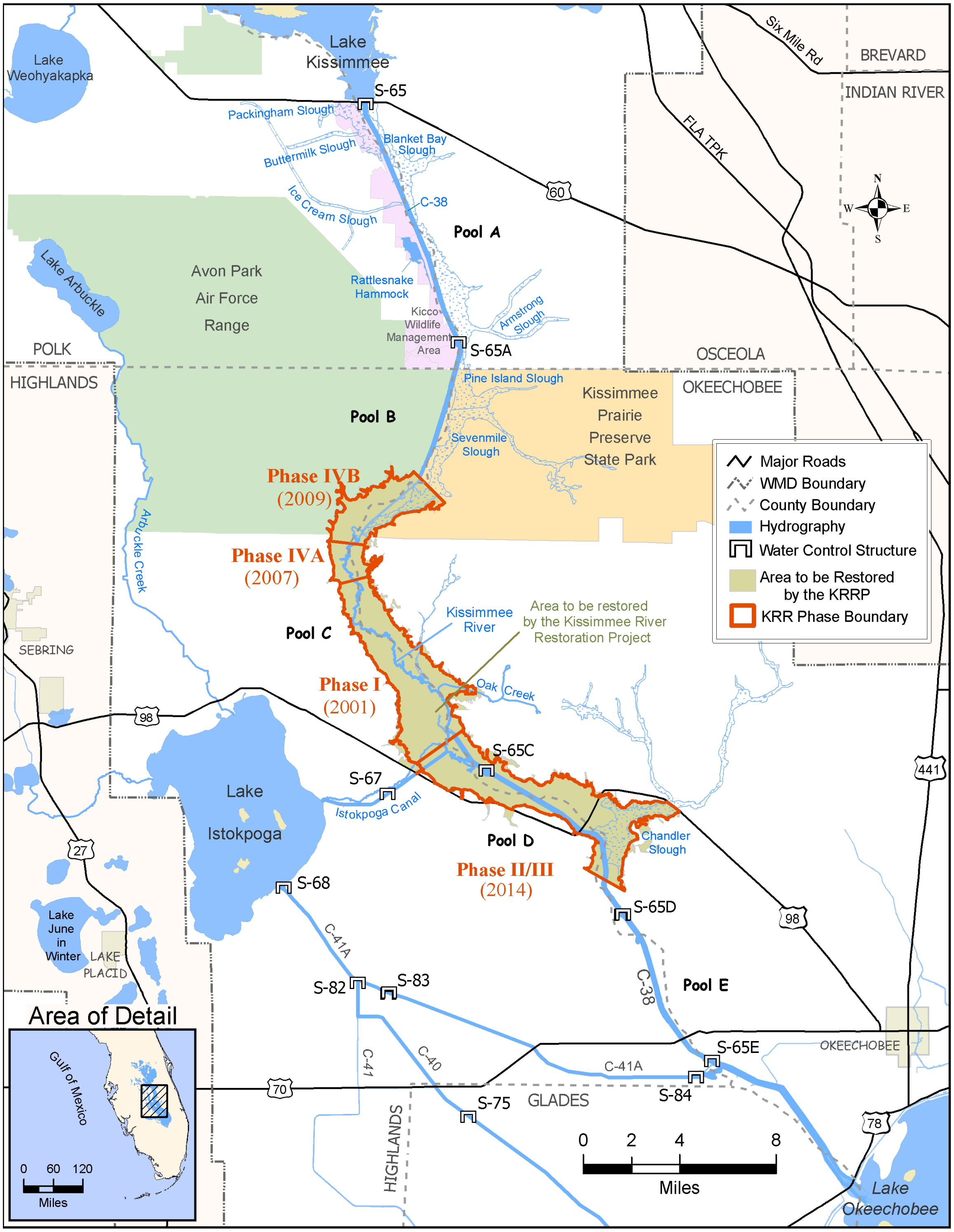

Figure 9-2. Lower Kissimmee Basin.

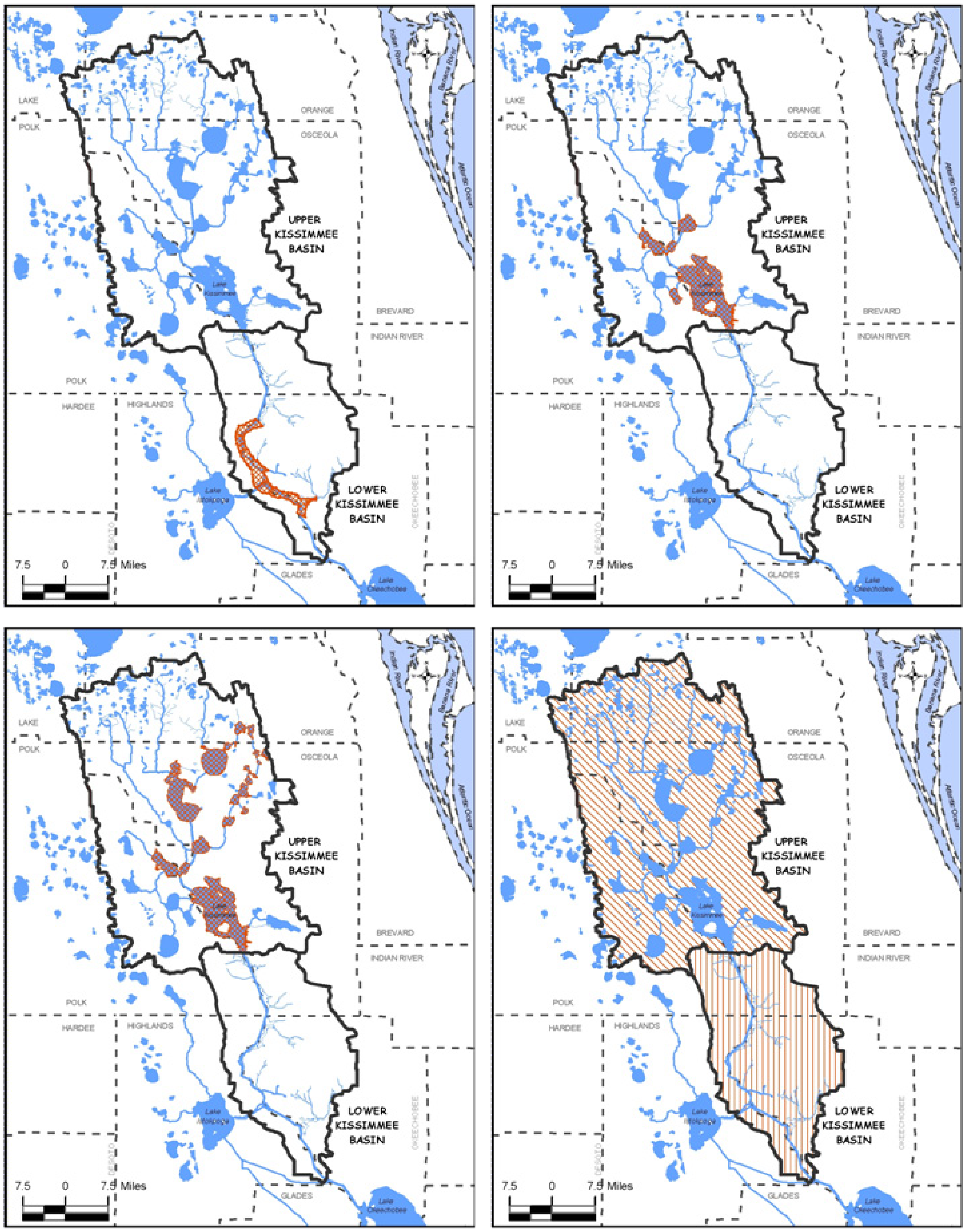

Figure 9-3. Geographic scopes (colored, hatched areas on maps) of major initiatives in the Kissimmee Basin including the (A) Kissimmee River Restoration Plan (KRRP), (B) headwater lakes component of the KRRP, (C) Kissimmee Chain of Lakes (KCOL) Long-Term Management Plan, and (D) Kissimmee Basin Modeling and Operations Study (KBMOS).

KISSIMMEE RIVER RESTORATION PROJECT

OVERVIEW

Concerns about environmental degradation and habitat loss in the Kissimmee River Valley and the potential contribution of the channelized river to eutrophication in Lake Okeechobee were the impetus for the KRRP. The goal of this project is to restore ecological integrity to the Kissimmee River and its floodplain. Successful restoration depends largely on reestablishing hydrologic conditions similar to the pre-channelization period (Toth, 1990). A headwaters component of the project is designed to allow additional storage capacity in the headwater lakes allowing more flexible operations that can more closely approximate the pre-channelized river's flow regime, including discharges with more natural timing, magnitude, and rates of change. An additional expected benefit is improvement in quantity and quality of lake littoral zone habitat in Lakes Kissimmee, Hatchineha, Tiger, and Cypress (USACE, 1996). Restoration is to occur without jeopardizing existing flood reduction benefits provided by the C&SF Project in the Kissimmee Basin.

In the Lower Kissimmee Basin, the KRRP is expected to restore ecological integrity to approximately one-third of the river and floodplain, modifying a contiguous area of floodplain-river ecosystem of over 39 square miles (sq mi). More than 20 sq mi of new wetlands will be reestablished in areas that were drained by the canal, and 40 miles (mi) of reconnected river channel will receive reestablished flow. In the Upper Kissimmee Basin, over 7,000 acres (ac) of littoral marsh are expected to develop on the periphery of the four lakes regulated by water control structure S-65 (USACE, 1996). The KRRP, which includes the KBMOS described later in this chapter, is funded under a 50-50 cost-share agreement between the SFWMD and the United States Army Corps of Engineers (USACE). Engineering and construction components of the project are the responsibility of the USACE, while the SFWMD's purview is land acquisition, hydrologic modeling, and ecological evaluation of the restoration project.

RESTORATION CONSTRUCTION COMPONENTS

Restoration components include (1) acquiring 65,603 ac of land in the Lower Kissimmee Basin, of which approximately 98 percent have been acquired to date, (2) backfilling approximately 22 mi of the C-38 canal (over one-third of the canal's length) from the lower end of Pool D north to the middle of Pool B, (3) reconnecting the original river channel across backfilled sections of the canal, (4) recarving sections of river channel destroyed during C-38 construction, (5) removing the S-65B and S-65C water control structures and associated tieback levees, and (6) modifying portions of the river's headwaters to supply continuous flow to the river (**Figure 9-2**). The material used for backfilling is the same that was dredged during construction of the C-38 canal. Composed primarily of sand and coarse shell, this material was deposited in large spoil mounds adjacent to the canal.

Reconstruction of the river-floodplain's physical template is being implemented in four phases (**Figure 9-2**) currently projected for completion by late 2014 (**Table 9-1**). Phase I construction was completed in February 2001. The second and third construction phases (Phase IVA and Phase IVB) extend north from the Phase I project area and were completed in September 2007 and December 2009, respectively. Phases II and III, the last major phases of construction, are scheduled to begin in 2012. While the restoration phases were originally named in the order of expected completion, the sequence has changed over time for logistical reasons (i.e., budgetary considerations, coordination with land acquisition, or ease of access).

Table 9-1. Sequence of backfilling construction phases of the Kissimmee River Restoration Project (KRRP) with selected benefits.

Construction Sequence	Name of Construction Phase	Timeline	Backfilled Canal (miles)	River Channel Recarved (miles)	River Channel to Receive Reestablished Flow (miles)	Total Area (acres)	Wetland Gained (acres)	Location and Other Notes
1	Phase I Project Area	1999–2001 (complete)	8	1	14	9,506	5,792	Most of Pool C, small section of lower Pool B
2	Phase IVA Project Area	2006–2007 (complete)	2	1	4	1,352	512	Upstream of Phase I in Pool B to Weir #1
3	Phase IVB Project Area	2008–2009 (complete)	4	4	6	4,183	1,406	Upstream of Phase IVA in Pool B (upper limit near location of Weir #3)
4	Phase II/III Project Area	2012–2014 (projected)	9	4	16	9,921	4,688	Downstream of Phase I (lower Pool C and Pool D south to CSX Railroad bridge)
Restoration Project Totals			**22**	**10**	**40**	**24,963**	**12,398**	

The three construction phases completed so far have backfilled 14 mi of flood control canal, recarved 6 mi of river channel that had been obliterated during canal dredging, and demolished a water control structure (S-65B). These efforts reestablished flow to 24 mi of continuous river channel and allowed intermittent inundation of 7,710 ac of floodplain (**Table 9-1**).

The KRRP will culminate with the implementation of a new stage regulation schedule, called the Headwaters Revitalization Schedule, to operate the S-65 water control structure. The new schedule will allow lake water levels to rise 1.5 feet (ft) higher than the current schedule and will increase the water storage capacity of Lakes Kissimmee, Hatchineha, Cypress, and Tiger by approximately 100,000 acre-feet (ac-ft). Approximately 97 percent of the 36,612 ac of land in the Upper Kissimmee Basin that will be impacted by the higher water levels have been acquired, and all projects, except the C-37 Canal Widening Project, needed to increase the conveyance capacity of canals and structures are in place to accommodate the larger storage volume. The C-37 Canal Widening Project will be completed in WY2012. The Headwaters Revitalization Schedule is expected to be implemented in 2015 after the C-38 backfilling and other construction projects are completed.

Because of the time lag between completion of the earliest phases of the construction project and the implementation of the Headwaters Revitalization Schedule, the USACE authorized an interim regulation schedule that allows the SFWMD to make releases from S-65 when the lake stage is in “Zone B,” an area below the maximum regulated stage. Zone B allows for releases for environmental purposes when flood control releases are not needed, and is used to maintain flow in the reach of the restored river channel continuously through the year and to allow seasonal variability. Environmental releases according to this interim schedule began in July 2001 after the Phase I construction was completed and lake levels began to rise following the 2000–2001 drought. Zone B releases have allowed continuous flow to the river since that time except for a 252 day dry period in 2006–2007. While the use of Zone B releases has been beneficial, it does not provide the full benefits of the Headwaters Revitalization Schedule is expected to provide.

CONSTRUCTION STATUS

In WY2011, construction activities consisted of the enlargement of the C-37 canal (between Lakes Hatchineha and Kissimmee) to provide greater conveyance capacity to other projects in Pool D of the Kissimmee River. These activities are scheduled for completion in WY2012 and WY2013. **Table 9-2** provides brief descriptions of current activities along with a chronological list of all the KRRP construction activities.

Table 9-2. Chronology of Kissimmee River Restoration Project construction. [Note: **Bold** text indicates C-38 backfilling contracts.]

Contract Number	Project Name and Description	Status	Start Date	End Date	Construction Cost
1	Test Backfilling – A short section of the C-38 canal was backfilled as a test to evaluate engineering and design construction methods.	Complete		May 1994	$1.2 million (M)
14B	Pool A Spoil Mound Removal – A portion of a spoil mound in Pool A was degraded and two 48-inch culverts were installed under an access road.	Complete		October 2000	$0.62 M
3	S-65 Enlargement – The S-65 structure was enlarged from a three-bay to a five-bay spillway to maintain the existing level of flood protection for the headwater lakes.	Complete		May 2001	$4.8 M
2A	C-35 Dredging – Maintenance dredging was conducted in the C-35 canal to maintain the existing level of flood protection for the headwater lakes. A portion of C-36 was enlarged to maintain the existing level of flood protection.	Complete		July 2001	$2.6 M
4	Degradation of Local Levees in Pools A, B, and C – Local levees and associated borrow canals were restored to natural elevation.	Complete		2001	$1.5 M
5	S-65A Tieback Levee – The western tieback levee was degraded and box culverts installed in the eastern tieback levee. This allows additional discharge capacity adjacent to S-65A through the floodplain to avoid upstream impacts.	Complete		April 2001	$2.1 M
7	**Reach 1 Backfilling – Seven miles of the C-38 canal were backfilled, new river channels were constructed, and the S-65B structure was removed.**	**Complete**		**April 2001**	**$24.2 M**
2B	C-36 Enlargement – The C-36 and C-37 canals were enlarged to maintain the existing level of flood protection for the headwater lakes. Due to turbidity issues, the C-37 portion of this contract was terminated before completion.	C-36 Complete C-37 Terminated		April 2003	$14.5 M
8	U.S. Highway 98 Causeway – The causeway was elevated and resurfaced, a 100 foot flat-span bridge was built, and ten concrete culverts, each 2 meters by 3 meters by 30 meters, were installed under the highway for flood control and to improve hydrologic conditions in the Kissimmee River floodplain.	Complete		January 2004	$6.3 M
6A1A	8-83A/84A Spillways – When Kissimmee River floodplain water levels restrict Lake Istokpoga Basin discharges via the Istokpoga Canal, the C-41A spillway additions will offset the loss of discharge capacity by rerouting flows to the C-41A canal.	Complete		July 2007	$11.8 M
6B	Basinger Grove –Protection of the Basinger property from flooding due to elevated post-project Kissimmee River and Istokpoga Canal stages including construction of levees and pumping stations and a 22.5 acre detention area.	Complete		May 2008	$20 M

Table 9-2. Continued.

Contract Number	Project Name and Description	Status	Start Date	End Date	Construction Cost
7B	Radio Tower – A radio tower at the S-65B structure was removed and a new one built approximately 11 miles to the west.	Complete		August 2007	$1.6 M
11	S-65D Grade Control Structure – Additional structures (S-65DX1 and S-65DX2) were built to increase the capacity of the S-65D structure.	Complete		October 2007	$7.5 M
13A	**Reach 4 Backfilling – 2.5 miles of the C-38 canal in Pool B were backfilled, a new river channel was excavated, and three existing navigable sheet pile weirs within the C-38 canal were removed.**	**Complete**		**October 2007**	**$29.8 M**
6A1B	S-68A Spillway – A new bypass channel was excavated, a gated spillway was constructed adjacent to the existing spillway, a portion of the existing levee was removed at the S-68 structure, and a temporary access road was constructed.	Complete		June 2009	$13.5 M
6A2	Istokpoga Canal Improvements – The G-85 weir was removed and replaced with the new S-67 control structure. Other features included construction of a tie-back levee, an access road, and a public boat ramp, and canal improvements.	Boat ramp complete S-67 almost finished		March 2010	$14.3 M
13B	**Reach 4 Backfilling – 3.5 miles of the C-38 canal were backfilled along Reach 4 extending from the upstream limit of Contract 13A backfill northward to the upstream limit of the backfill.**	**Complete**		**December 2010**	**$18 M**
15	River Acres Flood Reduction – A seepage levee, flood protection tieback levee, and navigation canal were constructed for the River Acres community.	Under construction	December 2009	December 2011	$2.97 M
2B1	C-37 Enlargement – The remainder of the C-37 canal, which was not completed under contract 2B, is being enlarged.	Under construction	June 2010	September 2012	$15.6 M
9	CSX Railroad Bridge – This contract consists of modifying the existing CSX railroad by building an elevated single track railroad bridge to allow navigation through the restored river channel.	Under construction	November 2010	December 2012	$6.8 M
18	Pool D Oxbow Excavation and Embankment – A new boat ramp and small parking area are being constructed.	Under construction	December 2010	December 2012	$2.8 M
10A	Oxbow Dredging – To accelerate completion of the KRRP, oxbow dredging to restore the historic river channel was removed from contract 10 and will be completed in this separate contract.	Not yet awarded	October 2011	October 2012	NA
18B	Pool D Boat Ramp – A new boat ramp and small parking area will be constructed.	Not yet awarded	October 2011	October 2012	NA
12A	S-69 Weir – The S-69 weir will serve as the terminus of the C-38 canal backfill.	Not yet awarded	August 2012	February 2014	NA
18A	S-65E Spillway Addition – A gated spillway will be constructed in the S-65E west tie-back levee.	Not yet awarded	August 2012	August 2012	NA
12	**Reach 3 Backfilling – New channels will be dredged and 2.5 miles of the C-38 canal will be backfilled.**	**Not yet awarded**	**April 2012**	**October 2013**	**NA**
10	**Reach 2 Backfilling – New channels will be dredged, 6.5 miles of the C-38 canal will be backfilled, and the S-65C structure will be removed.**	**Not yet awarded**	**March 2013**	**December 2014**	**NA**

Note: NA - not available

KISSIMMEE BASIN HYDROLOGIC CONDITIONS IN WATER YEAR 2011

This section discusses hydrologic conditions in WY2011 based on data collected by the SFWMD monitoring program. Locations of monitoring stations at water control structures are shown in **Figure 9-2**, and stage monitoring locations in the river channel and floodplain are shown in **Figure 9-4**.

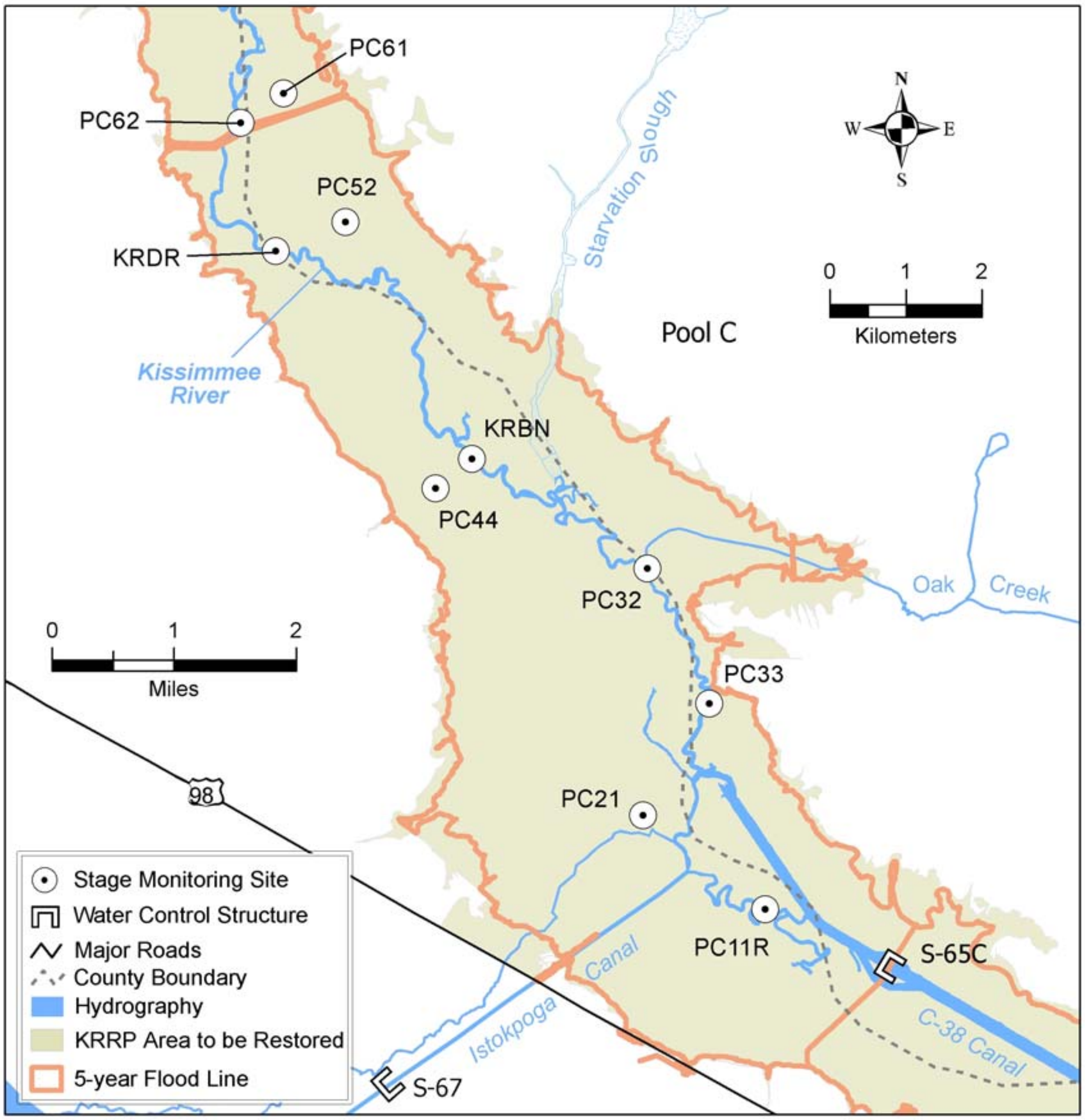

Figure 9-4. Location of hydrologic monitoring sites in Pool C used to guide operations and to evaluate restoration expectations.

RAINFALL

In WY2011, rainfall in the upper basin was below average for every month except August, January, and March (**Figure 9-5**). Total rainfall for the water year was 40.63 inches, which was 82 percent of the long-term average (1971–2000). Most of the deficit occurred in the wet season (June–October), which was eight inches below average. The dry season was only one inch below average.

In the lower basin, rainfall was below average in every month except July, August, January, and March (**Figure 9-5**). Total rainfall for the water year was 38.43 inches, which was 75 percent of the long-term average for the basin. The deficit was four inches for the wet season and nine inches for the dry season.

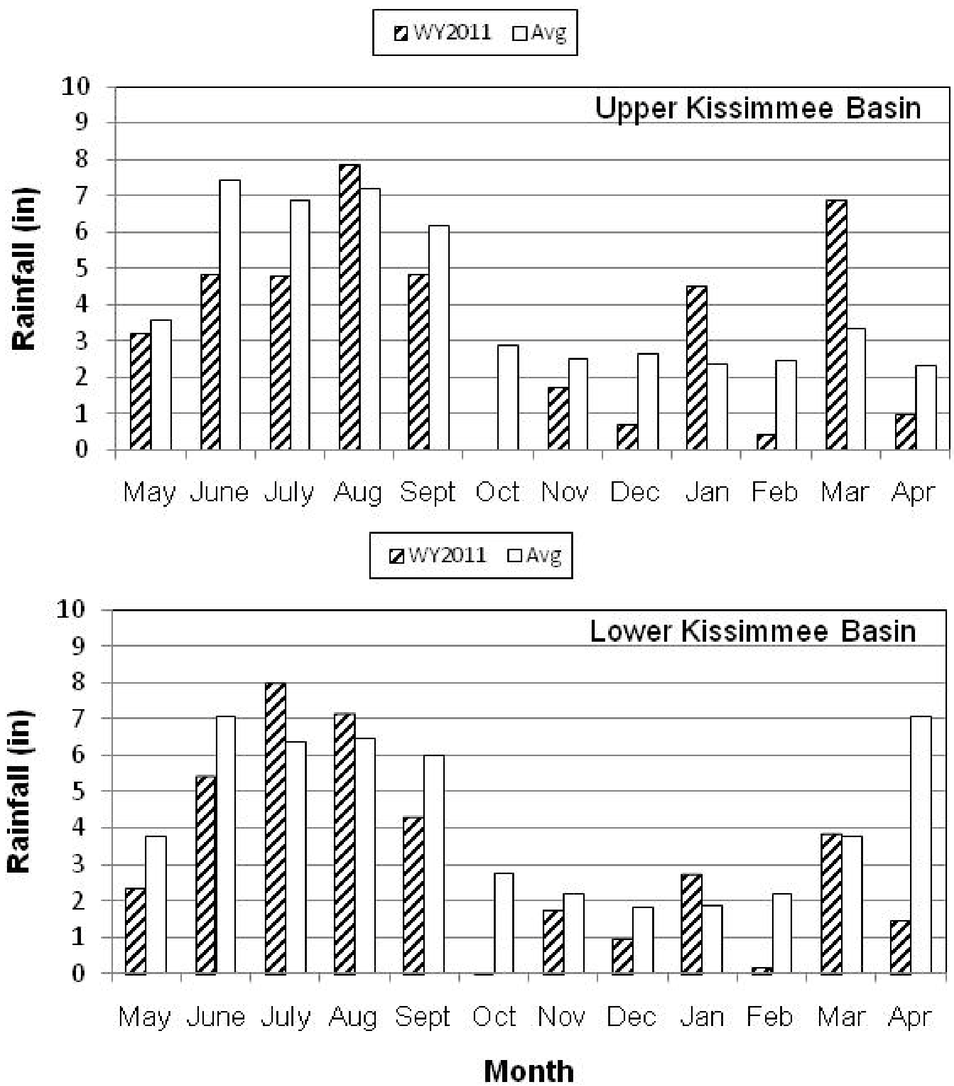

Figure 9-5. Monthly rainfall [in inches (in)] for Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) and average rainfall (1971–2000) in the Upper Kissimmee Basin (top) and the Lower Kissimmee Basin (bottom).

TEMPORAL HYDROLOGIC PATTERNS

At the beginning of WY2011, each of the upper basin lakes was being lowered to the lowest (low pool) stage of its regulation schedule (e.g., **Figures 9-6** and **9-7b**). Because of snail kite (*Rostrhamus sociabilis*) nesting on East Lake Tohopekaliga and Lake Tohopekaliga, these lakes were lowered only to within 0.5 ft of the low pool stage. The water levels in these lakes are lowered by increasing the discharge from the lake to the downstream water body, which results in more discharge from the upper basin at the S-65 structure. This discharge raised the stage above the floodplain ground elevation in the upper portion of the Phase I area, as shown for the stage monitoring station PC61 in **Figure 9-8**. Discharge at S-65 began the month of May at 3,800 cubic feet per second (cfs) and declined to less than 500 cfs in June (**Figure 9-7c**).

At the beginning of the wet season, the regulation schedule rises to a summer pool elevation before rising to the high pool at the end of the wet season. Despite the below average rainfall for most of the wet season, stage increased in all of the lakes (**Figures 9-6** and **9-7b**). However, none of the lakes refilled to the high pool stage by the end of the wet season. Because of the relatively low stage in the Cypress-Hatchineha-Kissimmee chain, the discharge at S-65 was only 250–500 cfs for most of the wet season. In mid-August, the stage in Lake Kissimmee rapidly approached the regulation schedule, so that the discharge was increased to 2,000 cfs (**Figure 9-7c**) and then rapidly decreased to approximately 300 cfs as the rise in lake stage slowed and the regulation schedule continued to rise. This increase in discharge coincided with a stage reversal on the floodplain of at least one foot at monitoring stations PC61 and KRBN (**Figure 9-8**). Because of the periods of increased discharge from the upper basin and above average rainfall in July, the floodplain was inundated for most of the wet season.

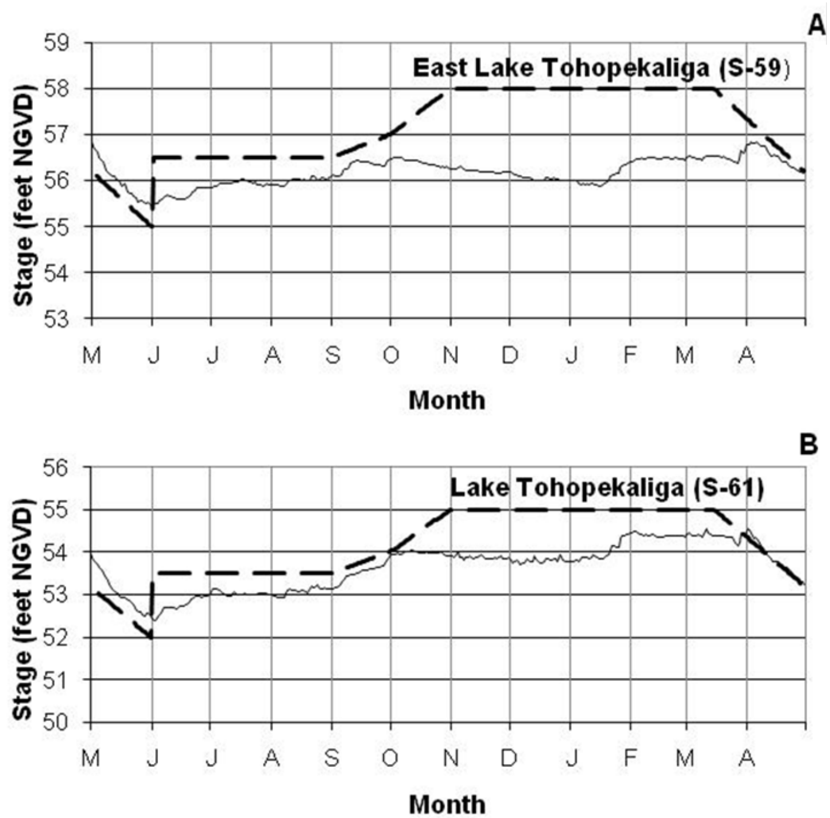

Figure 9-6. Regulation schedule (dashed line) and water level (solid line) in feet National Geodetic Vertical Datum (NGVD) for (A) East Lake Tohopekaliga and (B) Lake Tohopekaliga during WY2011.

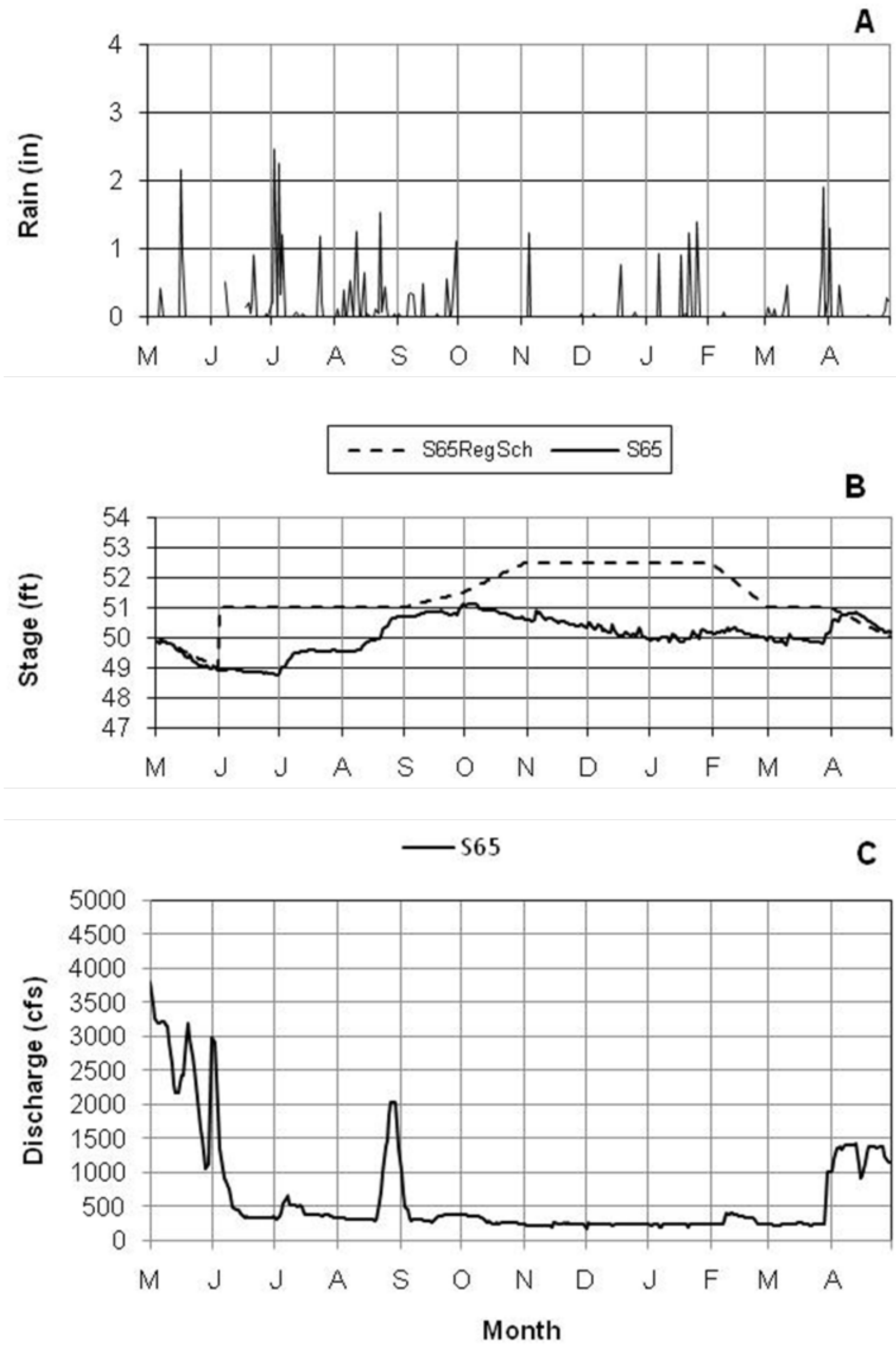

Figure 9-7. (A) Rainfall, (B) regulation schedule and water level in feet (ft), and (C) discharge in cubic feet per second (cfs) at the outlet for Lake Kissimmee (S-65 structure) for WY2011.

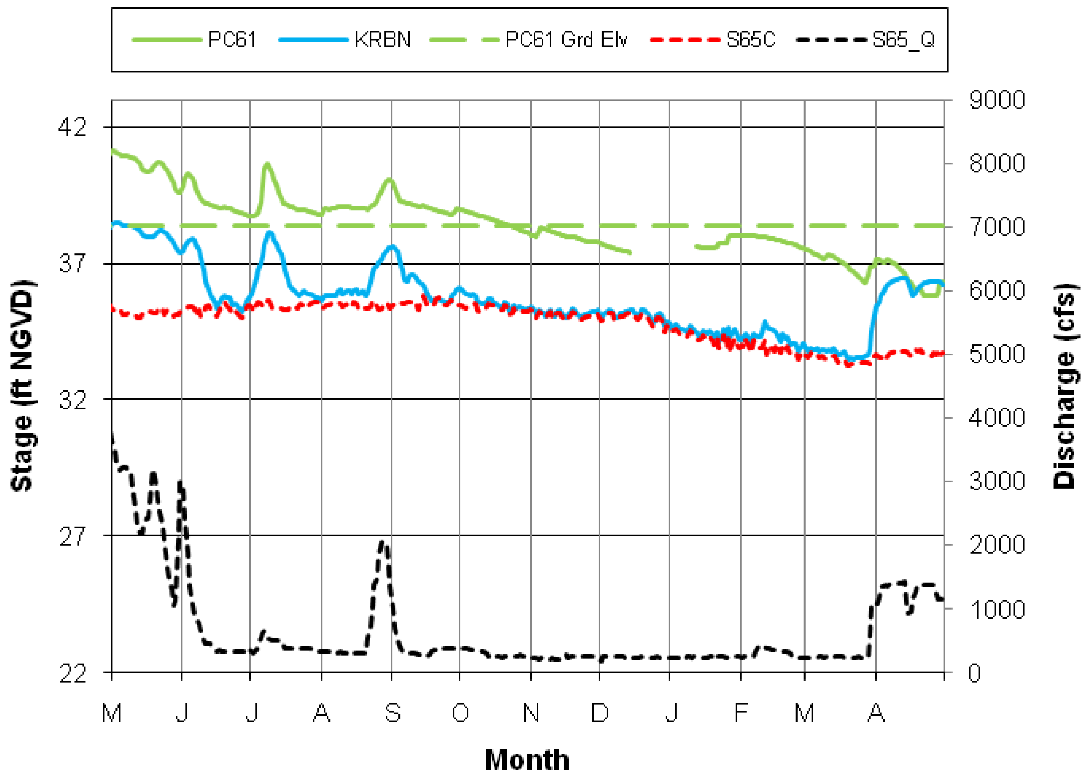

Figure 9-8. Mean daily stage on the floodplain at PC61, in the river channel at KRBN, and in the C-38 canal on the upstream side of S-65C in relation to mean daily discharge at S-65 during WY2011.

Early in the dry season, lake levels fell slightly with evapotranspiration. Water levels in the Cypress-Hatchineha-Kissimmee chain also declined because of continued releases to the Kissimmee River. Above average rainfall in January and March raised lake water levels in the upper basin (**Figure 9-6**). Lake Gentry was the only lake where stage rose to the high pool stage during the dry season.

Discharge at S-65 was maintained at 200–300 cfs for most of the dry season (**Figure 9-7c**). In late March, rainfall caused the stage in most of the lakes to rise. Discharge was increased from the lakes as rising water levels began to intersect the regulation schedule line, which was declining for the spring recession. At S-65, discharge was increased to more than 1,000 cfs in April. The increased discharge resulted in higher stage in the river channel (KRBN in **Figure 9-8**) and smaller increases in stage on the floodplain (PC61 in **Figure 9-8**) that inundated floodplain areas at lower elevations, especially those with connections to the river channel.

KISSIMMEE RIVER RESTORATION EVALUATION PROGRAM

A major component of the KRRP is the assessment of restoration success through the Kissimmee River Restoration Evaluation Program (KRREP), a comprehensive ecological monitoring program (SFWMD, 2005a; SFWMD, 2005b; 2007 SFER – Volume I, Chapter 11). Evaluating the success of the KRRP was identified as a SFWMD responsibility in its cost-share agreement with the USACE (Department of the Army and SFWMD, 1994). Success is being tracked, in part, using 25 performance measures (SFWMD, 2005b) to evaluate how well the project meets its ecological integrity goal. Ecological integrity is defined as a reestablished river-floodplain ecosystem that is "capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley, 1981). Targets for these performance measures, called restoration expectations, are based on estimated conditions in the pre-channelized system (reference conditions) and have undergone an external peer-review process. Trends and results from restoration evaluations are reported in several ways, including conference presentations, peer-reviewed and SFWMD technical publications, and the annual SFERs. Many of the restoration expectations, particularly those relating to floodplain responses, are dependent on removal of the S-65C structure during upcoming phases of construction, and implementation of the Headwaters Revitalization Schedule, currently scheduled for 2015. Therefore, a final evaluation of project success must wait until all restoration components are in place. Monitoring for ecological evaluation of restoration success will continue for at least five years after construction is complete or until ecological responses have stabilized.

Limited post-construction monitoring continued in WY2011 in the Phase I restoration area. Many of the Phase I studies, which include assessments of hydrology, geomorphology, water quality, river channel and floodplain vegetation, aquatic invertebrates, herpetofauna, fish, and birds, have already indicated significant changes consistent with those predicted by the expectations (performance measures) developed for the KRREP (SFWMD, 2005b). A comprehensive update of initial responses to Phase I reconstruction was published in Chapter 11 of the 2005 SFER – Volume I, with updates using newly available monitoring data published in Chapter 11 of subsequent SFERs – Volume I (2006, 2007, 2008, 2009, 2010, and 2011). The combined results for a group of interrelated river channel studies were presented in Chapter 11 of the 2006 SFER – Volume I. **Table 9-3** provides a directory of KRREP monitoring study updates since 2005.

To contain costs, most KRREP studies do not collect data continuously. Most studies are active for two to five years during the baseline (pre-restoration), interim, and/or post-restoration response periods. Many studies that collected baseline data will not collect data again until the entire project is complete. The "interim period" for KRREP evaluations of the Phase I area is defined as the years between completion of Phase I construction (2001) and completion of all remaining construction phases and implementation of the Headwaters Revitalization Schedule. During the interim period, the river's physical and hydrologic characteristics are only partially restored.

Only studies that collected new data in WY2011 are updated in this section. These new results from studies on hydrology, water quality, fish, wading birds, and waterfowl document the current interim status of these ecosystem components. Where applicable, the results are evaluated in relation to associated restoration expectations.

HYDROLOGY

The reestablishment of hydrologic conditions (water surface elevations and flow) comparable to those of the natural system is the primary driver for restoring ecological integrity to the Kissimmee River and its floodplain. Hydrologic conditions are being evaluated with respect to five expectations for the restored hydrology of the river channel and floodplain. These expectations reflect criteria that have guided the restoration project since its inception (SFWMD, 2005b). The ability to meet these expectations depends on the implementation of the Headwaters Revitalization Schedule. Until this schedule is implemented (currently projected for 2015), an interim regulation schedule for S-65 is providing discharge to the river that varies seasonally and with water levels in Lake Kissimmee.

Table 9-3. Directory of Kissimmee River Restoration Evaluation Program (KRREP) Phase I restoration response monitoring study updates in the *2005–2012 South Florida Environmental Reports* (SFERs).

KRREP Monitoring Study or Project	Expectation Number	Page Number in 2005–2012 SFERs – Volume I							
		2005	2006	2007	2008	2009	2010	2011	2012
Kissimmee River Restoration Evaluation Program		11-8	11-37	11-22	11-28	11-36	11-26	11-25	9-16
Hydrology									
Stage-discharge relationships	No expectation	11-20							
Continuous river channel flow	1	**[11-18]**				**[11-39]**	**[11-29]**	**[11-29]**	**[9-20]**
Variability of flow	2					**[11-40]**	**[11-31]**	**[11-32]**	**[9-20]**
Stage hydrograph	3	**[11-22]**				**[11-41]**	**[11-32]**	**[11-33]**	**[9-21]**
Stage recession rate	4	**[11-23]**	11-23	11-16	11-19	**[11-42]**	**[11-34]**	**[11-35]**	**[9-24]**
Flow velocity	5	**[11-25]**					**[11-35]**	**[11-37]**	**[9-24]**
Broadleaf marsh indicator	No expectation					11-43			
Geomorphology									
River bed deposits	6	**[11-26]**						**[11-70]**	
Sandbar formation	7	**[11-26]**						**[11-70]**	
Channel monitoring	No expectation					11-54		11-68	
Sediment transport	No expectation							11-71	
Floodplain processes	No expectation							11-72	
Dissolved Oxygen	8	**[11-28]**	**[11-44]**	**[11-25]**	**[11-28]**	**[11-45]**	**[11-36]**	**[11-38]**	
River Channel Metabolism	No expectation				11-35				
Phosphorus	No expectation	11-33	11-52	11-30	11-32	11-51	11-43	11-43	9-25
Turbidity	9	**[11-30]**	**[11-48]**	**[11-27]**					
Periphyton	No expectation	11-46							
River Channel Vegetation									
Width of littoral vegetation beds	10	**[11-36]**				**[11-59]**			
River channel plant community structure	11	**[11-37]**				**[11-59]**			
Floodplain Vegetation									
Areal coverage of floodplain wetlands	12	**[11-39]**			**[11-35]**			**[11-47]**	
Areal coverage of broadleaf marsh	13	11-40			**[11-35]**			**[11-47]**	
Areal coverage of wet prairie	14	11-40			**[11-35]**			**[11-47]**	

Table 9-3. Continued.

KRREP Monitoring Study or Project	Expectation Number	Page Number in 2005–2012 SFERs – Volume I							
		2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Invertebrates									
Macroinvertebrate drift composition	15	**[11-45]**	11-57						
Snag invertebrate community structure	16	**[11-46]**	11-55			11-62			
Aquatic invertebrate community structure in broadleaf marsh	17		11-57						
Benthic invertebrate community structure	18	**[11-45]**	11-58			11-62			
Native and nonnative bivalves	No expectation							11-52	
Herpetofauna		11-48							
Floodplain reptiles and amphibians	19		Response data will be collected after implementation of the Headwaters Regulation Schedule.						
Floodplain amphibian reproduction and development	20		Response data will be collected after implementation of the Headwaters Regulation Schedule.						
Fish Communities									
Small fishes in floodplain marshes	21	11-50	Response data will be collected after implementation of the Headwaters Regulation Schedule.						
River channel fish community structure	22	11-52	**[11-59]**			**[11-66]**			**[9-29]**
Mercury in fish	No expectation					11-20			
Floodplain fish community composition	23	11-50	Response data will be collected after implementation of the Headwaters Regulation Schedule.						
Birds									
Wading bird abundance	24	**[11-58]**	**[11-71]**	**[11-32]**	**[11-44]**	**[11-72]**	**[11-50]**		**[9-36]**
Waterfowl	25		**[11-67]**	**[11-35]**		**[11-73]**	**[11-52]**		**[9-37]**
Shore birds	No expectation	11-57							
Wading bird nesting	No expectation		11-68		11-40	11-72	11-47		9-33
Threatened and Endangered Species	No expectation	11-60							

[xxx] bolded brackets indicate a major update in reference to the status of a restoration expectation (performance measure)

The addition of WY2011 extends the evaluation of the Phase I interim period to ten years (WY2002–WY2011). This evaluation quantifies progress toward meeting the hydrologic expectations under the interim flow conditions. This year's update includes all five hydrologic expectations. Chapter 11 of the 2011 SFER – Volume I includes more detail on methods.

Expectation 1

> The number of days that discharge is equal to 0 cubic meters per second (m^3/s) in a water year will be zero for restored river channels of the Kissimmee River (SFWMD, 2005b).

In WY2011, mean daily discharge at S-65 ranged from 5 m^3/s to 103 m^3/s and averaged 18 m^3/s. While discharge was low for most of the year, it was continuous throughout WY2011 (**Figure 9-9a**). This increased the number of years with continuous flow to seven out of ten water years during the Phase I interim period (**Figure 9-9b**).

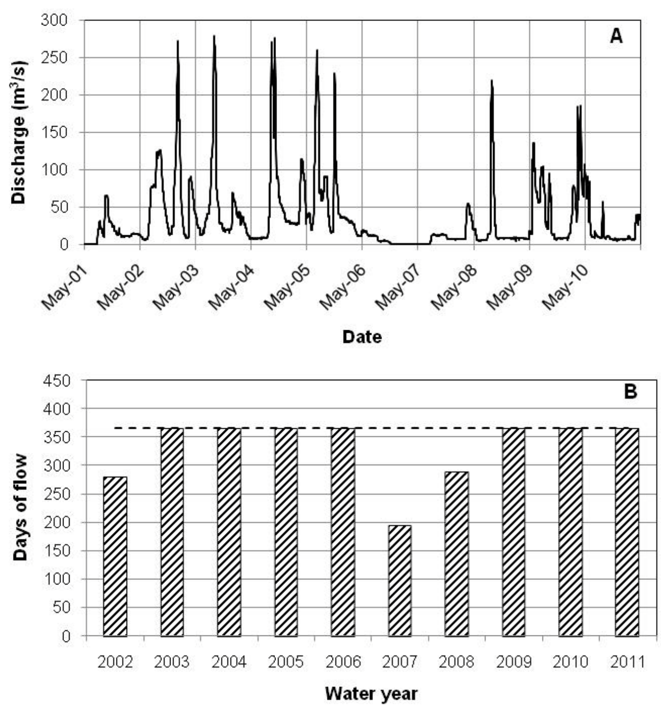

Figure 9-9. Mean daily discharge [cubic meters per second (m^3/s)] at the (A) S-65 structure, the outlet from the Upper Kissimmee Basin, and (B) number of days with flow for WY2002–WY2011.

Expectation 2

> Intra-annual mean monthly flows will reflect historical seasonal patterns and have intra-annual variability (coefficient of variation) < 1.0 (SFWMD, 2005b).

During WY2011, the maximum mean monthly discharge occurred in May and decreased to the minimum of 7 m^3/s in November–January (**Figure 9-10**). This pattern reflected the seasonal distribution of rainfall, especially the above average rainfall in March and April in WY2010, which preceded the maximum mean monthly discharge in May. This pattern for WY2011 differed from the average for the interim period, which reached the maximum in September and the minimum in May. However, the addition of WY2011 did not greatly alter the seasonal pattern of monthly averages for the interim period, which is now based on 10 years of data. During the interim period, the maximum mean monthly discharge occurs one month earlier than for the reference period, and the minimum is several months earlier. For WY2011, the coefficient of variation for mean monthly discharge ranged from 0.82 to 1.48. Only five months (February, March, April, August, and September) had a coefficient of variation less than 1.0, so the expectation was not met.

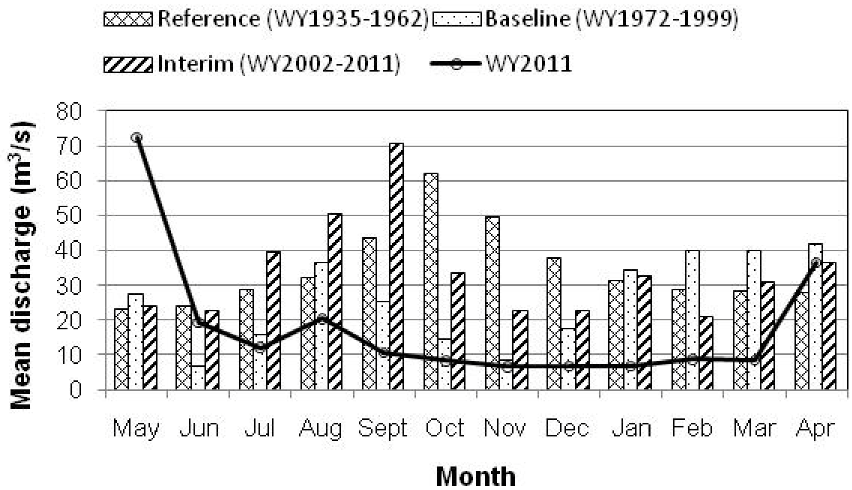

Figure 9-10. Seasonality of mean monthly discharge at S-65 for the reference period (WY1935–WY1962), baseline period (WY1972–1999), interim period (WY2002–2011), and WY2011.

Expectation 3

> River channel stage will exceed the average ground elevation for 180 days per water year and stages will fluctuate by at least 1.14 meters (m) (SFWMD, 2005b).

The amplitude of stage fluctuation and duration of water above ground level were quantified at five floodplain locations. From upstream to downstream, these sites are PC61, PC52, PC44, PC32, and PC21 (**Figure 9-4**). Water level fluctuation at the two most downstream sites (PC32 and PC21) is constrained by the downstream water control structure, S-65C, which is managed to keep water levels at an elevation between 10 and 11 m in relation to the National Geodetic Vertical Datum of 1929 (NGVD 1929). The ground elevations at PC32 and PC21 are near the lower end of the range of elevation at S-65C; therefore, water levels at these sites are regulated largely by S-65C, which will be removed in the next phase of restoration construction.

Stage at the three most upstream floodplain sites (PC61, PC52, and PC44) increased with discharge at the end of WY2010, and then generally decreased during WY2011 (**Figure 9-11**), although several stage reversals occurred during WY2011. Stage at PC32 and PC21 varied with the headwater stage at S-65C.

In WY2011, the three most upstream sites (PC61, PC52, and PC44) met the target for amplitude of stage fluctuation of at least 1.14 m as they had in all previous years (**Figure 9-12**). PC32 also met the target for amplitude although it has met the target in only six of the previous nine years. Because of the influence of the S-65C structure, PC32 and PC21 were inundated nearly continuously and met the target of inundation of at least 180 days. Of the three upstream sites, only PC52 exceeded the target of at least 180 days of inundation. PC61 almost met the target.

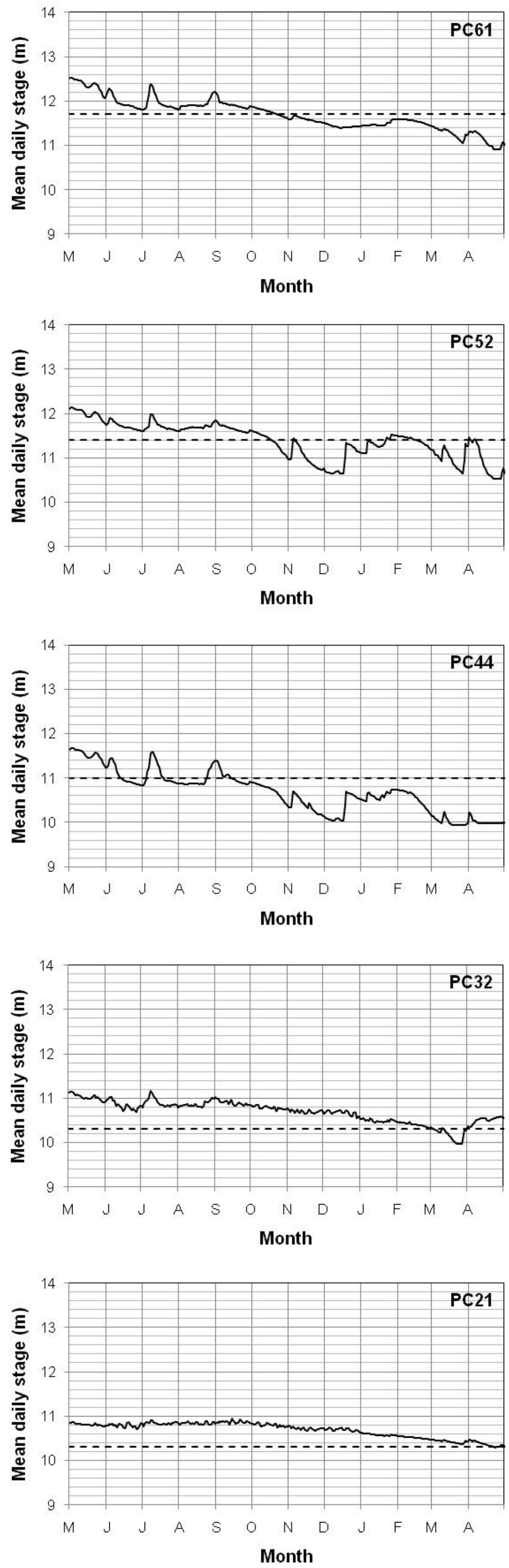

Figure 9-11. Water level (stage) in WY2011 at five floodplain locations. Dashed line is the ground elevation at the location.

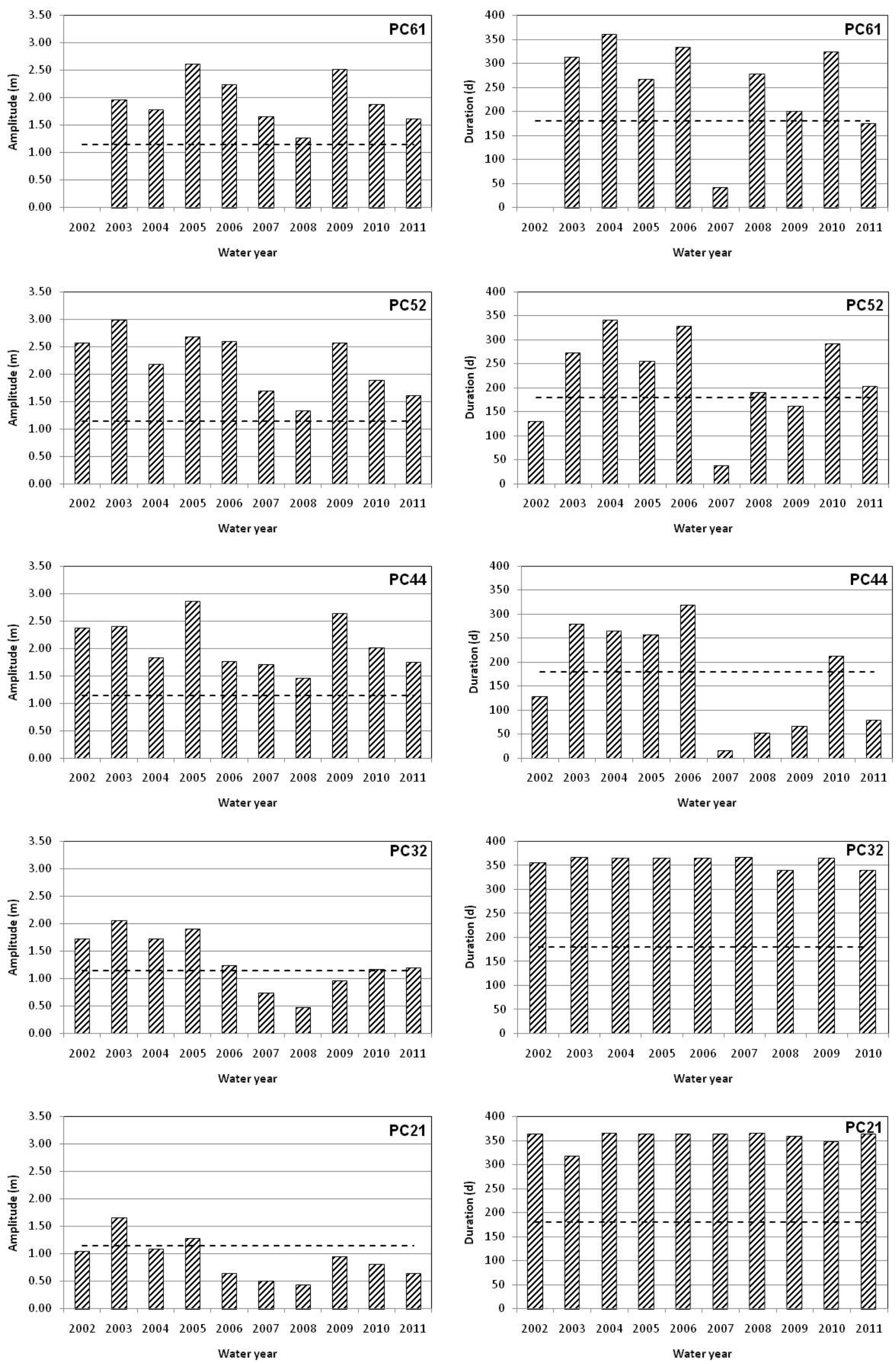

Figure 9-12. Amplitude of water level fluctuation (left) and duration of inundation (right) at five locations for WY2002–WY2011. The dashed horizontal lines represent minimum change in water level fluctuation of at least 1.14 meters (m) per year (right) and a minimum duration of 180 days per year for stage exceeding floodplain ground elevation (left).

Expectation 4

> An annual prolonged recession event will be reestablished with a duration of > 173 days and with peak stages in the wet season receding to low stage in the dry season at a rate that will not exceed 0.3 m per 30 days (SFWMD, 2005b).

The Phase I area continued to exhibit a complex pattern of stage recession events in WY2011 (**Table 9-4**). At PC61, a single recession event was measured, which had a duration of 288 days and a recession rate of 0.15 m per 30 days. At PC52, PC44, and PC32, multiple stage reversals occurred that were larger than 0.45 m, which is the criterion for counting the next recession event. Many of these recession events were shorter than the expected duration of greater than 173 days and had faster recession rates than the target of less than or equal to 0.3 m per 30 days. Therefore, this expectation was not met in WY2011 because most sites had multiple recession events that were shorter and faster than the slow, prolonged recession that is desired.

Table 9-4. Calculation of recession rates for WY2011 events at five sites. Recession rate is calculated from the timing (T_{max}) and elevation (h_{max}) of the maximum stage for the event to the timing (T_{min}) and elevation (h_{min}) of the minimum stage. The recession rate (R) is calculated by dividing the change in water level elevation (Δh) by the change in time (ΔT) and multiplying by 30 days. Recession rate values in bold indicate that the expectation of less than or equal to 0.3 m per 30 days was met.

Site	T_{max}	h_{max} (m)	T_{min}	h_{min} (m)	Δh (m)	ΔT (d)	R (m/30 days)
PC61	July 8, 2010	12.39	April 22, 2011	10.91	1.48	288	**0.15**
PC52	April 2, 2010	12.39	November 1, 2010	10.96	1.43	213	**0.20**
	November 5, 2010	11.43	December 5, 2010	10.64	0.79	40	0.59
	January 26, 2011	11.53	March 27, 2011	10.65	0.88	60	0.44
	April 1, 2011	11.46	May 8, 2011	10.52	0.94	37	0.76
PC44	July 9, 2010	11.59	August 7, 2010	10.85	0.74	29	0.77
	August 31,2010	11.4	December 8, 2010	10.03	1.37	99	0.42
	December 19, 2010	10.69	March 21, 2011	9.93	0.76	92	**0.25**
PC32	July 9, 2010	11.16	March 24, 2011	9.97	1.19	258	**0.14**
	April 28, 2011	10.58	June 2, 2011	9.97	0.61	35	0.52
PC21	April 2, 2010	10.95	June 11, 2011	9.91	1.04	435	**0.07**

Expectation 5

> Mean velocities within the main river channel will range from 0.2 to 0.6 meters per second (m/s) during a minimum of 85 percent of the year (SFWMD, 2005b).

The expectation for mean channel velocity was evaluated using velocity estimates made during field flow measurements (i.e., stream gauging) at five locations in the river channel (from upstream to downstream: PC62, KRDR, KRBN, PC33, and PC11R) (**Figure 9-4**). The previous update for this expectation in Chapter 11 of the 2011 SFER – Volume I included all velocity measurements and noted that measurements greater than 0.6 m/s occurred at greater than bankfull discharge. This year's update only considered measurements when the river was in-bank. This change is consistent with the development of the expectation. When measurements were considered only when flow was in-bank, none of the measurements exceeded 0.6 m/s.

The percentage of mean channel velocity estimates in the range of 0.2–0.6 m/s was less than the desired value of 85 percent at all cross-sections except at KRDR (**Table 9-5**). At the other sites, 25–78 percent of the measurements were less than 0.2 m/s. This large percentage of measurements in the lower velocity category is likely the result of multiple factors including the influence of the backwater effect of the S-65C structure and extended periods with low discharge.

Table 9-5. Total number of mean channel velocity [(meters per second (m/s)] measurements and percentage of measurements in two velocity categories for five river channel stations.

Site	Sample Size (N)	Velocity (m/s)	
		<0.20	0.2-0.6
PC62	85	35	65
KRDR	160	12	88
KRBN	161	25	75
PC33	172	50	50
PC11R	90	78	22

WATER QUALITY — TOTAL PHOSPHORUS

As Lake Okeechobee's largest tributary, the Kissimmee River is a major contributor of phosphorus to the lake (see Chapter 8 of this volume). Construction of the C-38 canal and lateral drainage ditches has presumably contributed to phosphorus loading from the Kissimmee Basin by facilitating downstream transport of phosphorus runoff and limiting opportunities for detention and assimilation in floodplain wetlands. Compared to the local drainages of Pools D and E, which have more intensive agricultural activity, the drainages of Pools A, B, and C (**Figure 9-2**) are not major exporters of phosphorus. Nevertheless, restoration of the river and floodplain may eventually lead to reduced loading from these pools and the headwater lakes in the Upper Kissimmee Sub-watershed.

To estimate phosphorus loading at each water control structure along the C-38 canal (**Figure 9-2**), baseline and post-construction total phosphorus (TP) concentrations have been monitored routinely at each structure along with daily estimates of discharge. TP concentrations were measured from grab samples collected every two weeks (although sampling has ranged from weekly to monthly during portions of the period of record) and composite samples collected by auto-samplers. The auto-sampler gathered samples 10 times per day, which were combined into a single bottle collected on a weekly basis. Estimates of daily TP loads were computed from measured or interpolated TP concentrations and daily discharges and then summed annually. Because TP loads can vary greatly between wet years and dry years, annual TP loads were divided by annual discharges to obtain flow-weighted mean (FWM) TP concentrations at each structure. These annual FWM concentrations provide a more useful metric for evaluating trends.

Calendar years 1974–1995, during which the C-38 canal was intact, were chosen as the baseline period of record. During those 22 years, TP loading averaged 51 metric tons per year (mt/yr) at S-65C and 83 mt/yr at S-65D (**Figure 9-13**). These amounts comprised 43 and 71 percent of the average load at S-65E, respectively. These values serve as the baseline level for TP loads downstream of the restoration area. Annual FWM TP concentrations averaged 53 parts per billion (ppb), or micrograms per liter (µg/L), at S-65C (range of 33–87 ppb), and 78 ppb at S-65D (range of 47–141 ppb) (**Figure 9-14**). Concentrations were greater during years of lowest flow (1981 and 1985). At S-65, upstream of the restoration project area, the mean loading rate was 35 mt/yr (**Figure 9-13**) and the FWM TP concentration was 43 ppb (**Figure 9-14**).

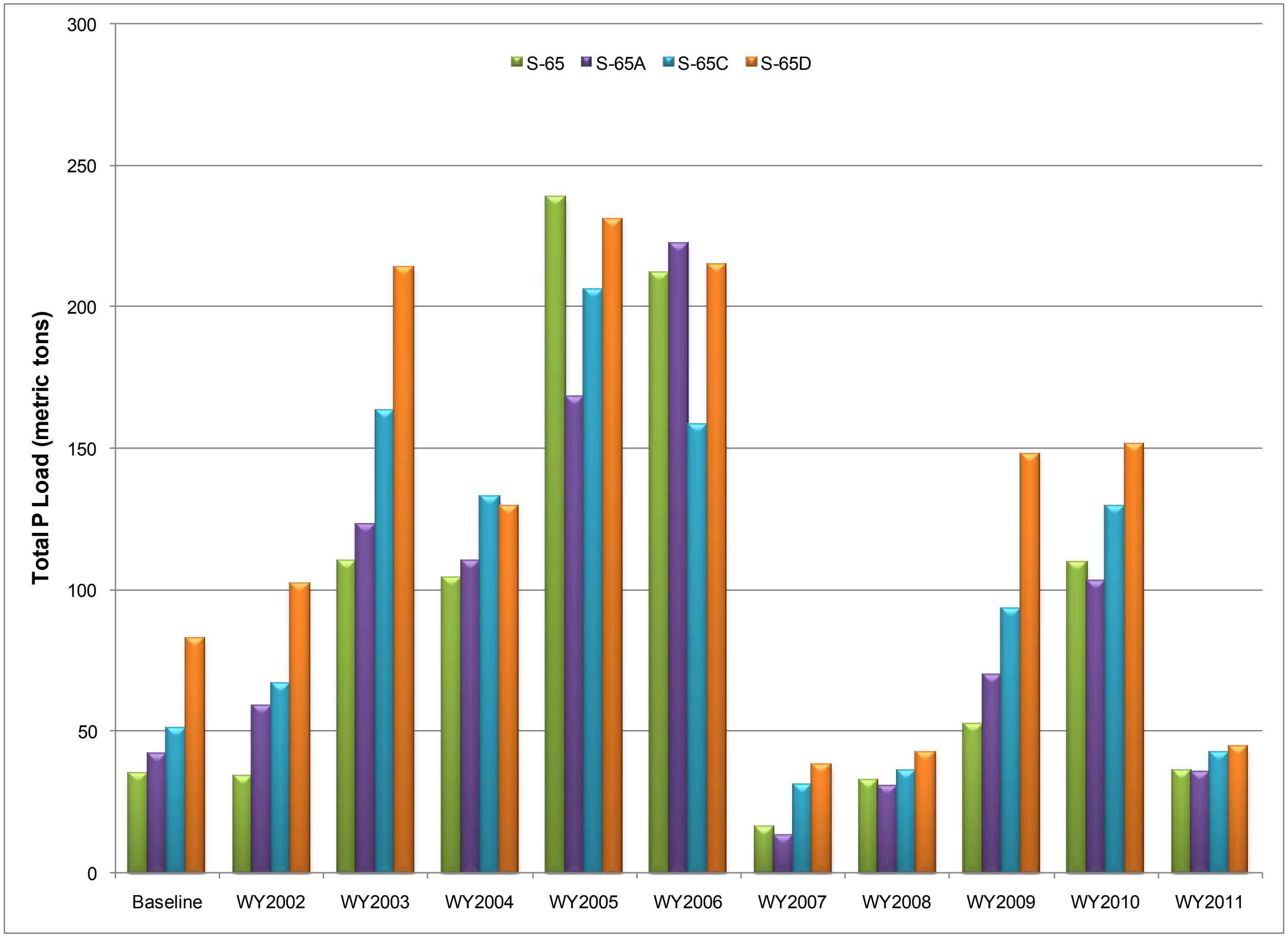

Figure 9-13. Annual total phosphorus (TP) loads from C-38 structures for WY2002–WY2011 in comparison to average annual baseline loads during calendar years 1974–1995. WY2002, WY2007, WY2008, and WY2011 were drought years and WY2005 was wet due to hurricanes.

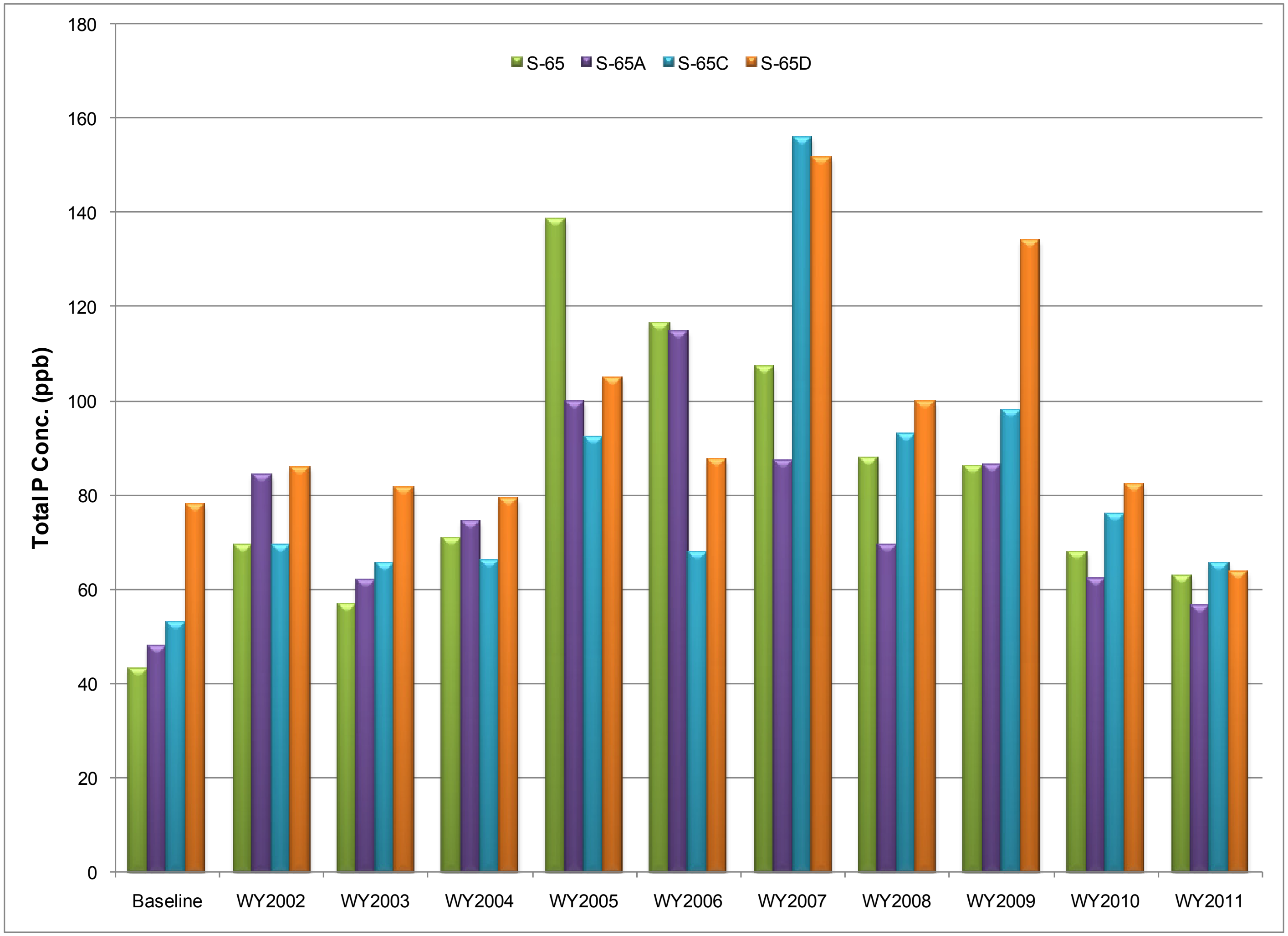

Figure 9-14. Annual flow-weighted mean (FWM) TP concentrations in parts per billion (ppb) at C-38 structures for WY2002 to WY2011 in comparison to average annual baseline concentrations during calendar years 1974–1995.

Reference, pre-channelization conditions for TP loads and concentrations in the Kissimmee River cannot be determined with much certainty because phosphorus was not routinely monitored before channelization. Nevertheless, knowledge of the river's former characteristics and its floodplain and watershed make it reasonable to assume that concentrations were lower prior to channelization and watershed development (SFWMD, 2005a).

Although quantitative performance measures have not been established for TP, river restoration should favor a return to lower concentrations when a more natural hydroperiod and a stable wetland ecosystem become established. The desired hydrologic conditions are expected after the Headwaters Revitalization Schedule is implemented in 2015. In the meantime, TP concentrations may increase periodically as the nutrient runs off former pastures and the floodplain transitions from terrestrial to wetland vegetation.

Under the current interim regulation schedule, the floodplain in the restoration area was inundated intermittently, but periodic dry conditions, especially in WY2007, WY2008 and WY2011, limited hydrologic interaction between the river channel and floodplain. Under these hydrologic conditions, wetland vegetation has become reestablished to a large extent, but the composition of wetland community types still has not attained the proportions that are expected once the KRRP is entirely completed (2011 SFER – Volume I, Chapter 11). Therefore, in the transitional years since 2001, the river-floodplain system is unlikely to have sequestered phosphorus at its highest potential efficiency.

Determining loading trends is difficult because loading is highly dependent on the amount of discharge, which varies from year to year. For most of the last 10 years, loads at the C-38 structures have been greater than the 1974–1995 baseline averages. They were lower in WY2007, WY2008, and WY2011 (**Figure 9-13**). Since WY2002, most of the TP flowing through the restoration area has come from the Upper Kissimmee Basin. This was especially evident in WY2011, when the load at S-65 was 80 percent of the load at S-65D. Overall, total loading in the last five years (WY2007–WY2011) has been over 50 percent lower than loading in the previous five years (WY2002–WY2006). This reduction is significant for Lake Okeechobee phosphorus control efforts, although it could reverse depending on future hydrologic conditions.

FWM TP concentrations have been higher at all structures since the baseline period. However, they have shown a general decline since WY2005 when three hurricanes crossed the Kissimmee Basin (**Figure 9-14**). This decline, particularly at S-65, can be attributed in part to the time elapsed since the disturbance caused by these hurricanes.

In WY2011, concentrations were similar (57 to 65 ppb) upstream and downstream of the restoration area, which may be indicative of the influence of headwater flow and the lack of lateral inputs through the year. This influence is also indicated by the last 10 years of data, which show a relationship between the concentration at S-65 and concentrations at downstream structures, particularly S-65A and S-65C (**Figure 9-14**).

Although TP loads and concentrations have been declining, the data summarized in **Figures 9-13** and **9-14** do not yet indicate an apparent effect from river restoration. This is not unanticipated, however, and for reasons already mentioned, the restoration's potential to affect phosphorus transport is not expected to be achieved until the project is complete. While monitoring phosphorus at the C-38 water control structures provides important trend data, further investigations are needed to determine if the restoration of natural hydrology and wetland vegetation is increasing the retention of phosphorus. However, distinguishing the KRRP's effects from other factors such as variations in annual discharge and changes in land use and runoff is difficult. To better understand and predict phosphorus movement through the restored river, a study of nutrient dynamics was initiated in 2009. A strategy document developed for this study concluded that data were needed on the phosphorus content of river channel sediments and floodplain soils, and the interaction of sediment and soil phosphorus with the overlying water. In WY2011, the SFWMD initiated a survey to fill this information need. This survey will collect sediment and soil samples from the river channel and floodplain, measure the content of phosphorus, nitrogen, and related constituents, estimate phosphorus storage capacity, and compare the TP content in floodplain soils with the content in other soils of the Lake Okeechobee Watershed. The survey will conclude in WY2012.

ASSEMBLAGE STRUCTURE OF RIVER CHANNEL FISH

Expectation 22

> Mean annual relative abundance of fishes in the restored river channel will consist of ≤ 1 percent bowfin (*Amia calva*), ≤ 3 percent Florida gar (*Lepisosteus platyrhincus*), ≥ 16 percent redbreast sunfish (*Lepomis auritus*), and ≥ 58 percent centrarchids (sunfishes) (SFWMD, 2005b).

The expectation for the assemblage structure of fish species inhabiting the restored reach of the river channel was developed from data collected in three reference rivers in peninsular Florida because of the lack of available data from the Kissimmee River prior to channelization. Electrofishing data from the St. Johns, Withlacoochee, and Ocklawaha rivers, collected annually during the autumn low water period from 1983 to 1990, were used as reference condition data. All three rivers are located entirely within or have headwaters originating in peninsular Florida below the Suwannee and St. Johns drainages, the demarcation between peninsular and northern fish assemblages (Swift et al., 1986; Gilbert, 1987). All of the reference rivers have undergone varying degrees of anthropogenic alteration including channelization, impoundment, and point sources of pollution (Bass, 1991; Estevez et al., 1991; Livingston, 1991; Livingston and Fernald, 1991) and, therefore, are not pristine reference sites for the historical Kissimmee River. However, this information about the composition of riverine fish assemblages within peninsular Florida was utilized as the best available data.

Relative abundance measures of three species (bowfin, Florida gar, and redbreast sunfish) and one family [centrarchids, which include largemouth bass (*Micropterus salmoides*) and other sunfishes] showed strong differences between baseline data collected from the Kissimmee River in 1992–1994 and reference data from the other three rivers (SFWMD, 2005b). These differences are believed to reflect the taxa's dependence on functional, physiochemical, or biological characteristics expected after the Kissimmee River is restored. Consequently, these taxa were selected for development of the restoration expectation. The expectation predicts that the relative abundance of centrarchids will increase in proportion to the relative abundance of bowfin, gar, and other fish species. This section evaluates this expectation for the interim period to date.

River channel fish were sampled in the summers of 2004, 2007, and 2010, approximately three, six, and nine years, respectively, after completion of Phase I construction. Sampling occurred along the littoral edge of the physically restored river channel in Pool C (impact area), and remnant channels of the unrestored Pool A (control area). Six 15-minute transects were sampled in the impact area, and nine in the control area using a boat-mounted electrofishing unit (Smith-Root VVP-15B). Three sampling transects in the lowermost river reach in the impact area were eliminated from data analyses because this reach received approximately 20 percent of flow relative to other reaches in the physically restored area, due to a construction-related diversion of flow to the C-38 canal. This diversion will be rectified in the final phase of restoration construction, and these transects will be included in post-restoration sampling. Mean relative abundance (MRA) was calculated by averaging the relative abundances of each transect, which was calculated by dividing the number of individuals of a taxon collected by the total time a transect was sampled, and then dividing by total catch per unit effort (CPUE). CPUE for each transect was calculated as the total number of fish caught divided by the total time a transect was sampled. Tests for significance were performed using a student's t-test to compare MRAs for each taxon between years or between pools. All means are presented plus or minus their standard errors (SE). The results are shown in **Figure 9-15**.

The bowfin MRA was low in both pools in 2010, representing 0.74 percent ± 0.24 percent of the relative abundance in the impact area and zero percent in the control area. Even though no individuals were collected in the unrestored area, the percentage of bowfin in the physically restored area met the expectation of less than or equal to one percent MRA and was significantly lower ($p < 0.05$) in 2010 than the MRA in 2004.

The Florida gar MRA was 1.7 percent ± 0.8 percent in 2007 and 3.7 percent ± 1.5 percent in 2010. Although the increase was not significant, the MRA of gar failed to meet the expectation of less than or equal to three percent. The Florida gar MRA did not change significantly in the unrestored area.

The redbreast sunfish MRA for 2010 did not change significantly from previous sampling events in either pool, with MRAs of 0.22 percent ± 0.21 percent and 0.17 percent ± 0.17 percent in the physically restored area and the control area, respectively. These values are far from the expected greater than or equal to 16 percent MRA. Relative abundance of centrarchids fell significantly ($p < 0.05$) in the physically restored area in 2010 to 23.4 percent ± 5.8 percent, down from 63.8 percent ± 8.8 percent in 2007 and 65.8 percent ± 2.9 percent in 2004, failing to meet the expectation of greater than or equal to 58 percent, while not changing significantly in the control area with an MRA of 37.6 percent ± 9.3 percent.

While centrarchids did not meet the restoration target value in 2010, both Florida gar and bowfin metrics have declined to near target values. The reason for the low numbers of bowfin found in the control area remains unexplained. The MRA of redbreast sunfish remains far below the expected level for the post-restoration river. Factors potentially affecting the MRA of redbreast sunfish more than other centrarchids may include the species' requirements for sustained flow velocities (Kearns, 2001) and low turbidity (Aho et al., 1986). Redbreast sunfish populations may increase relative to other species upon completion of the KRRP and implementation of the Headwaters Revitalization Schedule, which is expected to maintain mean flow velocities within a range (0.2–0.6 m/s) that is more suitable for this species.

The MRA analysis demonstrated changes only in the proportion of taxa in relation to the total fish population. This metric is used for purposes of fish assemblage structure expectation evaluation, but actual transect counts of centrarchids did not decrease significantly between 2007 and 2010 (23.4 ± 4.9 fish per transect in 2007 and 17.0 ± 4.4 in 2010), indicating that increasing abundance of other taxa is responsible for the decline in centrarchid MRA. However, in recent years, monitoring data also indicate that bass mean mass has decreased dramatically, from 386 grams (g) ± 74 g and 214 g ± 74 g in 2001 and 2004 respectively, to 12.3 g ± 2.6 g and 43.5 g ± 19 g in 2007 and 2010, respectively (L. Dirk and L. Glenn, SFWMD, unpublished data). The decrease in abundance of larger size classes of largemouth bass, a top predator, may have influenced increases in smaller prey species.

The shift to smaller size classes of largemouth bass may be due to the combined effects on reproductive age classes of various hydrologic impediments that have occurred in Pool C since 2006, including limited floodplain inundation that may have inhibited recruitment. Although mean dissolved oxygen (DO) concentrations in the physically restored area have generally remained high (Colangelo, in preparation), facilitating conditions suitable for centrarchids, several times in the last decade (2004, 2006, 2009, and 2010) rainfall events coincident with low stages at the onset of the wet season have resulted in pulsed flow events of water with critically low levels of DO [less than 0.8 milligrams per liter (mg/L)] in Pool C (Colangelo, in preparation),

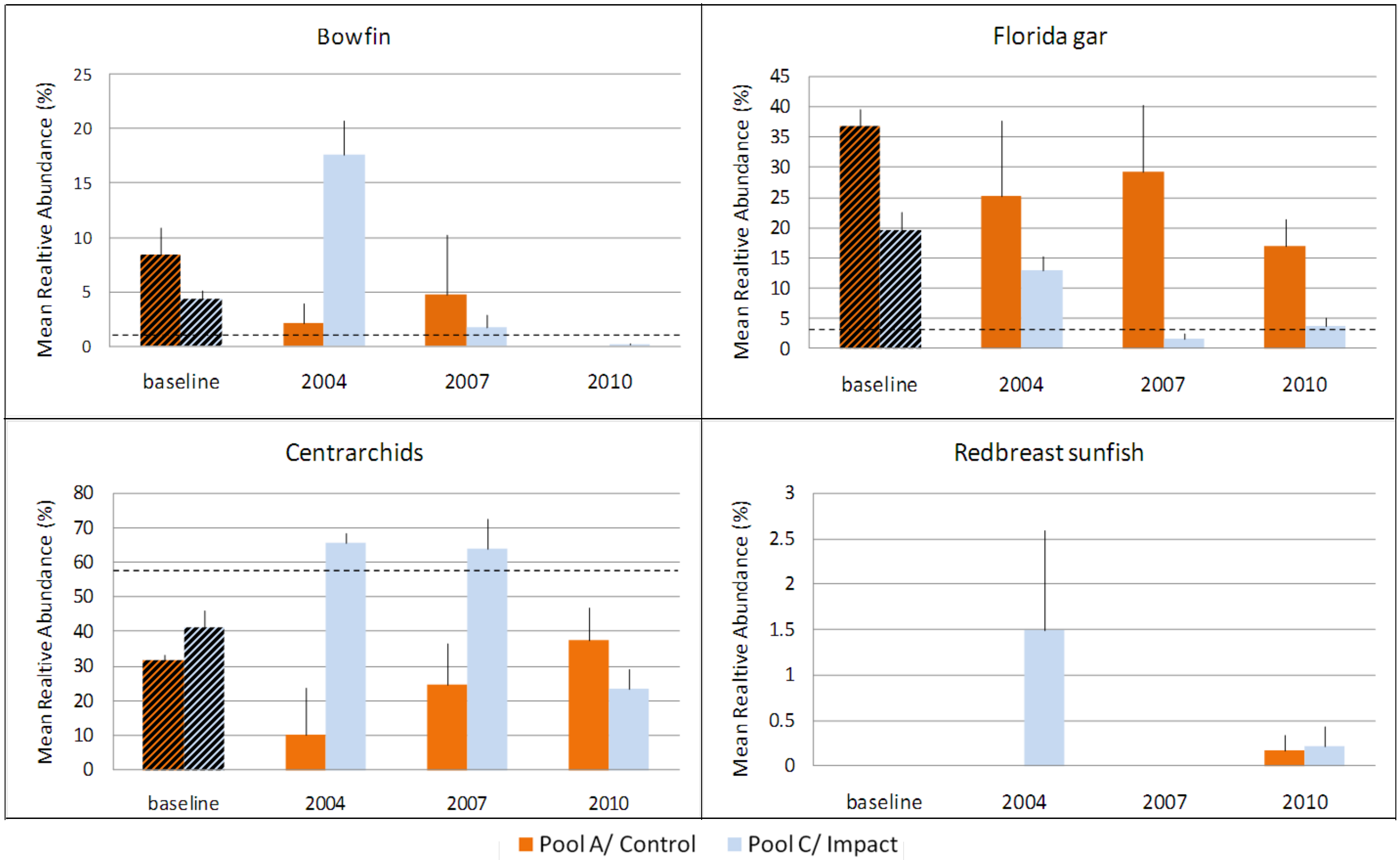

Figure 9-15. Mean annual relative abundance of fish taxon or family sampled in the Kissimmee River during the baseline period (1992–1994) and the post-Phase I interim period (2004, 2007, and 2010). Because the baseline data are an average of three years instead of an annual mean, they are presented here for reference only. Dashed lines indicate expected values for the species or family following restoration. Results are presented plus or minus the standard error of the mean. Sample sizes are n=6 for Pool C and n=9 for Pool A. Three transects that received only 20 percent of the flow for Pool C are not included in interim results. They will be included in the study when flow is restored.

as have occurred in other bodies of water (Ochumba, 1990; Sabo, et al., 1999; Townsend and Edwards, 2003). Many centrarchid taxa occurring in the Kissimmee River, particularly larger individuals of these taxa, become stressed when DO levels fall below 2 mg/L (Moss and Scott, 1961). Acute hypoxia (DO < 1.0 mg/L) can cause death when fish are unable to adapt to or evade hypoxic conditions, such as these pulsed hypoxic events suggest. Large numbers of dead fish were found at the downstream end of the restored area following each event. In most events, adult largemouth bass and other sunfish suffered the greatest impact, composing 89.6 percent of the 570 dead fish surveyed in the 2010 fish kill, as these species are more sensitive to hypoxia than most other fish in the river, as well as their younger counterparts.

Another potential reason for this decline in abundance is the cessation of flow in Pool C for a 252 day period from November to July of 2006–2007 during the spawning and nesting season of centrarchids. This may have reduced available nesting space if off-channel runs were not sufficiently inundated. Because floodplain inundation is dependent on high flow, this event likely impacted the ability of young-of-the-year to take refuge in floodplain habitats to avoid predation. Recruitment also may have suffered because of this potential increase in predation pressure and reduced prey availability, thereby reducing the number of adults years later.

The decrease in mean size of largemouth bass and the potential effect that it has had on abundances of other taxa highlights the importance of fully restored hydrologic conditions to Kissimmee River fish assemblages, and is a reminder that the area is currently only physically restored. However, largemouth bass and sunfish are quick to grow and mature, especially in warmer waters, with male largemouth bass reaching sexual maturity at 180 millimeters (mm) (age class 1+) and females at 230 mm (age class 2+) (Beamish et al., 2005; Rodriguez-Sanchez et al., 2009). Therefore, if future population impediments are minimized, it is likely that centrarchids, and largemouth bass in particular, will grow into large size classes quickly, potentially increasing relative abundances of centrarchids by increasing top-down control on other species. Implementation of the Headwaters Revitalization Schedule, scheduled for 2015, will help to alleviate hydrologic pressures on large centrarchids.

Finally, these current investigations (i.e., 2004, 2007, and 2010) are used to gauge trends in the response of specific fish assemblage metrics under physically restored and interim hydrologic conditions. Final surveys to determine if restoration targets for fish assemblage metrics have been achieved will take place between 2015 and 2020, following implementation of the Headwaters Regulation Schedule, and will be evaluated using a three-year rolling average. Final conclusions regarding the response of fish community structure to restoration will be made at that time.

Current monitoring efforts also have revealed the introduction of a new sailfin catfish species in the Kissimmee River. A single specimen of the leopard sailfin catfish (*Pterygoplichthys pardalis*) was collected in June 2011. It is closely related to the vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*), which was first collected from the river during baseline studies in 1998 and has since become abundant. Both species are indigenous to the Amazon Basin in South America. Each species constructs nesting burrows in shorelines, a condition that has increased dramatically in physically restored river reaches and potentially accelerates river bank erosion. Monitoring of these species will continue through annual electrofishing surveys, although no efforts to control their populations are planned at this time.

WADING BIRDS AND WATERFOWL

Birds are integral to the Kissimmee River-floodplain ecosystem and highly valued by the public. While quantitative pre-channelization data are sparse, available data and anecdotal accounts indicate that the system supported an abundant and diverse bird assemblage (National Audubon Society, 1936–1959; FGFWFC, 1957). Restoration is expected to reproduce the necessary conditions to once again support such an assemblage. Since many bird groups (e.g., wading birds, waterfowl) exhibit a high degree of mobility, they are likely to respond rapidly to restoration of appropriate habitat (Weller, 1995). Detailed information regarding the breadth of the avian evaluation program and the initial response of avian communities to Phase I restoration can be found in Chapter 11 of the 2005 SFER – Volume I. The objective of this section is to highlight portions of the avian program for which data were collected during the winter and spring of 2010–2011 and compare recent data to restoration expectations.

Wading Bird Nesting Colonies

As part of the KRREP, the SFWMD performed systematic aerial surveys on February 25, March 22, April 25, and May 24, 2011, to search for wading bird nesting colonies within the Kissimmee River floodplain and surrounding wetland-upland complex approximately 2 mi east and west of the 100 year flood line. Nesting colonies were also monitored, when encountered, during separate aerial surveys of foraging wading birds on January 26, February 15, March 17, April 12, and May 17, 2011. Known colonies in Lakes Mary Jane, Kissimmee (Rabbit Island), and Istokpoga were surveyed at least once. The numbers of nests reported here represent the maximum number of nests for each species observed. It is likely the nests for a relatively small number of dark-colored birds, such as little blue heron (*Egretta caerulea*), glossy ibis (*Plegadis falcinellus*), tricolored heron (*Egretta tricolor*), yellow-crowned night heron (*Nyctanassa violacea*) and black-crowned night heron (*Nycticorax nycticorax*), were undercounted during the aerial surveys because of their lower visibility from above (Frederick et al., 1996). Thus, the colony totals presented in **Table 9-6** are considered conservative. Nest fate and nesting success were not monitored but one ground survey was conducted at the Rabbit Island colony in Lake Kissimmee (May 24) to obtain a more accurate nest count and determine the presence of less visible dark-colored species. Five colonies were surveyed during 2011, only two of which occurred within the Kissimmee River survey area (**Table 9-6**, **Figure 9-16**). The other three colonies were observed in Lakes Mary Jane, Kissimmee, and Istokpoga.

The largest colony, Rabbit Island, was composed of approximately 540 white ibis (*Eudocimus albus*), 250 great egret (*Ardea alba*), 350 cattle egret (*Bubulcus ibis*), 75 great blue heron (*Ardea herodias*), and 75 small white heron [snowy egret (*Egretta thula*) and juvenile little blue heron] nests. The peak number of nests of all aquatic species combined was observed during the April survey, while the peak number of nests of the terrestrial cattle egret was observed during May. Rabbit Island has supported the largest colony in both the Upper and Lower Kissimmee basins in recent years (**Table 9-6**; 2008, 2009, and 2010 SFERs – Volume I, Chapter 11). The number of white ibis nests this year was down from last year's total of 1,156, while nests of other aquatic species were at levels similar to the previous year. Cattle egret nests were slightly more abundant this year than last (350 versus 200, respectively).

One possible factor contributing to the lower number of white ibis nests in 2011 may be the above average rainfall for March (6.85 inches versus an average of 3.35 inches) in the Upper Kissimmee Basin. This rainfall caused a reversal of stage in Lake Kissimmee of approximately 1.1 ft between March 9 and April 13, and may have caused water level reversals in surrounding isolated wetlands where a portion of these birds were likely foraging outside of Lake Kissimmee. A similar reversal occurred during March 2010 as well, and a significant proportion of the nesting white ibis appeared to abandon the colony shortly after the rain event (2010 SFER – Volume I, Chapter 11). Reversal of declining water levels during the dry season is thought to decrease prey availability for wading birds by redistributing prey over a larger area and decreasing prey density, thereby leading to fewer nest initiations or nest abandonment when sufficient food cannot be captured to feed young.

Table 9-6. Peak numbers of wading bird nests inside or within two miles of the Kissimmee River 100 year flood line (between the S-65 and S-65D structures) and within Lakes Mary Jane, Kissimmee, and Istokpoga. Surveys were conducted March–June 2004, March–June 2005, February–June 2006, May–July 2007, January–May 2008, February–April 2009, February–May 2010, and February-May 2011.

Kissimmee River

Year	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	Total
2004	-	-	-	-	-	-	-	-	-	-
2005	400	81	-	-	5	-	-	-	-	486
2006	500	133	-	-	4	-	-	-	-	637
2007	226	-	-	-	-	-	1	-	-	227
2008	-	2	-	-	4	-	-	-	-	6
2009	240	126	-	-	27	11	3	-	-	407
2010	891	35	-	-	31	22	15	-	-	994
2011	751	14	-	8	35	26	9	-	-	843
Total	**3,008**	**391**	**-**	**8**	**106**	**59**	**28**			**3,600**

Lake Mary Jane

Year	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	WOST	BCNH	Total
2010	-	250	-	-	-	-	-	100	1	**351**
2011	-	200	-	-	-	-	-	200	-	400
Total	-	**450**	-	-	-	-	-	**300**	**1**	**751**

Lake Kissimmee

Year	CAEG	GREG	WHIB	SMWH	GBHE	LBHE	TRHE	GLIB	BCNH	Total
2009	740	150	75	-	50	42	87	10	3	**1,157**
2010	200	249	1,156	-	59	-	-	-	-	**1,664**
2011	350	250	540	75	75	-	-	-	-	**1,290**
Total	**1,290**	**649**	**1,771**	**75**	**184**	**42**	**87**	**10**	**3**	**4,111**

Lake Istokpoga

Year	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	WOST	BCNH	Total
2010	103	325	110	-	75	-	-	-	-	**613**
2011	381	200	50	-	45	-	-	-	-	676
Total	**484**	**525**	**160**	**-**	**120**	**-**	**-**	**-**	**-**	**1,289**

CAEG = cattle egret (*Bubulcus ibis*)
GREG = great egret (*Ardea alba*)
WHIB = white ibis (*Eudocimus albus*)
SNEG = snowy egret (*Egretta thula*)
GBHE = great blue heron (*Ardea herodias*)
LBHE = little blue heron (*Egretta caerulea*)
TRHE = tricolored heron (*Egretta tricolor*)
GLIB = glossy ibis (*Plegadis falcinellus*)
WOST = wood stork (*Mycteria americana*)
BCNH = black-crowned night heron (*Nycticorax nycticorax*)

SMWH = small white heron (snowy egret and juvenile little blue herons combined

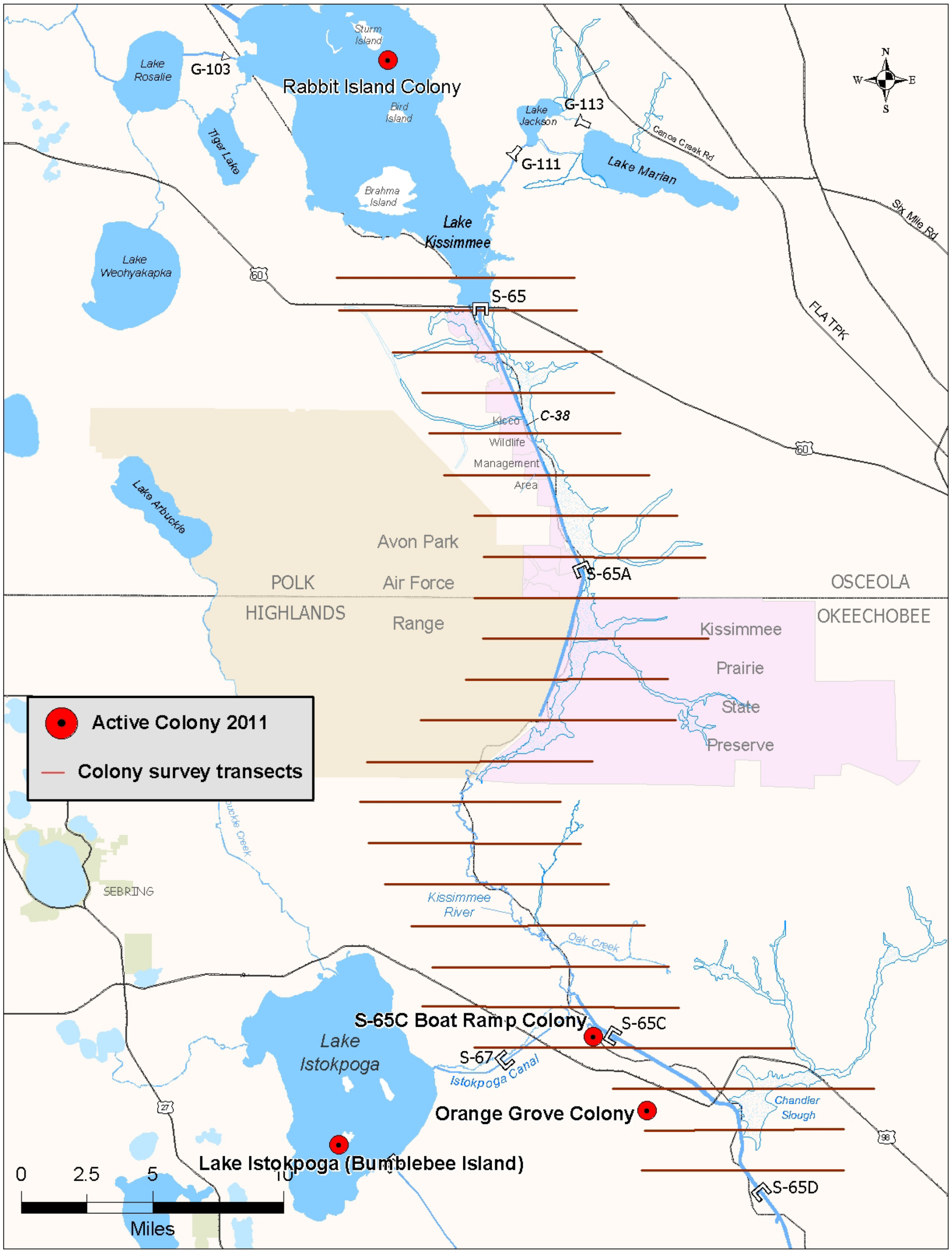

Figure 9-16. Aerial survey transect routes and nesting colony sites within the Kissimmee River floodplain and surrounding wetland-upland complex during 2011. The Lake Mary Jane colony (not shown) is approximately 30 miles to the north-northeast of Lake Kissimmee and 16 miles southeast of Orlando.

The largest colony to form along the Kissimmee River in 2011 was the S-65C boat ramp colony, located just south of the Phase I restoration area (**Figure 9-16**). This colony was composed of 676 cattle egret, 26 little blue heron, nine tricolored heron, and eight snowy egret nests, similar to last year's numbers. The other colony (Orange Grove) along the Kissimmee River also formed outside of the restored portion of the river floodplain to the southwest of Pool D (**Table 9-6** and **Figure 9-16).**

Wading Bird Abundance

Expectation 24

> Mean annual dry season density of long-legged wading birds (excluding cattle egrets) on the restored floodplain will be ≥ 30.6 birds per square kilometer (birds/km^2) (SFWMD, 2005b).

Monthly aerial surveys were used to estimate foraging wading birds abundance. Prior to the restoration project, dry season abundance of long-legged wading birds in the Phase I restoration area averaged ± SE 3.6 ± 0.9 birds/km^2 in 1997 and 14.3 ± 3.4 birds/km^2 in 1998. Since completion of Phases I, IVA, and IVB of restoration construction in 2001, 2007, and 2009, respectively, abundance has exceeded the restoration expectation of 30.6 birds/km^2 (evaluated as a three-year running average), except during 2007–2009 and 2009–2011 (**Table 9-7**, **Figure 9-17**).

Table 9-7. Post-restoration abundance as three-year running averages ± SE of long-legged wading birds excluding cattle egrets during the dry season (December–May) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River. The restoration expectation for wading bird abundance is 30.6 birds per square kilometers (birds/km^2) (three-year running average).

Period	Three-year Running Average ± SE
2002–2004	65.4 ± 5.1
2003–2005	74.3 ± 3.5
2004–2006	76.4 ± 4.8
2005–2007	58.9 ± 8.8
2006–2008	49.3 ± 27.4
2007–2009	21.4 ± 7.0
2008–2010	33.9 ± 8.6
2009–2011	29.0 ± 9.8

Mean monthly wading bird abundance within the restored portions of the river during the 2010–2011 season (19.9 birds/km^2) was below the long-term (nine-year) average (≈44.0 birds/km^2), and less than half of last year's mean of 48.5 birds/km^2. Numbers were below the long-term monthly averages at the start of the dry season in November and continued well below average until February, when abundance peaked for the season at 38.6 birds/km^2. March is traditionally the month when most birds are observed, but numbers decreased significantly after February and reached the lowest monthly abundance ever recorded post-restoration during April at 6.4 birds/km^2. The 2010–2011 dry season began early and floodplain foraging habitat was already beginning to dry out by November, thereby limiting foraging opportunities for wading birds by December. The stage reversal on the river in March and April (**Figure 9-8**) caused much of the floodplain to be unseasonably reinundated after having nearly dried out completely. While the reversal created new foraging areas in some cases, many areas became too deep, and the remaining prey base was likely dispersed across a much larger area, thereby reducing foraging efficiency.

White ibis and glossy ibis dominated numerically, followed in order of abundance by great blue herons, cattle egrets, great egrets, small white herons (snowy egrets and juvenile little blue herons), small dark herons (tricolored herons and adult little blue herons), black-crowned night-herons, roseate spoonbills (*Platalea ajaja*), yellow-crowned night herons, and wood storks (*Mycteria americana*).

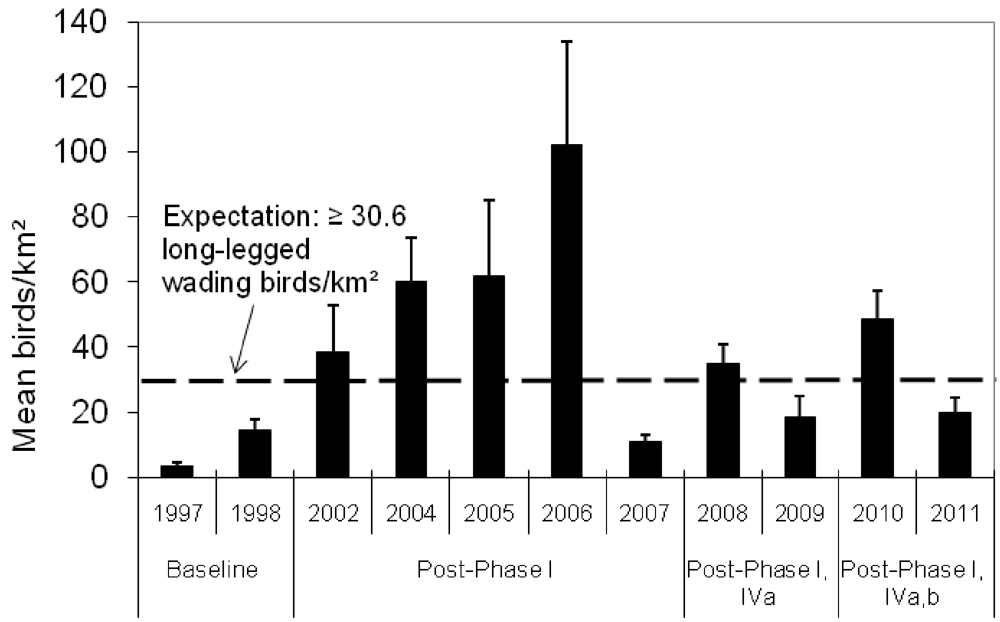

Figure 9-17. Baseline and post-Phases I, IVA, and IVB mean abundance ± S.E. of long-legged wading birds (excluding cattle egrets) per square kilometer (birds/km^2) during the dry season (December–May) within the 100 year flood line of the Kissimmee River.

Waterfowl Abundance

Expectation 25

> Winter densities of waterfowl within the restored area of the floodplain will be ≥ 3.9 ducks per square kilometer (ducks/km^2). Species richness will be ≥ 13 (SFWMD, 2005b).

Four duck species, blue-winged teal (*Anas discors*), green-winged teal (*Anus crecca*), mottled duck (*Anus fulvigula*), and hooded merganser (*Lophodytes cullulatus*), were detected during baseline aerial surveys. During the same period, casual observations of wood duck (*Aix sponsa*) were made during ground surveys for other projects (SFWMD, 2005a). Mean annual abundance ± SE was 0.4 ± 0.1 ducks/km² in the Phase I area before restoration construction, well below the restoration expectation of 3.9 ducks/km². Since post-construction monitoring began in 2001, abundance has exceeded the restoration expectation of 3.9 ducks/km^2 (three-year running average) every year (**Table 9-8**, **Figure 9-18**). Waterfowl abundance during the 2010–2011 survey (8.5 ± 3.4 ducks/km^2) was similar to the previous year's mean of 8.0 ± 2.4 ducks/km^2. Mottled ducks dominated numerically, followed closely by teal (both blue- and green-winged, which are typically the most abundant species), hooded mergansers, and northern pintails (*Anas acuta*).

Table 9-8. Post-restoration abundance as three-year running averages ± SE of waterfowl during the winter (November–March) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River. The restoration expectation for waterfowl abundance is 3.9 ducks per square kilometer (ducks/km^2) (three-year running average).

Period	Three-year Running Average ±SE
2002–2004	14.1 ± 4.0
2003–2005	9.9 ± 2.2
2004–2006	17.5 ± 9.8
2005–2007	15.2 ± 11.2
2006–2008	15.7 ± 11.1
2007–2009	4.0 ± 1.5
2008–2010	6.3 ± 1.5
2009–2011	6.6 ± 1.7

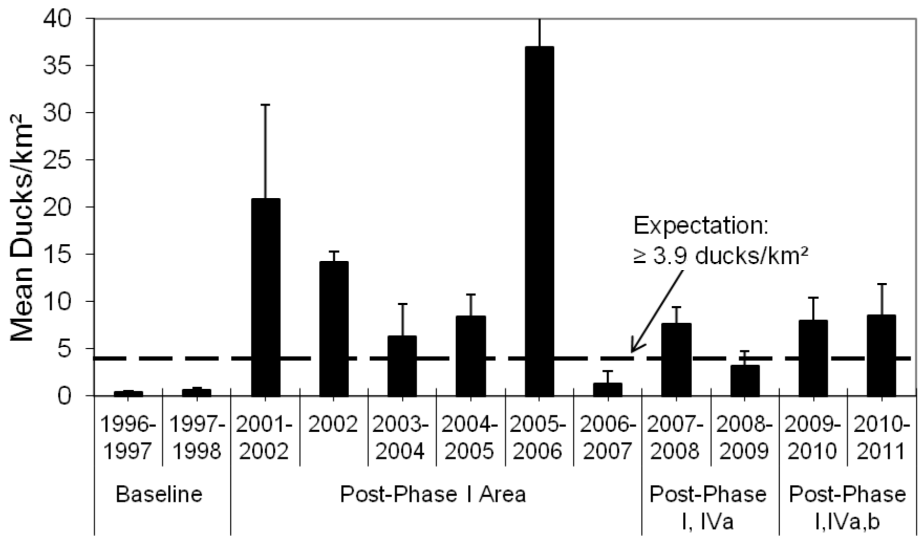

Figure 9-18. Baseline and post-Phases I, IVA, and IVB mean abundance ± SE of waterfowl [ducks per square kilometer (ducks/m^2)] during winter (November–March) within the 100 year flood line of the Kissimmee River. Baseline abundance was measured in the Phase I area prior to restoration. Measurement of post-restoration abundance began approximately nine months following completion of Phase I.

The American wigeon (*Anus americana*), northern pintail, northern shoveler (*Anus clypeata*), ring-necked duck (*Aythya collaris*), and black-bellied whistling duck (*Dendrocygna autumnalis*) were not detected during baseline surveys, but have been present following restoration. However, these species are not regularly observed, and the restoration target for waterfowl species richness (≥ 13 species) has yet to be reached on an annual basis. Blue-winged teal and mottled duck remain the two most commonly observed species, accounting for over 95 percent of observations.

Restoration of the physical characteristics of the Kissimmee River and floodplain, along with the hydrologic characteristics of headwater inputs, is expected to produce hydropatterns and hydroperiods that will lead to the development of extensive areas of wet prairie and broadleaf marsh, two preferred waterfowl habitats (Chamberlain, 1960; Bellrose, 1980). Changes in the species richness and abundance of waterfowl within the restoration area are likely to be directly linked to the rate of development of floodplain plant communities and the faunal elements they support. Extrinsic factors, such as annual reproductive output on summer breeding grounds and local and regional weather patterns, also may play a role in the speed of recovery of the waterfowl community.

KISSIMMEE BASIN MODELING AND OPERATIONS STUDY

The Kissimmee Basin Modeling and Operations Study (KBMOS) is the first comprehensive review of water management operations for the Kissimmee Basin in more than 25 years. Its goal is to evaluate alternative operations for C&SF Project water control structures in the Upper Kissimmee Basin that will better align these upstream operations with operational requirements for KRRP headwater discharges at S-65 and improve habitat conditions for fish and wildlife in the KCOL. The study was initiated in 2004 and is a component of the KRRP. It has produced a number of products including the following:

- Three versions of Kissimmee Basin planning and flood event modeling tools
- Lake and river evaluation performance measures
- Evaluation and ranking of over 100 alternative plans for modification of Kissimmee Basin structure operating criteria
- Project documentation for the alternative plan selection process including performance metrics, the alternative evaluation system, and description of the alternative plans evaluated during screening and formulation including performance, scoring, and ranking
- Development of a managed extreme low water level drawdown decision tree defining considerations that need to occur at the local and regional level prior to implementation of such an event
- Extensive public outreach and involvement at the federal, state, local, and individual stakeholder level

The study is expected to be completed by September 2013. The work remaining includes completion of the USACE joint probability flood analyses, final evaluation of the top performing alternative plans, public outreach to vet the top performing alternative plans, selection of a preferred plan, preparation of the operational guidance memorandum for the preferred plan, and transmittal of the preferred plan to the USACE. Once a preferred plan is identified, the final phase of the USACE environmental impact statement will move forward. Further information about the KBMOS is available at www.sfwmd.gov/kissimmee.

UPPER KISSIMMEE BASIN PROJECTS

KISSIMMEE CHAIN OF LAKES LONG-TERM MANAGEMENT PLAN

The Kissimmee Chain of Lakes (KCOL) Long-term Management Plan is a multiagency/stakeholder project initiated by the passage of SFWMD Governing Board Resolution 2003-468. This resolution directs the SFWMD to work with the USACE and other interested parties to improve the health and sustainability of the KCOL by developing a long-term management plan for regulated lakes in the Upper Kissimmee Basin (**Figure 9-1** and **Figure 9-3c**). The SFWMD is the lead agency responsible for coordinating the KCOL Long-term

Management Plan interagency activities and producing the plan. The other agencies and stakeholders include the Florida Fish and Wildlife Conservation Commission (FWC), Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, United States Fish and Wildlife Service, United States Environmental Protection Agency, USACE, local governments, community leaders, Lake Mary Jane Alliance, Audubon of Florida, The Nature Conservancy, Alligator Chain of Lakes Home Owners Association, Alligator Chain Heritage Association, and others.

The intent of the plan is to increase awareness of the complicated management challenges facing the KCOL and justify the allocation of more resources to the region. The plan defines management objectives and assessment targets for the lakes and defines a shared vision for enhancing and/or sustaining the KCOL resources through cooperation and coordination of federal, state, and local agency resources.

The draft version of the KCOL Long-term Management Plan was completed in October 2008 (SFWMD et al., 2008). Release of the plan to the public was placed on hold to allow agency management and resource priorities to be evaluated relative to fiscal constraints resulting from the economic downturn. A decision was made not to release the draft plan to the public but instead finalize the current version as an interagency draft. That version of the plan was distributed to participating agencies in June 2011.

KISSIMMEE CHAIN OF LAKES AND KISSIMMEE UPPER BASIN MONITORING AND ASSESSMENT PROJECT

The KCOL and Kissimmee Upper Basin Monitoring and Assessment Project was initiated in October 2010. The project is addressing ecological data deficiencies identified over the past ten years that are needed to support (1) management decision making; (2) consumptive use permitting, compliance, and rule making; (3) the Northern Everglades and Estuaries Protection Plan; and (4) pre- and post-project implementation for the KBMOS. The project scope includes collection, evaluation, and application of scientific and technical data. The geographic scope includes the Kissimmee Upper Basin watershed and C&SF Project water bodies in the KCOL. Major deliverables to be produced over the life of the project are (1) updated bathymetric maps and stage-area-volume tables for C&SF Project water bodies in the KCOL, (2) littoral vegetation maps for KCOL C&SF Project water bodies, (3) hydroperiod tool implementation for KCOL C&SF Project water bodies, (4) pilot study of groundwater and surface water exchange, (5) nutrient budgets for each lake basin and sub-basin, (6) identification of nutrient-impaired watershed wetlands, (7) data and evaluations characterizing fish utilization of lake littoral zones, (8) updated fish and wildlife surveys, (9) updated assessment of watershed wetlands, and (10) initiation of an annual assessment report summarizing the state of the water resources in the KCOL and Kissimmee Upper Basin.

THREE LAKES WILDLIFE MANAGEMENT AREA RESTORATION

The Three Lakes Wildlife Management Area Hydrologic Restoration Project is a joint initiative between the SFWMD and the FWC to restore wetlands and historical flow patterns to the Three Lakes Wildlife Management Area. This water management area is located in the Kissimmee Upper Basin, just north of the S-65 water control structure, on the east side of Lake Kissimmee near Lake Marian (**Figure 9-19**). The ultimate goal of the restoration project is to restore flow through Fodderstack Slough and improve the hydrology of over 6,000 ac of wetland area in this state-managed site of over 61,000 ac.

Figure 9-19. Boundaries of the Three Lakes Wildlife Management Area.

This project is part of the Northern Everglades Phase II Technical Plan management measure tool box and is divided into four phases:

- **Phase I – Hydrologic Assessment:** Compile data and prepare recommended modeling approach for the Three Lakes Water Management Area (completed in February 2007).
- **Phase II – Modeling Work Plan Implementation:** Develop the modeling tool to formulate, evaluate, and rank alternatives; develop and evaluate alternative plans; and select the preferred alternative (completed in 2008).
- **Phase III – Project Design and Permitting:** Prepare design documents (plans and specifications) for the permitting and implementation of the preferred alternative (initiation has been delayed and activities are being restructured to allow a phased implementation of restoration project features).
- **Phase IV – Construction and Construction Support Services:** Implement the preferred alternative.

Phase I and II are complete. The scope of Phase III was revised in 2009 to address reduced FWC revenues. Priority was given to design and permitting of the G-113 structure replacement component because the G-113 structure was rendered "inactive" in 2007 by the USACE. Phase IV, construction of the replacement G-113 structure, is scheduled to start in October 2011, with an expected completion date of July 2012.

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