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 integrating 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) collect ecological data to evaluate river restoration and support management decision making, (3) enhance and sustain natural resource values in the Kissimmee Chain of Lakes (KCOL), and (4) retain the flood reduction benefits of the Central and Southern Florida Flood Control Project (C&SF Project) in the Kissimmee Basin. In addition to projects under the KRRP, major non-KRRP initiatives include the KCOL and Kissimmee Upper Basin Monitoring and Assessment Project and the Three Lakes Wildlife Management Area Hydrologic Restoration Project.

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 meet hydrologic criteria for river restoration. The first three construction phases of restoration, completed 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 2012 (WY2012) (May 1, 2011–April 30, 2012) in the headwaters and lower part of the river (Pool D). The next major phase of construction is scheduled to begin in WY2013. The KRRP is on schedule for completion in late 2014.

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 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 related 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 regulation schedule will allow additional storage capacity in the headwater lakes, thereby allowing more flexible operations that can more closely approximate the prechannelized 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, 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 for guiding water management after the project is complete. Key WY2012 highlights of this chapter include the following:

- **Hydrologic conditions.** Although rainfall in the Kissimmee Basin was below average in WY2012, an extreme rainfall event on October 7–10, 2011, allowed all of the KCOL water bodies to refill by the end of the wet season for the first time since WY2006. The storm also resulted in the highest discharge rate measured in the Kissimmee River at S-65 and S-65C. Prior to the storm, the floodplain of the upper Phase I area of the restoration project was inundated briefly in July by runoff from the lower basin and in September when discharge from the upper basin increased. After the storm, which inundated the entire floodplain, discharge and floodplain inundation decreased so that by the end of February most of the upper floodplain was drying out. Water levels continued to decrease in the KCOL and Kissimmee River floodplain over the remainder of the dry season.
- **River channel hydrology.** Although flow was effectively continuous in the Phase I area throughout WY2012, discharge at S-65 was stopped for five days in July 2011 to conserve water in the upper basin, when lower basin runoff from a large rainfall event exceeded the discharge that could be sustained from the upper basin. Under the interim regulation schedule, continuous flow to the restoration area has been achieved in 8 of the last 11 years. The expectation for seasonal flow pattern was not achieved in WY2012 due to below-average rainfall and extended periods of low discharge.
- **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. The fluctuation target was also met in the lower part of the restoration area, which has happened less frequently because the downstream structure, S-65C, can limit the amount of fluctuation in the lower end of the restoration area. The floodplain inundation target of at least 180 days was met at only one of three floodplain sites in the upper floodplain and at both monitoring sites in the lower floodplain. Although floodplain stage generally declined during WY2012, 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).
- **Dissolved oxygen.** Concentrations of dissolved oxygen (DO) in the river channel of the restoration area continued to be higher than pre-restoration levels. Two components of the dissolved oxygen performance measure met expected values in WY2012. The mean daytime, near-surface DO concentration during the dry season was 7.0 milligrams per liter (mg/L), within the expected range of 5–7 mg/L. The mean daytime concentration within 1 meter of the channel bottom was more than 1 mg/L for 96 percent of the time, exceeding the restoration expectation of

50 percent. Concentrations with regard to the other two components (mean daytime, near-surface DO concentration in the wet season, and percent of mean daily DO concentrations > 2 mg/L) fell slightly short of their expected values. The final determination of restoration success with respect to DO will be made after the restoration project is completed.

- **Total phosphorus loads and concentrations.** Annual loads of total phosphorus (TP) have declined since WY2006 due to lower discharges and the diminishing effect of three hurricanes that crossed the headwater lakes in 2004. Concentrations of TP also decreased. Most of the TP entering the Kissimmee River restoration area usually comes from the headwater lakes, but in WY2012 the October 7–10 storm flooded the S-65A sub-basin with over 12 inches of rain, causing it to contribute most of the TP load. Monitoring following the October storm showed that high TP concentrations in runoff from the S-65A sub-basin dissipated as water flowed across the floodplain of the restoration area. TP load also declined substantially, suggesting that the restored Kissimmee River floodplain can retain large amounts of phosphorus during flood events. This assimilation capability is being investigated further. Because the Kissimmee Basin is the largest contributor of TP to Lake Okeechobee, the reduced loading in recent years and the floodplain's potential to retain phosphorus is significant for Lake Okeechobee phosphorus control efforts.
- **Total nitrogen loads and concentrations.** Concentrations of total nitrogen (TN) in the C-38 canal do not vary as much as TP. Since WY2002, annual flow-weighted mean TN concentrations ranged from 0.96 to 1.55 mg/L and were similar among monitoring locations at C-38 structures. Consequently, TN loads depended mainly on the volume of discharge through the canal. In WY2012, TN concentrations at the five structures fell within a narrow range of 1.12 to 1.20 mg/L. Unlike TP, the concentration of TN at S-65A was not unusually high.
- **Wading bird nesting.** River restoration is expected to reproduce conditions necessary to once again support an abundant and diverse assemblage of wading birds and waterfowl. Seven nesting colonies of wading birds were observed in 2012 — four near the Kissimmee River restoration project area and one each in Lake Mary Jane, Lake Kissimmee, and Lake Istokpoga. The total number of aquatic bird nests was down by 293 from the previous year, while the number of cattle egret nests was up by 675.
- **Wading bird abundance.** Since 2001, the abundance of foraging wading birds usually has met the restoration expectation of 30.6 birds per square kilometer (km^2), but has fallen short of this target during drier conditions in 2007–2011. During the 2011–2012 season, mean monthly wading bird abundance within the restored portions of the river (44.4 birds/km^2) was more than double the previous year's estimate, raising the three-year running average above the restoration target. As water levels receded following record-setting rainfall in October, wading bird numbers gradually increased and reached a peak of 105 birds/km^2 in March, at which time a record-setting flock of more than 2,000 wading birds was observed, with an additional 237 white pelicans (*Pelecanus erythrorhynchos*).
- **Waterfowl abundance.** Waterfowl abundance during the 2011–2012 survey (13.6 ducks/km^2) was greater than the previous year's value of 8.5 ducks/km^2, maintaining the three-year running average well above the restoration target of 3.9 ducks/km^2. Blue-winged teals (*Anas discors*) dominated numerically, followed by green-winged teals (*A. crecca*), mottled ducks (*A. fulvigula*), and hooded mergansers (*Lophodytes cullulatus*). The restoration target for waterfowl species richness (greater than or equal to 13 species) has not yet been reached.

INTRODUCTION

The Kissimmee Basin includes 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 did not allow lake stages to rise as high or drop as low as they did when they were unregulated. The reduced ranges of fluctuation altered or eliminated 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 integrated 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) collect ecological data to evaluate river restoration and support management decision making, (3) enhance and sustain natural resource values in the KCOL, and (4) retain the flood reduction benefits of the C&SF Project in the Kissimmee Basin. In addition to projects under the KRRP (**Figure 9-3a** and **b**), major non-KRRP initiatives include the KCOL and Kissimmee Upper Basin Monitoring and Assessment Project (**Figure 9-3c**) and the Three Lakes Wildlife Management Area Hydrologic Restoration Project. 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 9 of the 2012 SFER – Volume I. It focuses on progress of the KRRP and other Kissimmee Basin projects during Water Year 2012 (WY2012) (May 1, 2011–April 30, 2012). The chapter also summarizes hydrologic conditions during WY2012 and presents newly available data from the evaluation of the river restoration project.

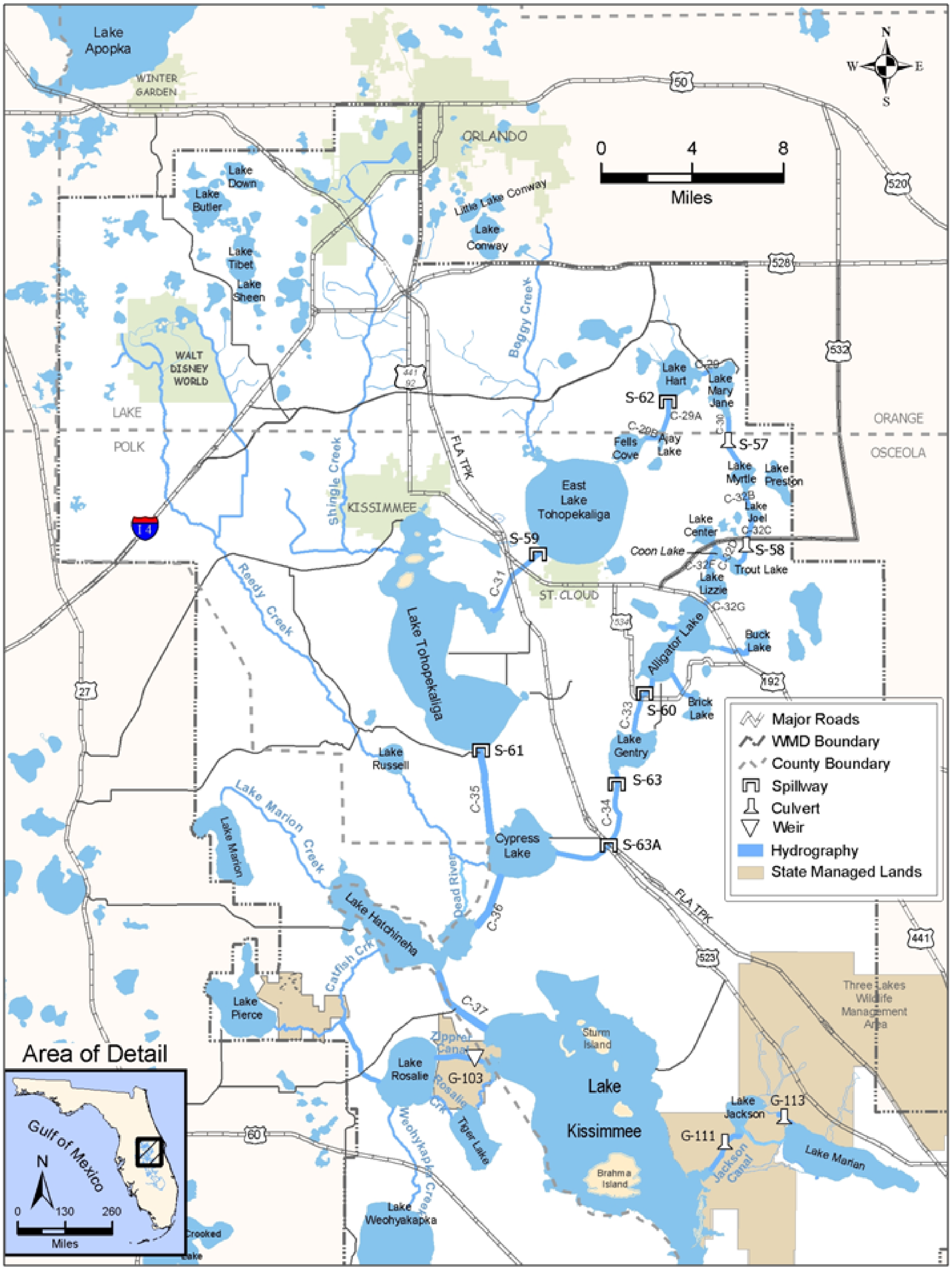


Figure 9-1. Upper Kissimmee Basin.

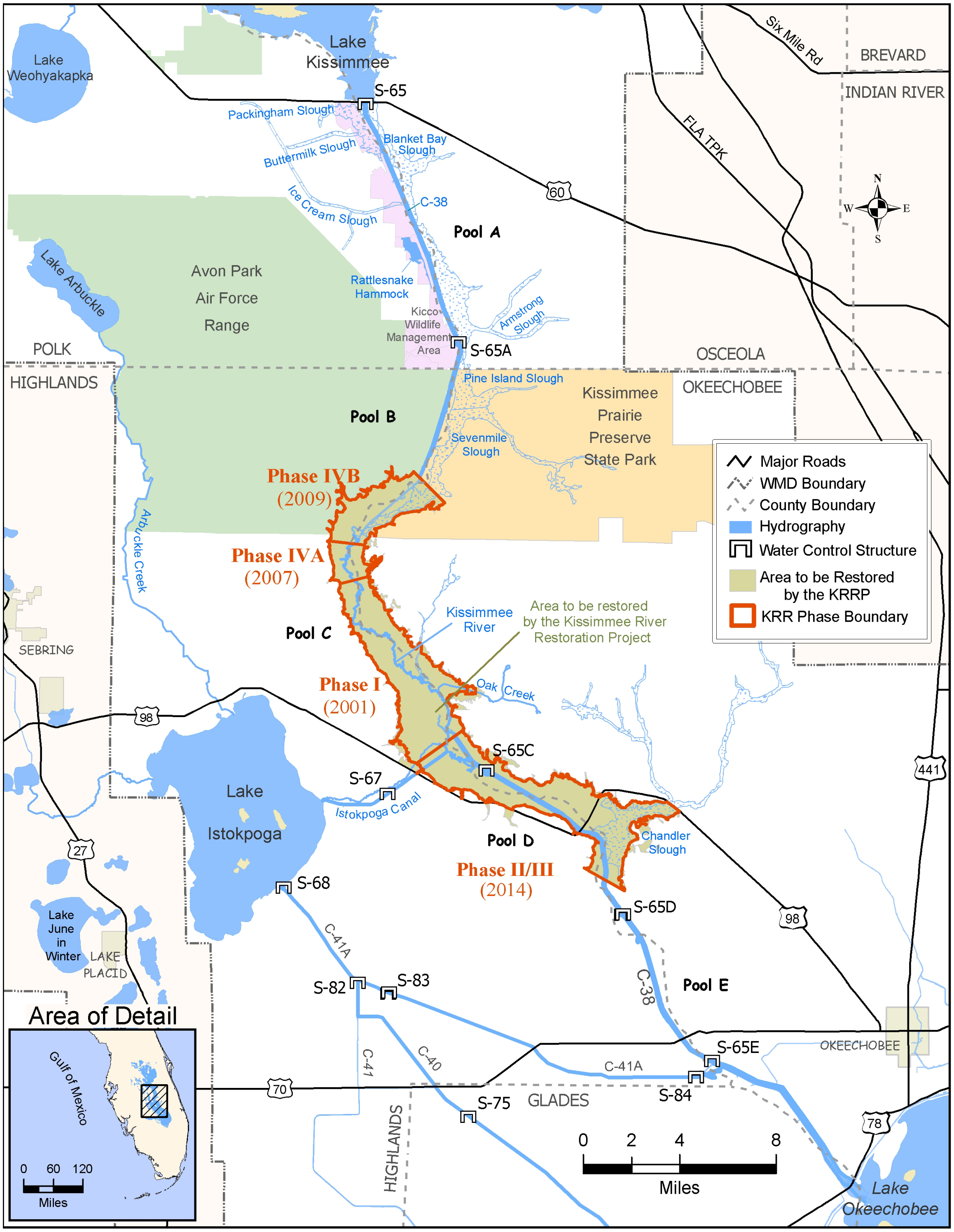


Figure 9-2. Lower Kissimmee Basin.

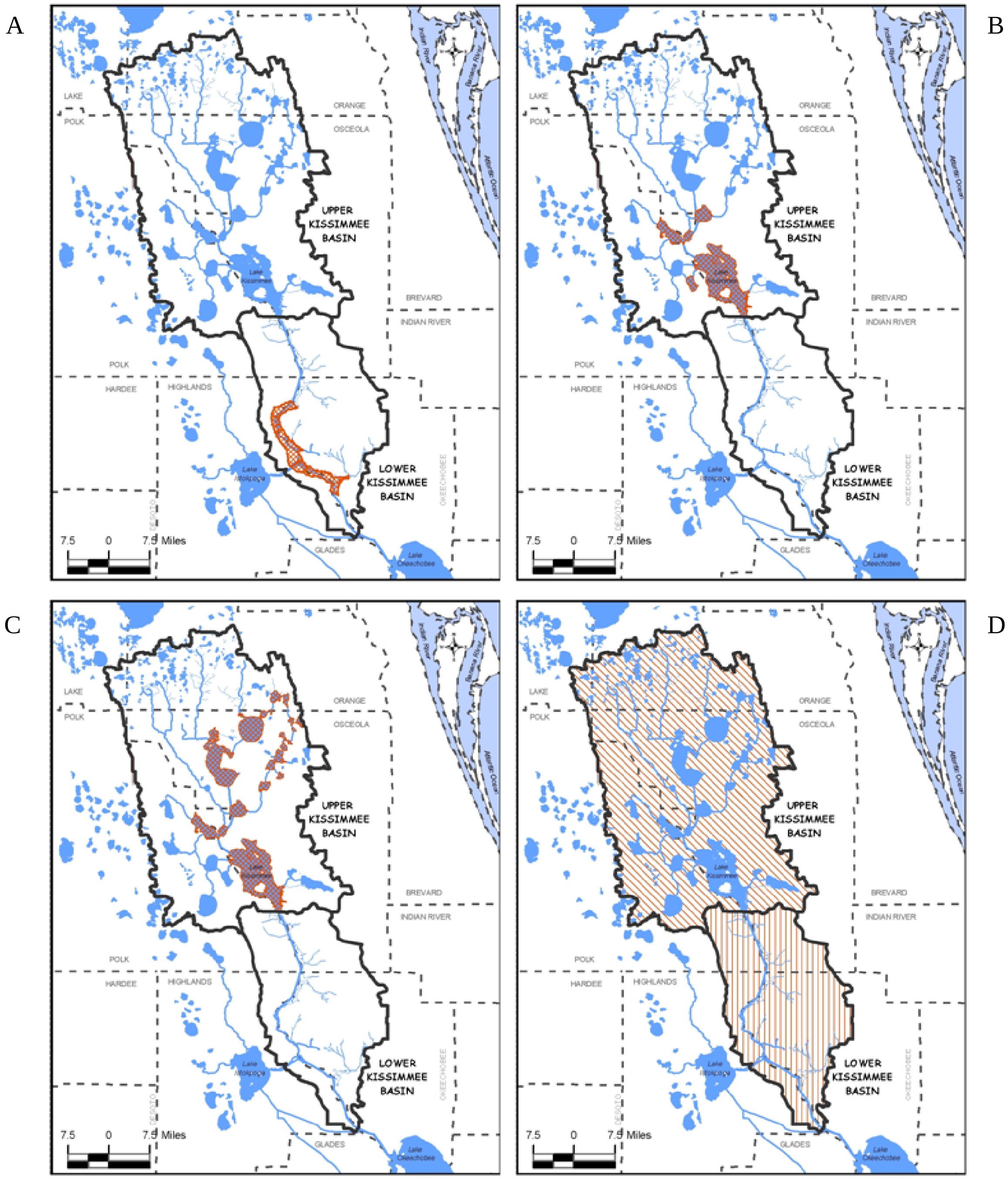


Figure 9-3. Geographic scopes (colored, hatched areas on maps) of major initiatives in the Kissimmee Basin including the (A) Kissimmee River Restoration Project (KRRP), (B) headwater lakes components of the KRRP, (C) Kissimmee Chain of Lakes (KCOL) and Kissimmee Upper Basin Monitoring and Assessment Project, 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 prechannelization period (Toth, 1990). A headwaters component of the project is designed to allow additional storage capacity in the headwater lakes, providing more flexible operations that can more closely approximate the prechannelized river's flow regime, including discharges with more natural timing, magnitude, and rates of change. Increasing storage in the headwater lakes by allowing higher stages for longer periods of time is expected to have the additional benefit of improving the 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 Kissimmee Basin Modeling and Operations Study (KBMOS; **Figure 9-3d**) 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, construction, and water control manual modification 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 99 percent has 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 meet hydrologic criteria for river restoration (**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 December 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 WY2013. While the restoration phases were named in the order of expected completion, the sequence has changed over time for logistical reasons (i.e., budgetary considerations, coordination with land acquisition, 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 modification of the Kissimmee Basin water control structure operations including the implementation of a new stage regulation schedule, called the Headwaters Revitalization Schedule, to operate the S-65 water control structure. The Headwaters Revitalization Schedule will allow lake water levels to rise 1.5 feet (ft) higher than the current S-65 schedule and will increase the water storage capacity of Lakes Kissimmee, Hatchineha, Cypress, and Tiger by approximately 100,000 acre-feet (ac-ft). Ninety-nine percent of the 36,612 ac of land in the Upper Kissimmee Basin that will be affected by the higher water levels have been acquired, and all projects needed to increase the conveyance capacity of canals and structures are in place to accommodate the larger storage volume. The last of these headwaters projects, the C-37 Canal Widening Project, was completed in 2012.

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 within a certain range (termed “Zone B”) below the maximum regulated stage. Zone B allows releases from S-65 for environmental purposes when flood control releases are not needed. It is used to maintain flow in the reach of the restored river channel throughout 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 that the Headwaters Revitalization Schedule is expected to provide.

CONSTRUCTION STATUS

In WY2012, construction activities consisted of the enlargement of the C-37 canal (between Lakes Hatchineha and Kissimmee) as well as projects in the Lower Kissimmee Basin such as S-67 repairs, Reach 2 and 3 Oxbow Excavation, S-65D Boat Ramp, CSX Railroad Bridge, River Acres Flood Reduction, and Pool D Oxbow and Embankment. These activities were completed in WY2012 or are scheduled for completion in 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.	Complete		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.	Complete	December 2009	July 2012	$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 – An elevated single track railroad bridge is being constructed 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 oxbow connecting existing oxbows and an embankment along C-38 were constructed.	Complete	December 2010	November 2011	$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 was completed in this separate contract.	Complete	September 2011	June 2012	$4.8 M
18B	Pool D Boat Ramp – A new boat ramp and small parking area will be constructed.	Under construction	September 2011	October 2012	$0.9 M
12A	S-69 Weir – The S-69 weir will serve as the terminus of the C-38 canal backfill.	Awarded but under protest	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**	**August 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**	**December 2012**	**December 2014**	**NA**

Note: NA - not available

KISSIMMEE BASIN HYDROLOGIC CONDITIONS IN WATER YEAR 2012

This section discusses hydrologic conditions in WY2012 based on data collected by the SFWMD monitoring program at water control structures (**Figure 9-2**) and stage monitoring locations in the river channel and floodplain (**Figure 9-4**).

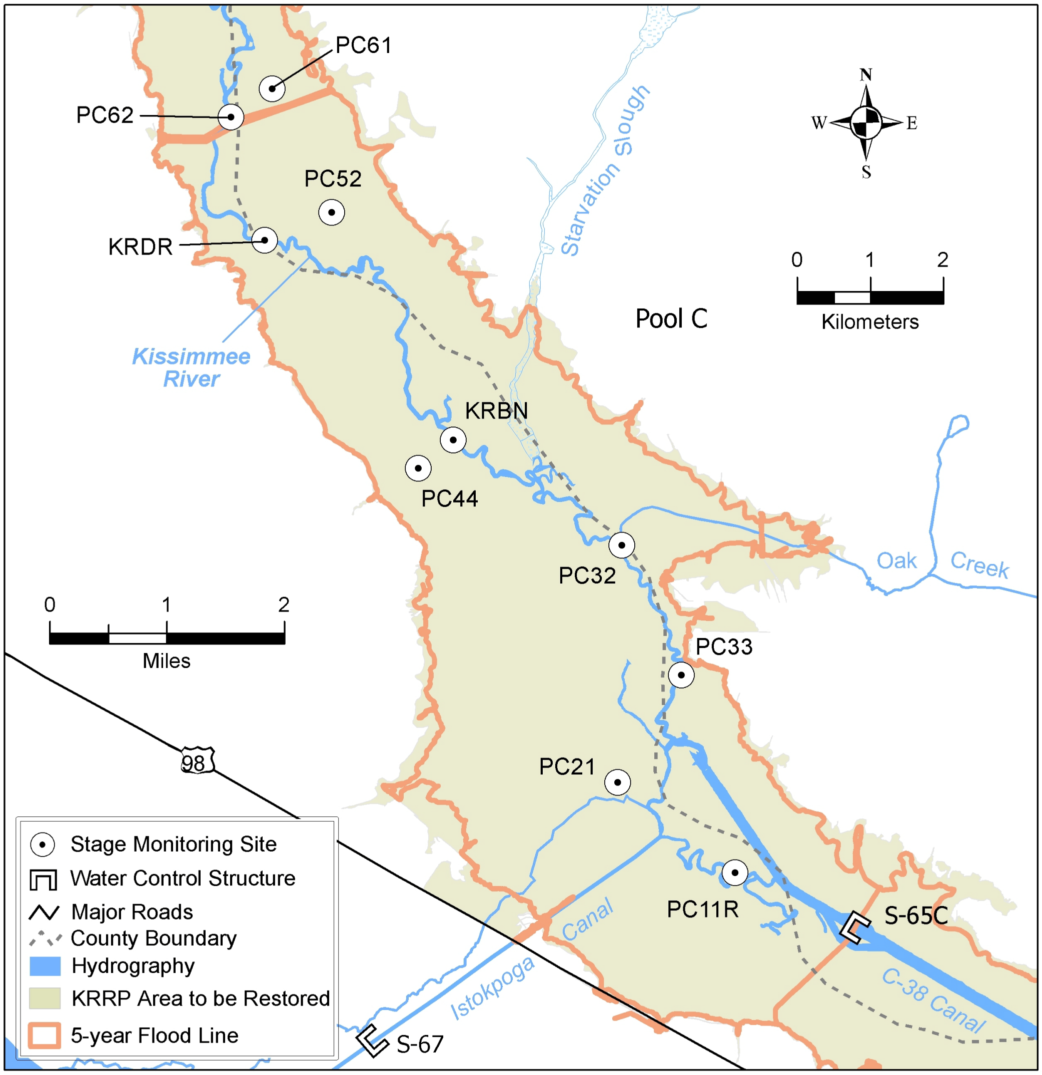


Figure 9-4. Locations of hydrologic monitoring sites in Pool C used to guide operations and to evaluate restoration expectations.

RAINFALL

Drought conditions persisted throughout most of WY2012, but an exceptionally high rainfall event in October strongly affected the total rainfall for the year and for the wet season.

In WY2012, rainfall in the upper basin was near or above average for every month of the wet season (June–October) and below average during the dry season (November–May) (**Figure 9-5**). In October, the upper basin received 9.81 inches of rainfall, which was greater than an event with a 50-year wet return period (Ali and Abtew, 1999). Most of this rainfall was associated with a single event, the No-Name Storm, which passed over the basin on October 7–10, 2011. Rainfall from this storm exceeded the value for a 100-year return interval for a 72-hour rainfall at certain monitoring stations in the upper and lower basins (see Chapter 2 of this volume). Total rainfall for the water year was 46.70 inches, which is 94 percent of the historical long-term average (1971–2000). The dry season total was 13 inches below average; the wet season was 9 inches above average.

In the lower basin, rainfall was below average in every month except July, August, and October (**Figure 9-5**). The No-Name Storm resulted in October rainfall of 11.29 inches, which was greater than an event with a 100-year wet return period (Ali and Abtew, 1999). Total rainfall for the water year was 44.29 inches, which was 86 percent of the long-term average for the basin. Total rainfall for the wet season exceeded the long-term average by 8 inches; the dry season was 15 inches below average.

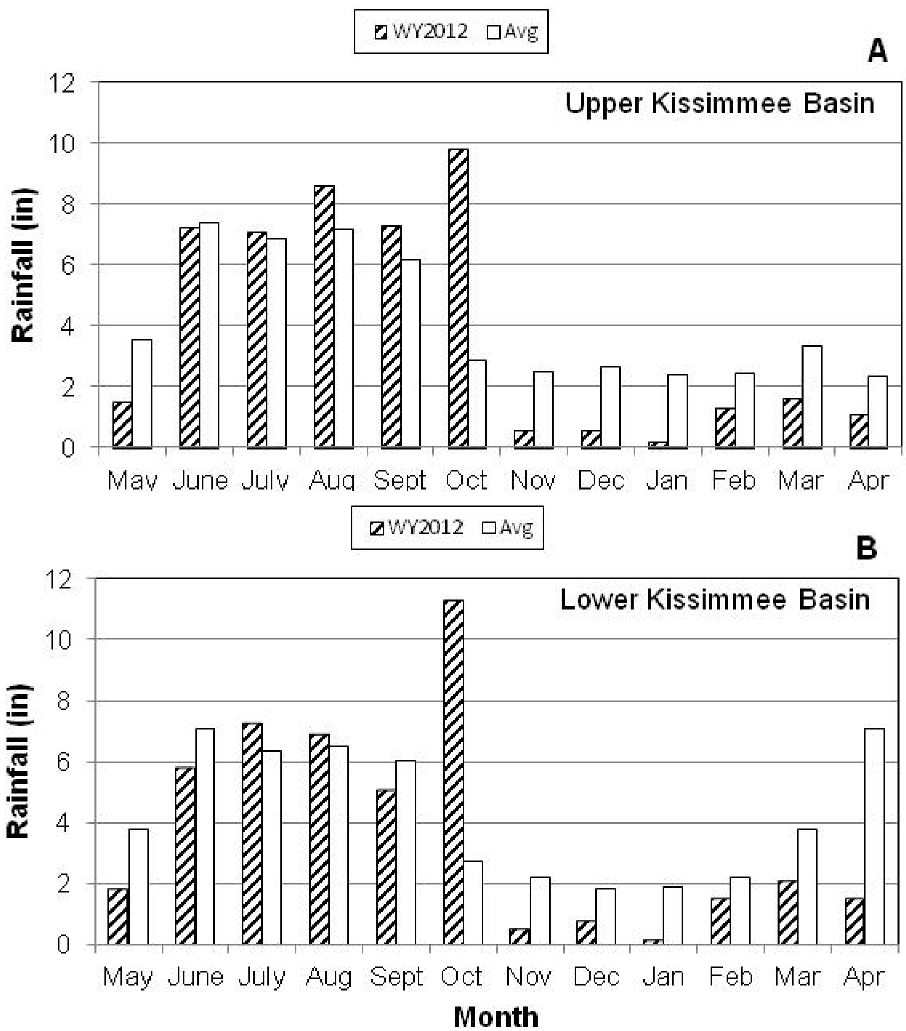


Figure 9-5. Monthly rainfall [in inches (in)] for Water Year 2012 (WY2012) (May 1, 2011–April 30, 2012) and average rainfall (1971–2000) in the Upper Kissimmee Basin (A) and the Lower Kissimmee Basin (B).

TEMPORAL HYDROLOGIC PATTERNS

WY2012 began with each of the water bodies in the KCOL being lowered according to its regulation schedule. Since the federally endangered snail kite (*Rostrhamus sociabilis plumbeus*) was nesting on larger lakes in the KCOL – East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, and Lake Kissimmee – the water levels in East Lake Tohopekaliga and Lake Tohopekaliga were lowered only to within 0.5 ft of the low pool stage (**Figures 9-6**). The previous wet season had not refilled most of the lakes to the high pool of the regulation schedule. Consequently, less water needed to be discharged to lower the lakes, which is reflected in the discharge at S-65 of only 1,146 cubic feet per second (cfs) on May 1, 2011 (compared to 3,800 cfs in WY2011), declining to a low of 125 cfs in mid-June (**Figure 9-7c**). During May and June, this discharge at S-65 was insufficient to raise 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**.

At the beginning of the wet season, the regulation schedule for each KCOL water body rises to a summer pool elevation before again rising to the high pool at the end of the wet season. Water levels in the KCOL water bodies rose to the summer pool in July–September (e.g., **Figures 9-6** and **9-7b**) because of the above-average rainfall in the upper basin for most of the wet season (**Figure 9-5**). Discharge at S-65 was kept at low levels to allow the Kissimmee–Cypress–Hatchineha system to refill to the summer pool.

On July 15-16, 2011, a substantial rain event (2.91 inches at S-65A during the two-day period) produced sufficient runoff from the S-65A basin to prompt an increase in discharge at S-65A from approximately 500 cfs to more than 2,500 cfs for flood control. Because the lower basin runoff more than compensated for the discharge from the upper basin, the discharge at S-65 was stopped for five days (July 16–July 20) to conserve water in the upper basin for release later in the season. The increased runoff and discharge associated with the July rainfall event caused water levels to rise briefly above ground level on the Kissimmee River floodplain as shown for PC61 (**Figure 9-8**).

During the July event, the concentration of dissolved oxygen (DO) in the river channel decreased to less than 0.5 milligrams per liter (mg/L). Such decreases in DO have been observed previously in the Kissimmee River, when high rainfall occurs after periods of low discharge (2006, 2008, 2009, and 2010 SFER – Volume I, Chapter 11). Such low concentrations may result in a fish kill. For centrarchids (largemouth bass and other sunfish) in the Kissimmee River, DO concentrations of 1–2 mg/L are stressful and concentrations less than 1 mg/L can cause death (see details in the 2008 SFER – Volume I, Chapter 11). On July 22, 2011, a fish kill was reported in the Kissimmee River. A survey on July 25 found 1,500–2,000 dead fish in the Phase I restoration area river channel. Over 95 percent of the dead fish were blue tilapia (*Oreochromis aureus*); very few centrarchids were found. The lock tender at S-65C observed many more dead bass and other sunfish earlier in the week, which might be expected because centrarchids are more sensitive to low DO concentrations than blue tilapia (L. Dirk, personal communication). The fish kill was likely the result of the DO decline caused by the high rainfall.

District scientists are studying the problem of DO crashes in Fiscal Year 2013. The mechanisms involved likely include some combination of the following: (1) influx of organic material from the floodplain and tributaries causing a rapid increase in biological oxygen demand (BOD), (2) dilution of oxygenated river channel water with anoxic water from runoff and upstream discharge (e.g., C-38 in Pool A), (3) effects on photosynthesis including flushing of photosynthetic aquatic organisms by increased flow and attenuation of light by increased water depth and turbidity, and (d) seepage of anoxic groundwater from the surficial aquifer.

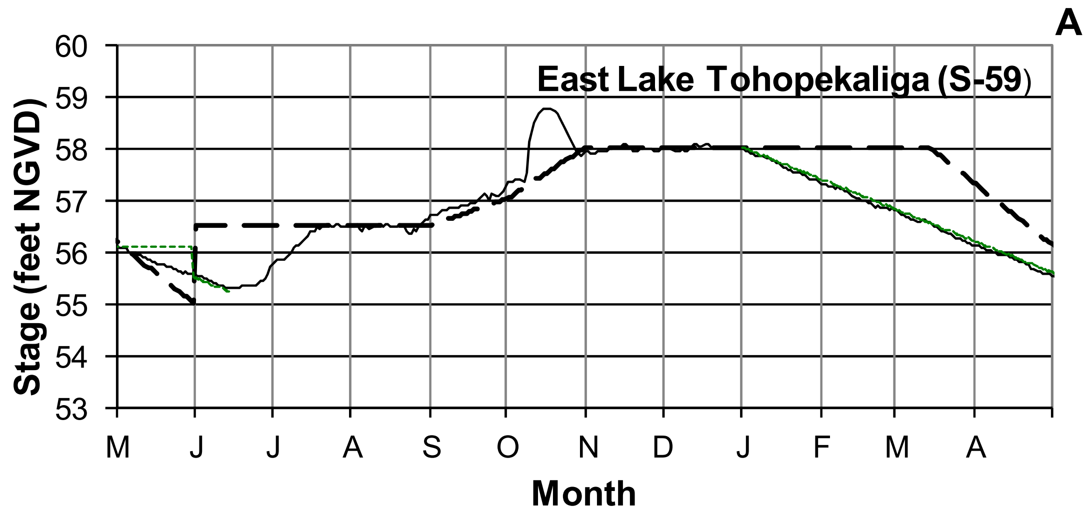
Water levels in the KCOL water bodies continued to rise in response to wet season rainfall and runoff (**Figures 9-6** and **9-7**). As water levels reached the regulation schedule, discharge at S-65 was increased to keep them from exceeding the regulation schedule. By the end of August, the water level in Kissimmee–Cypress–Hatchineha had reached the regulation schedule. In September, the discharge at S-65 was increased to greater than 2,000 cfs on two occasions (**Figure 9-8**). The first of these raised the water level at PC61 above the ground level, where it remained for the rest of the wet season.

In October 2011, the No-Name Storm raised the water level in each of the KCOL water bodies above the high pool stage by 1–3 ft. Water levels on the Kissimmee River increased by as much as 4.5 ft as shown for PC61 (**Figure 9-8**). Water levels were lowered by increasing the discharge in the lower basin first (shown for S-65C in **Figure 9-8**). The discharge rate at S-65C peaked at 19,564 cfs on October 12, which was the highest value measured at this location. Discharge at S-65 peaked at 11,555 cfs on October 18, which is the highest value measured at this location since measurements began in October 1933.

Water levels in the KCOL water bodies were brought back to the high pool stage by the end of October, so that each water body began the dry season at the high pool stage. WY2012 was the first water year since WY2006 that all of the lakes had refilled at the end of the wet season. In WY2006, Hurricane Wilma passed over the basin in late October. The hurricane resulted in total rainfall for October of 9.89 inches in the upper basin, which was almost the same as that for WY2012.

By November 1, discharge had decreased to 2,012 cfs at S-65 and 5,323 cfs at S-65C. Discharge continued to decrease at both locations until similar levels were measured over the remainder of the dry season (**Figure 9-8**). On November 12, the water level at PC61 had decreased to 40.18 feet, which approximated the pre-event water level at this floodplain station (**Figure 9-8**).

During the dry season, water levels in the upper basin lakes declined due to evapotranspiration and managed releases. Releases at S-59 and S-61 started in January to create a more gradual recession during the snail kite nesting season (**Figure 9-6**). Releases continued to be made at S-65 for the Kissimmee River, which kept the lake at or below the recession line for snail kite nesting (**Figure 9-7b**). Water levels on the Kissimmee River continued to decline over the dry season (**Figure 9-8**).



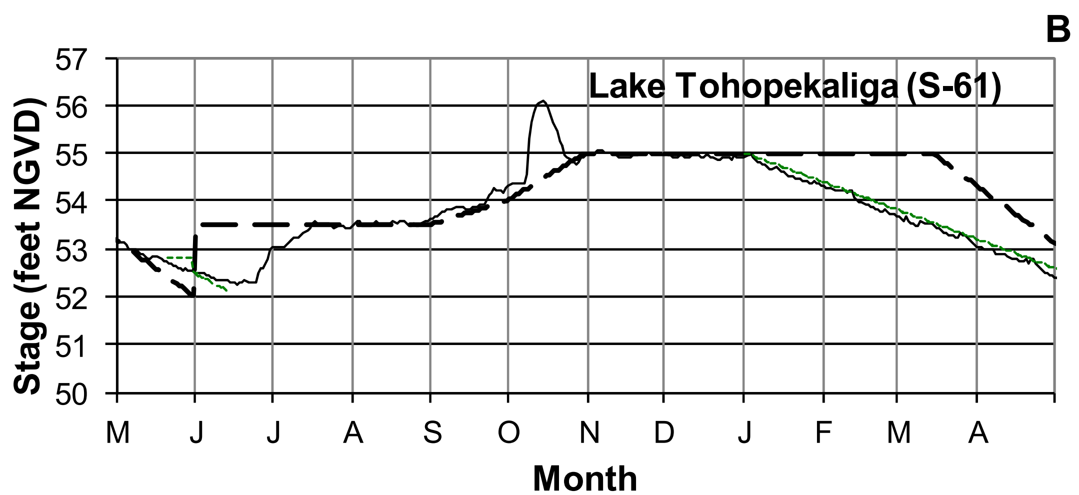


Figure 9-6. Regulation schedule (dashed line) and water level (solid line) in feet relative to the National Geodetic Vertical Datum of 1929 (NGVD) for (A) East Lake Tohopekaliga and (B) Lake Tohopekaliga during WY2012. Dotted lines are desired water level recession for snail kites.

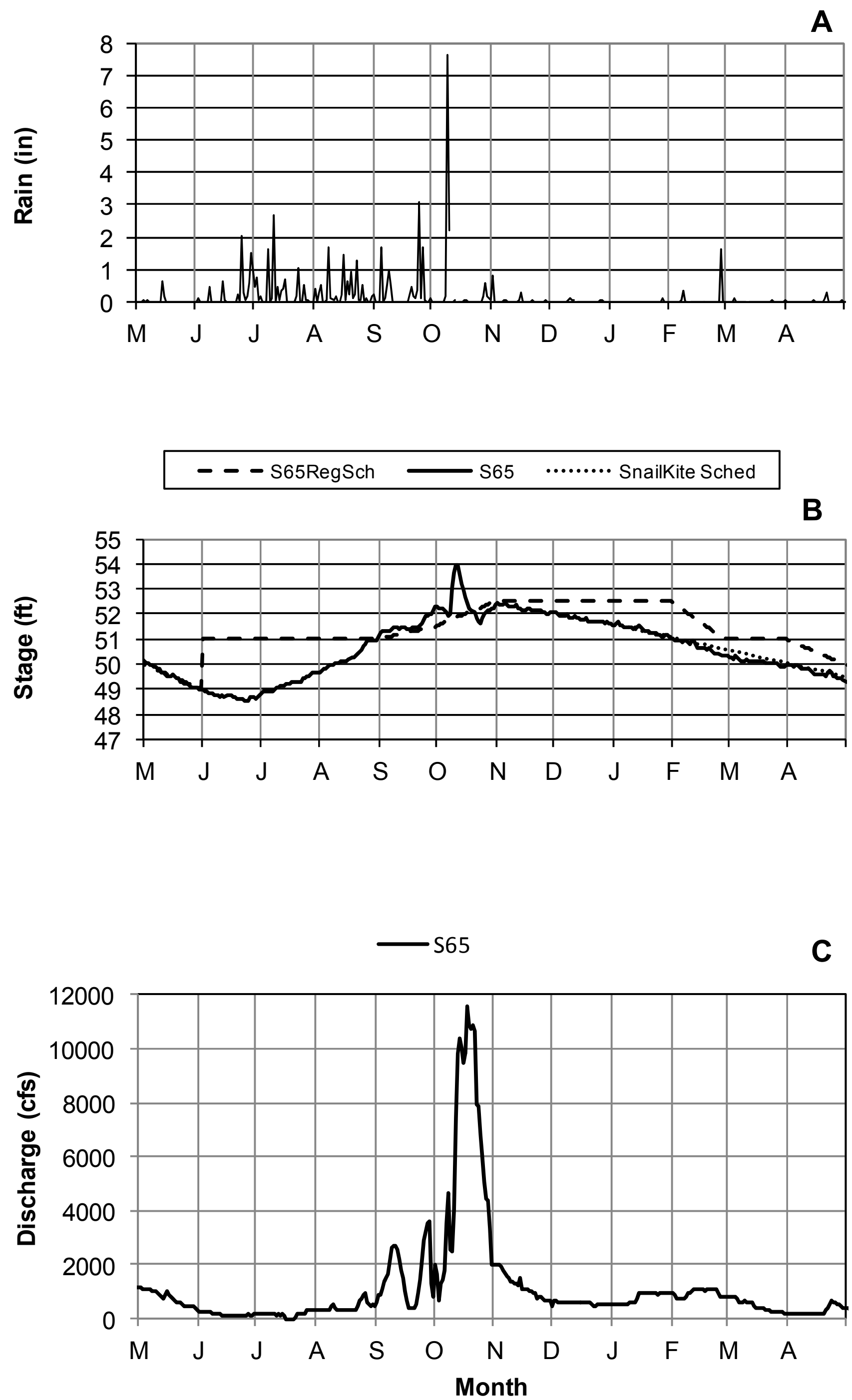


Figure 9-7. (A) Rainfall, (B) regulation schedule and water level in feet (ft), and (C) discharge in cubic feet per second (cfs) at the outlet of Lake Kissimmee (S-65 structure) for WY2012. Zone B releases are made when the lake stage is between the regulation schedule line in panel B and 48.5 feet.

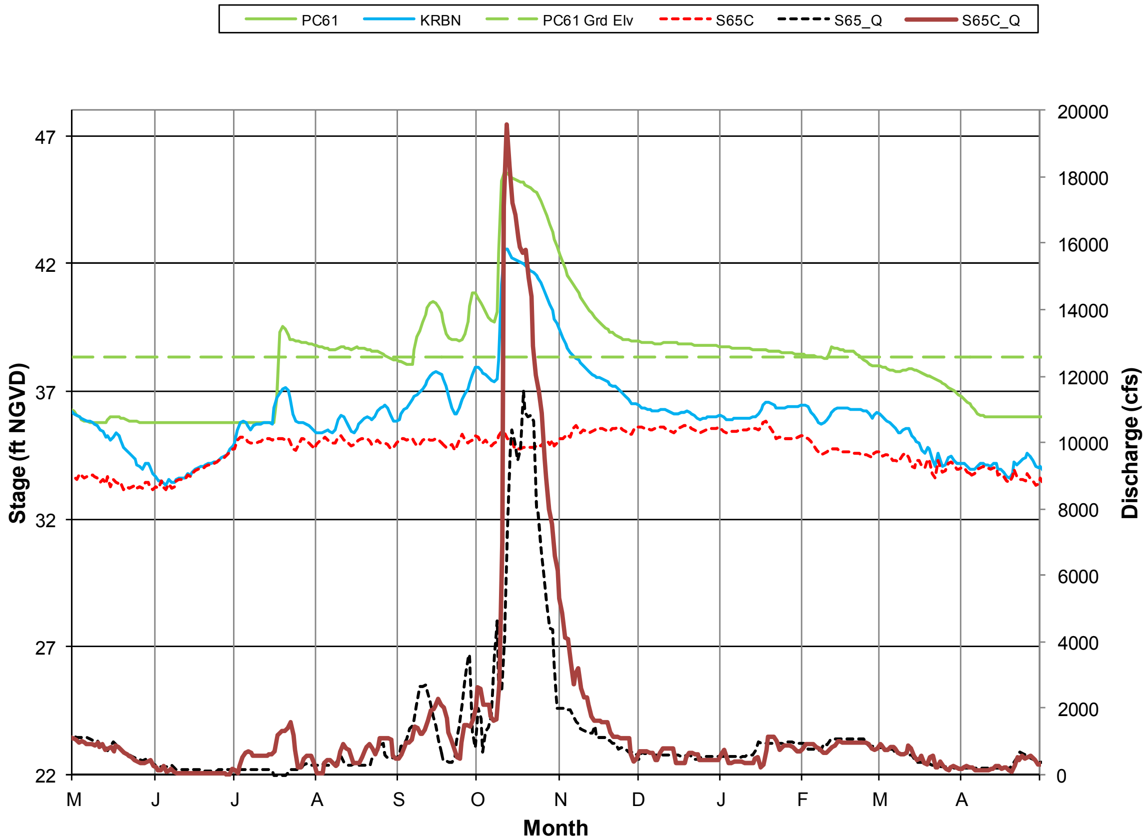


Figure 9-8. Mean daily stage on the floodplain at PC61, in the river channel at KRBN, and in the C-38 canal on the upstream side of S-65C in relation to mean daily discharge at S-65 and S-65C during WY2012. See **Figure 9-4** for locations of hydrological monitoring sites.

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 prechannelized 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 annual SFER chapters. 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. Therefore, a final evaluation of project success must wait until all restoration components are in place. However, ecological responses being documented prior to project completion are used to evaluate the ongoing status of ecosystem recovery and adaptive management of the system. 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 WY2012 in the Phase I restoration area. Many of the Phase I studies, which include collection of data on hydrology, geomorphology, water quality, river channel and floodplain vegetation, aquatic invertebrates, herpetofauna, fish, and birds, have already indicated changes consistent with those predicted by the expectations 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 subsequent SFERs. 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. 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 WY2012 are updated in this section. These new results from studies on hydrology, dissolved oxygen, nutrients, 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, an interim regulation schedule for S-65 is providing discharge to the river that varies seasonally and with water levels in Lake Kissimmee. However, this interim schedule is not expected to fully deliver the seasonal pattern of discharge needed for river restoration.

The addition of WY2012 data extends the evaluation of the Phase I interim period to eleven years (WY2002–WY2012). This evaluation quantifies the status of the hydrologic expectations under the interim flow conditions. This year's update focuses on four hydrologic expectations for discharge and stage. A fifth expectation for water velocity was evaluated in last year's report. Chapter 11 of the 2011 SFER – Volume I includes more detail on methods. For purposes of scientific evaluation of restoration, hydrologic responses are presented in SI units instead of English units, which are the convention for water management and are used elsewhere in this chapter.

Table 9-3. Directory of Kissimmee River Restoration Evaluation Program (KRREP) Phase I restoration response monitoring study updates in the *2005–2013 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	2013
Kissimmee River Restoration Evaluation Program		11-8	11-37	11-22	11-28	11-36	11-26	11-25	9-16	9-19
Hydrology										
Stage-discharge relationships	No expectation	11-20								
Continuous river channel flow	1	**[11-18]**				**[11-39]**	**[11-29]**	**[11-29]**	**[9-20]**	**[9-23]**
Variability of flow	2					**[11-40]**	**[11-31]**	**[11-32]**	**[9-20]**	**[9-23]**
Stage hydrograph	3	**[11-22]**				**[11-41]**	**[11-32]**	**[11-33]**	**[9-21]**	**[9-24]**
Stage recession rate	4	**[11-23]**	11-23	11-16	11-19	**[11-42]**	**[11-34]**	**[11-35]**	**[9-24]**	**[9-27]**
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]**		**[9-27]**
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	9-31
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**	**2013**
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]**	**[9-41]**
Waterfowl	25		**[11-67]**	**[11-35]**		**[11-73]**	**[11-52]**		**[9-37]**	**[9-42]**
Shore birds	No expectation	11-57								
Wading bird nesting	No expectation		11-68		11-40	11-72	11-47		9-33	9-38
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)

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 WY2012, mean daily discharge at S-65 ranged from 0 m^3/s to 327 m^3/s and averaged 32 m^3/s (**Figure 9-9a**). The maximum discharge of 327 m^3/s was the highest rate of mean daily discharge measured at this location since records began in October 1933. As described in the *Temporal Hydrologic Patterns* section, discharge at S-65 was stopped for a five-day period in July 2011 to conserve water while runoff from the S-65A sub-basin discharged to the Kissimmee River. Consequently, even though discharge at S-65 was not continuous during WY2012, discharge in the Phase I area was continuous because of the runoff from the S-65A sub-basin. So, the expectation has been met for 8 of 11 years, including WY2012 (**Figure 9-9b**).

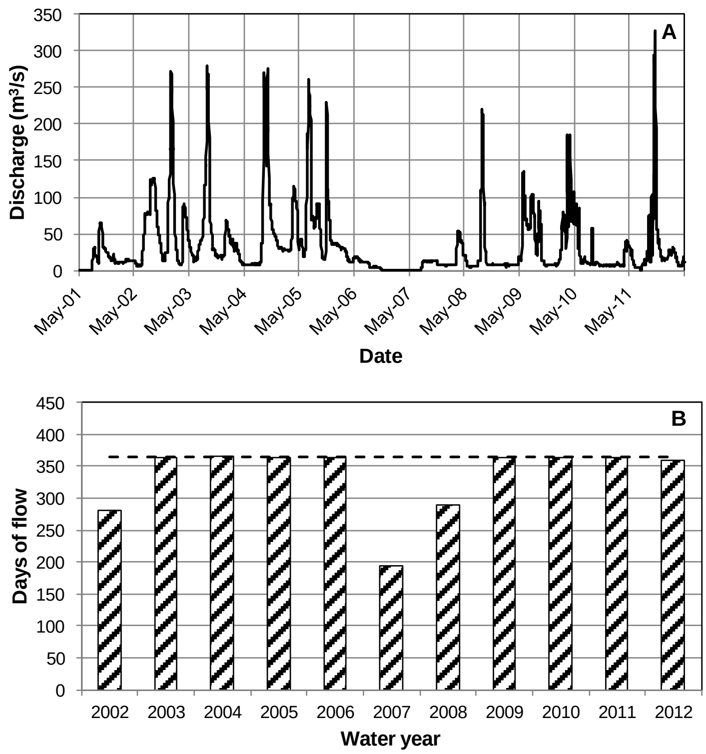


Figure 9-9. Mean daily discharge [cubic meters per second (m^3/s)] at the (A) S-65 structure, the outlet from the Upper Kissimmee Basin, and (B) number of days with flow for WY2002–WY2012.

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 WY2012, the minimum mean monthly discharge at S-65 occurred in July (4 m^3/s) and increased to a maximum of 169 m^3/s in October (**Figure 9-10**). The overall pattern of discharge reflected the seasonal distribution of rainfall, especially the above-average rainfall in October due to the No-Name Storm. The pattern for WY2012 departed slightly from the average for the interim period, which reaches the minimum one month earlier in June and the maximum one month earlier in September. During the interim period, the maximum mean monthly discharge occurs one month earlier than for the reference period of WY1935–WY1962, and the minimum is one month later. For WY2012, the coefficient of variation for mean monthly discharge ranged from 0.81 to 1.45. Only five months (May, August, September, February, and March) had a coefficient of variation less than 1.0, so the expectation was not met.

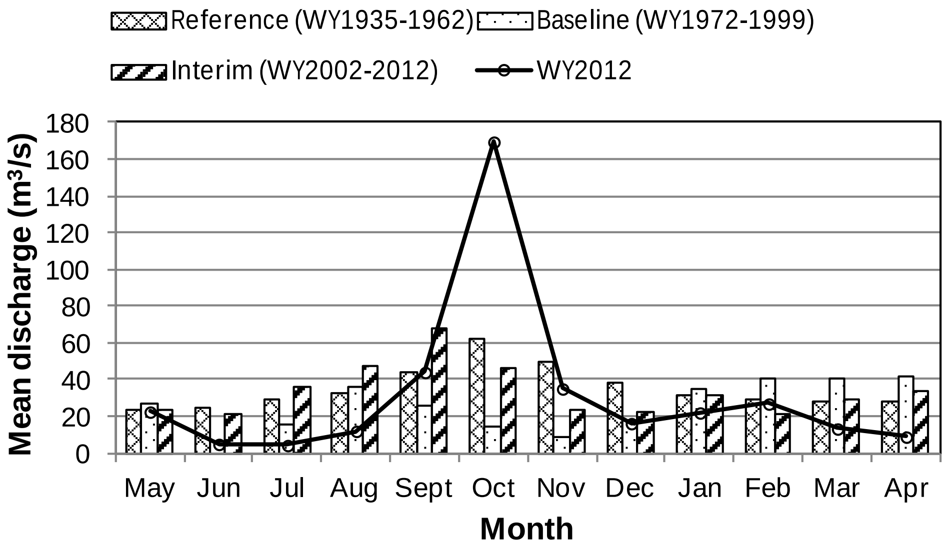


Figure 9-10. Seasonality of mean monthly discharge at S-65 for WY2012 and for average values for reference (WY1935–WY1962), baseline (WY1972–1999), and interim periods (WY2002–2012).

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 (NGVD29). 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.

At the beginning of WY2012, the three most upstream floodplain sites (PC61, PC52, and PC44) were dry. It was not until July that water levels began to fluctuate in response to increased rainfall and discharge. Water levels exceeded ground elevation briefly at these sites following the July rainfall event, exceeded ground elevation again in September, peaked in October following the No-Name Storm, and then generally decreased over the remainder of WY2012 (**Figure 9-11**). At the lower sites (PC32, PC21), stage varied with the headwater stage at S-65C although water levels at both locations rose above that of S-65C following the No-Name Storm (**Figure 9-11**).

In WY2012, all five stations met the target for amplitude of stage fluctuation of at least 1.14 m (**Figure 9-12**). The three most upstream sites (PC61, PC52, and PC44) also met the target in each of the preceding ten years of the interim period; the two downstream sites met the target less frequently – PC32 in seven years and PC21 in only two years. The target for inundation duration of at least 180 days was met at one of the upstream locations (PC61) and at both downstream locations (PC32, PC21). The duration of inundation at PC32 and PC21 was shorter than in previous years because the water level at S-65C was lowered for part of the year. In conclusion, the expectation for river channel stage fluctuation and inundation duration was not met at all monitoring locations in WY2012.

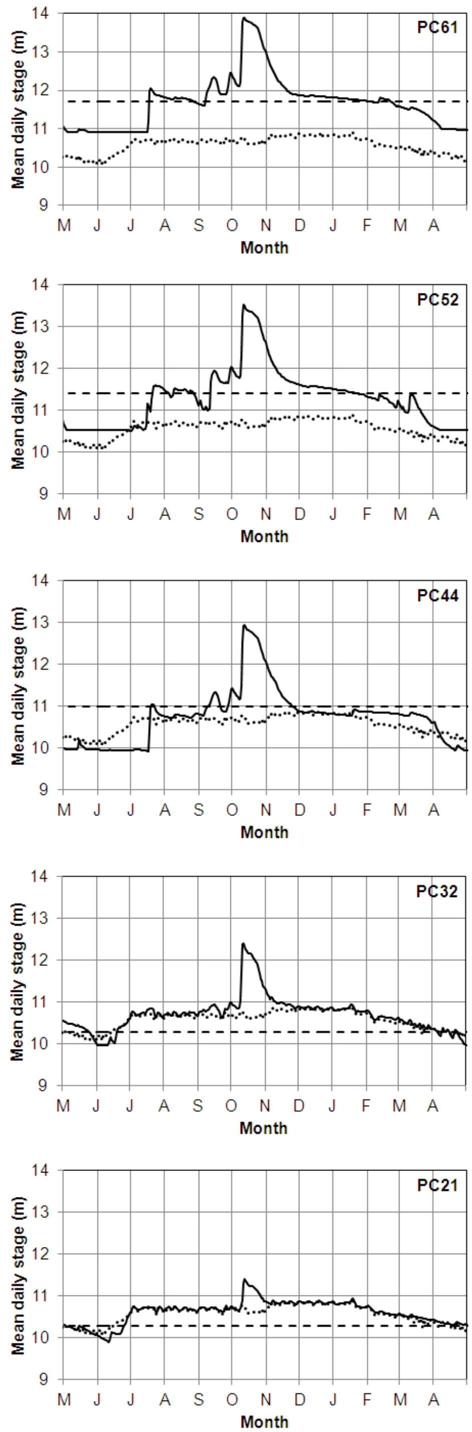


Figure 9-11. Water level (stage) in meters (m) during WY2012 at five floodplain locations. Dashed line is the ground elevation at the location. Dotted line is the headwater stage at S-65C.

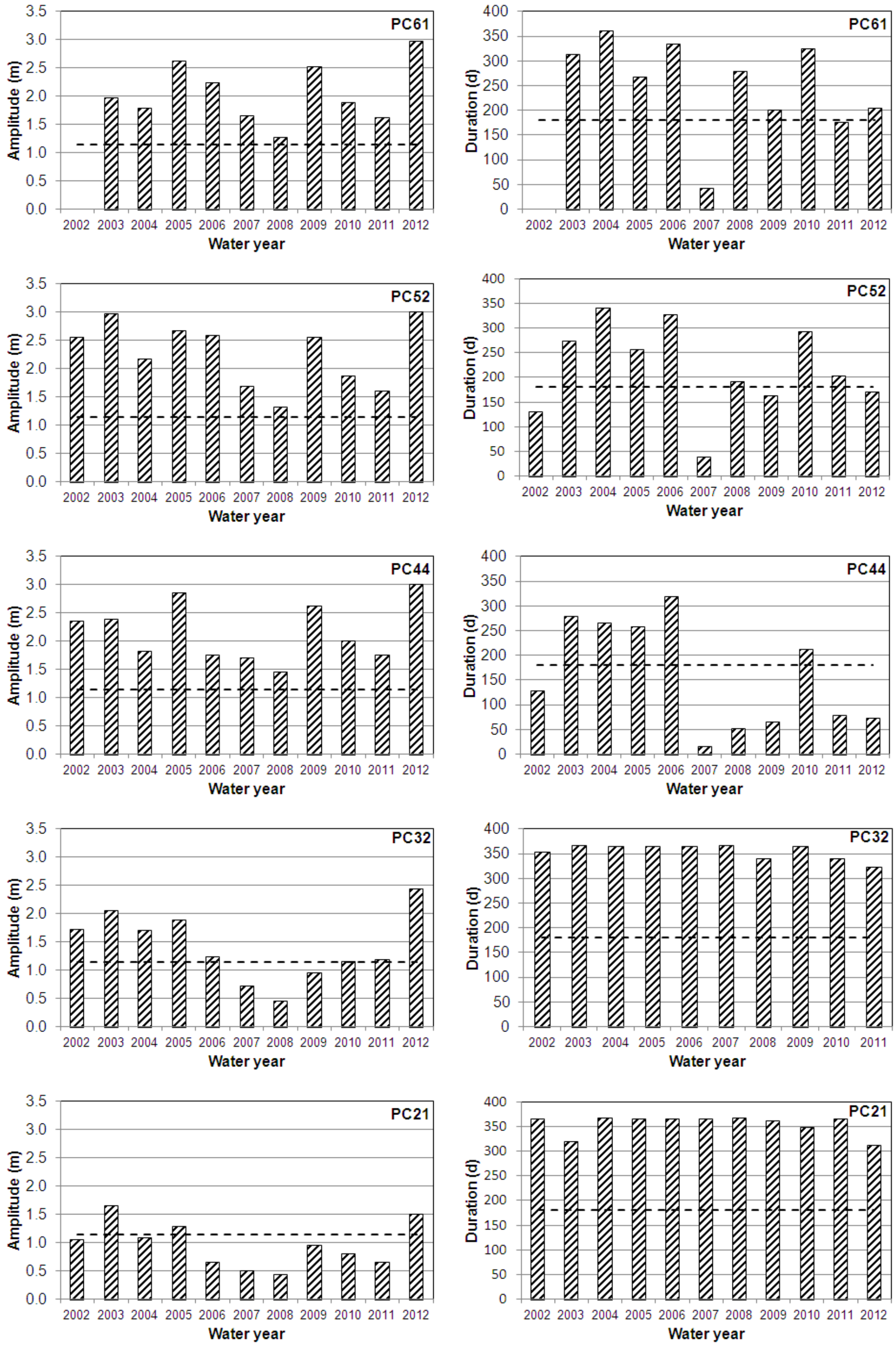


Figure 9-12. Amplitude of water level fluctuation (left) and duration of inundation (right) at five locations for WY2002–WY2012. The dashed horizontal lines represent minimum change in water level fluctuation of at least 1.14 m per year (left) and a minimum duration of 180 days per year for stage exceeding floodplain ground elevation (right).

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).

During WY2012, three to four recession events, identified by a stage reversal larger than 0.45 m, occurred at the three upstream floodplain stage monitoring sites (PC61, PC52, PC44) (**Table 9-4**). None of these events met the combination of a duration longer than 173 days and an event recession rate that did not exceed 0.3 m per 30 days. Only the event associated with the increased discharge following the October No-Name Storm lasted more than 173 days and a recession rate that approached 0.3 m per 30 days. At the two lower floodplain sites (PC32, PC21), the only stage reversal that could be distinguished from the headwater stage at S-65C was associated with the October No-Name Storm. At these two sites, this recession event had a shorter duration and more rapid rate than was measured at the upper floodplain. The expectation for a prolonged recession event was not met in WY2012 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 WY2012 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.

Site	T_{max}	h_{max} (m)	T_{min}	h_{min} (m)	Δh (m)	ΔT (d)	R (m/30 days)
PC61	July 19, 2011	12.05	September 5, 2011	11.59	0.46	48	0.29
	September 14, 2011	12.35	September 22, 2011	11.89	0.46	8	1.73
	September 30, 2011	12.46	October 7, 2011	12.11	0.35	7	1.50
	October 11, 2011	13.89	April 9, 2012	10.98	2.91	181	0.48
PC52	July 25, 2011	11.59	September 5, 2011	11.01	0.58	42	0.41
	September 15, 2011	11.94	September 24, 2011	11.66	0.28	9	0.93
	October 11, 2011	13.53	April 18, 2012	10.53	3	190	0.47
PC44	July 21, 2011	11.04	August 22, 2011	10.74	0.3	32	0.28
	September 16, 2011	11.34	September 26, 2011	10.96	0.38	10	1.14
	October 12, 2011	12.94	April 29, 2012	9.95	2.99	200	0.45
PC32	October 12, 2011	12.41	December 14, 2011	10.87	1.54	63	0.73
PC21	October 12, 2011	11.42	November 12, 2011	10.82	0.6	31	0.58

DISSOLVED OXYGEN

Expectation 8

Mean daytime concentration of dissolved oxygen in the Kissimmee River channel at 0.5-1.0 m depth will increase from < 1-2 mg/L to 3-6 mg/L during the wet season (June-November) and from 2-4 mg/L to 5-7 mg/L during the dry season (December-May). Mean daily concentrations will be greater than 2 mg/L more than 90% of the time. Dissolved oxygen concentrations within 1 m of the channel bottom will exceed 1 mg/L more than 50% of the time (SFWMD, 2005b).

Restoration has been expected to improve DO concentrations in the river channel. However, reference DO data from the prechannelized, flowing river are not available to support quantitative performance measures. Therefore, reference conditions for the prechannelized river were derived from data from other free-flowing, blackwater streams in South Florida. At least 11 samples were collected from each of the seven streams over a minimum of one year. Some streams were sampled for more than 10 years (**Figure 9-13**). The period of record for these reference data is 1973–1999. The mean daytime DO concentration in the reference streams was 4.2 milligrams per liter (mg/L) during the wet season and 6.1 mg/L during the dry season (**Figure 9-14**). In five of the seven streams, DO was greater than 5 mg/L in more than 50 percent of the samples. In seven of the eight streams, more than 90 percent of the samples had concentrations greater than 2 mg/L.

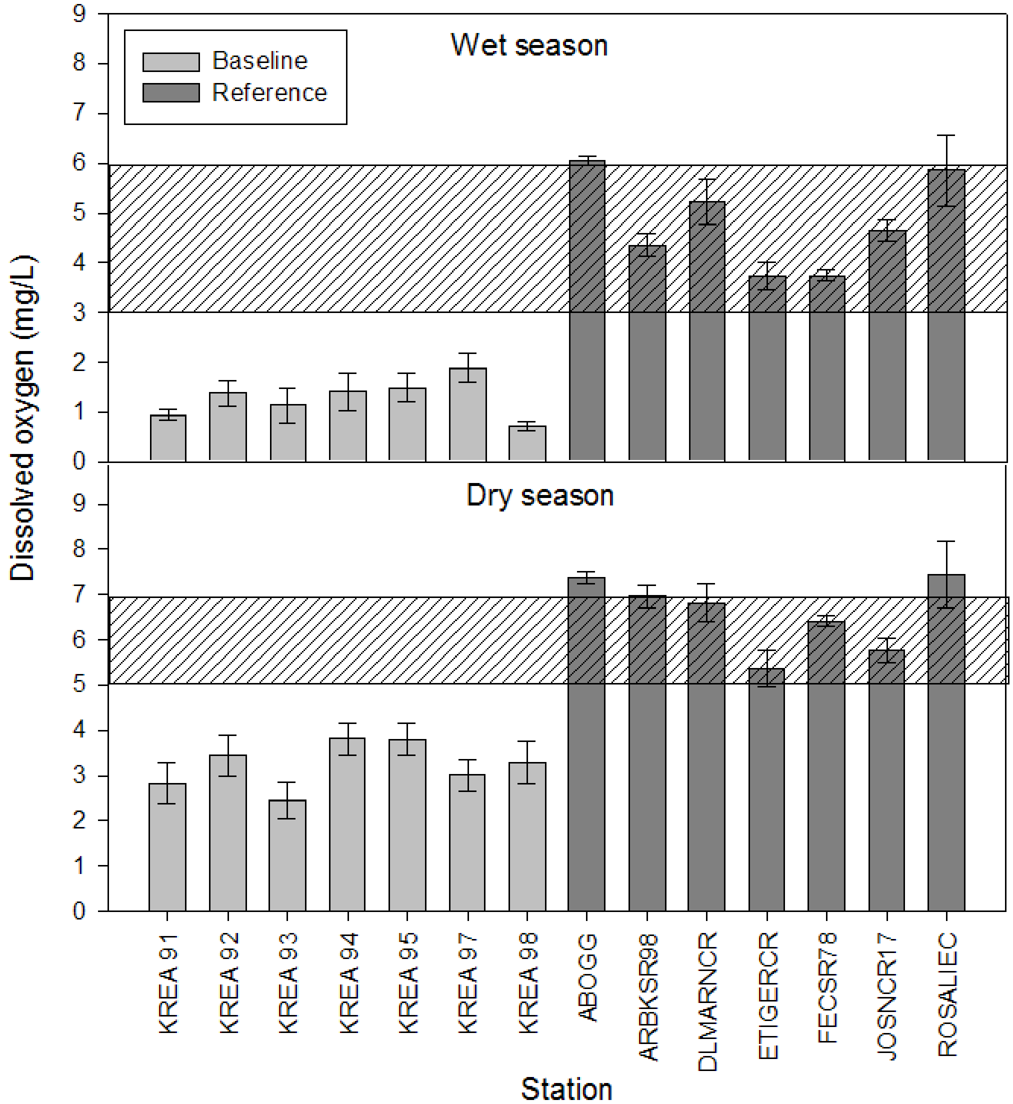


Figure 9-13. Mean [± standard error (S.E.) of the mean] dissolved oxygen (DO) concentrations in milligrams per liter (mg/L) in free-flowing, blackwater South Florida streams (dark-shaded) and remnant runs (light-shaded) of the channelized Kissimmee River during the wet (June–November) and dry (December–May) seasons. Hatched areas represent expected range of DO concentrations in the Kissimmee River after restoration. Station names shown are South Florida Water Management District (SFWMD) monitoring sites.

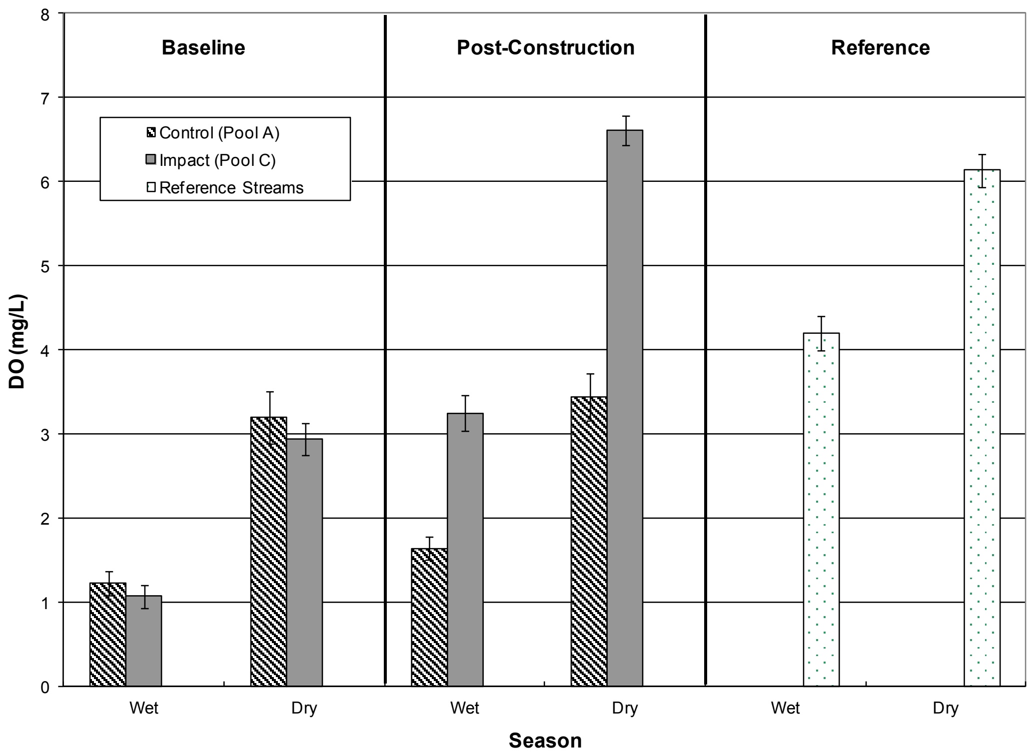


Figure 9-14. Mean (± S.E.) DO concentrations (mg/L) in reference streams (period of record = 1973–1999) and control and impact areas during the wet and dry seasons, during the baseline (1997–1999) and post-restoration (2001–present) periods.

To establish baseline conditions in the stagnant river runs, DO was monitored daily over 24 hours at a depth of approximately 1 m in two remnant river channel stations in Pool C. Sampled river channels were approximately 20–30 m wide and 2–3 m deep. DO also was sampled monthly, during the day, within seven remnant river runs in Pools A and C. This monitoring has continued beyond the 1997–1999 baseline period and provides comparisons of conditions before and after the Phase I restoration construction.

Within the remnant river runs during the baseline period, DO concentrations were frequently below 1 mg/L throughout the water column at all times of day. A gradient in DO concentration, decreasing with depth, was common during the warmer months of the year. DO concentrations near the surface could reach 4–5 mg/L, but concentrations near the bottom were lower than the detection limit (< 0.2 mg/L). During 1997–1999, mean DO concentrations in remnant river runs in Pool A and C were 1.2 mg/L and 1.1 mg/L, respectively, during the wet season, and 3.2 mg/L and 3.0 mg/L, respectively, during the dry season (**Figure 9-14**). DO concentrations exceeded 2 mg/L for only 22 percent of the baseline period, and 5 mg/L for only 6 percent of this period.

The reference and baseline data were used to develop four components of Expectation 8 (SFWMD, 2005b) to evaluate changes in DO as restoration proceeds (**Table 9-5**).

Following completion of the first phase of construction, DO concentrations within the restoration area (Pool C) averaged 3.3 mg/L during the wet season and 6.6 mg/L during the dry season (**Figure 9-14**). In comparison, post-construction DO concentrations in the control area (Pool A) averaged 1.6 and 3.4 mg/L during the wet and dry seasons, respectively (**Figure 9-14**). Annual mean DO concentrations in the restoration area increased from less than 3.0 mg/L before construction to 4.6 mg/L in WY2012 (**Figure 9-15**). Also in WY2012, mean daily water column DO concentrations were greater than 2.0 mg/L for 78 percent of the time. Concentrations within 1 m of the channel bottom were greater than 1 mg/L for 96 percent of the time and more than 2 mg/L for 85 percent of the time (**Table 9-5**). In summary, two of the four metrics used to evaluate DO response were met under the interim regulation schedule during WY2012. The final determination of restoration success with respect to DO in the river channel will be made after implementation of the Headwaters Revitalization Schedule.

Table 9-5. DO restoration expectation metrics and WY2012 values.

Expectation Metric	WY2012 Value	Metric Achieved in WY2012?
Mean daytime DO concentration in the river channel at 0.5–1.0 m depth will increase from < 2 mg/L to 3–6 mg/L during the wet season (June–October).	2.5 ± 0.4 mg/L	No
Mean daytime DO concentration in the river channel at 0.5–1.0 m depth will increase from 2–4 mg/L to 5–7 mg/L during the dry season (December–May).	7.0 ± 0.2 mg/L	Yes
Mean daily DO concentrations in the river channel will be > 2 mg/L for more than 90 percent of the time (annually).	78%	No
DO concentrations within 1 m of the channel bottom will be > 1 mg/L for more than 50 percent of the time annually.	96%	Yes

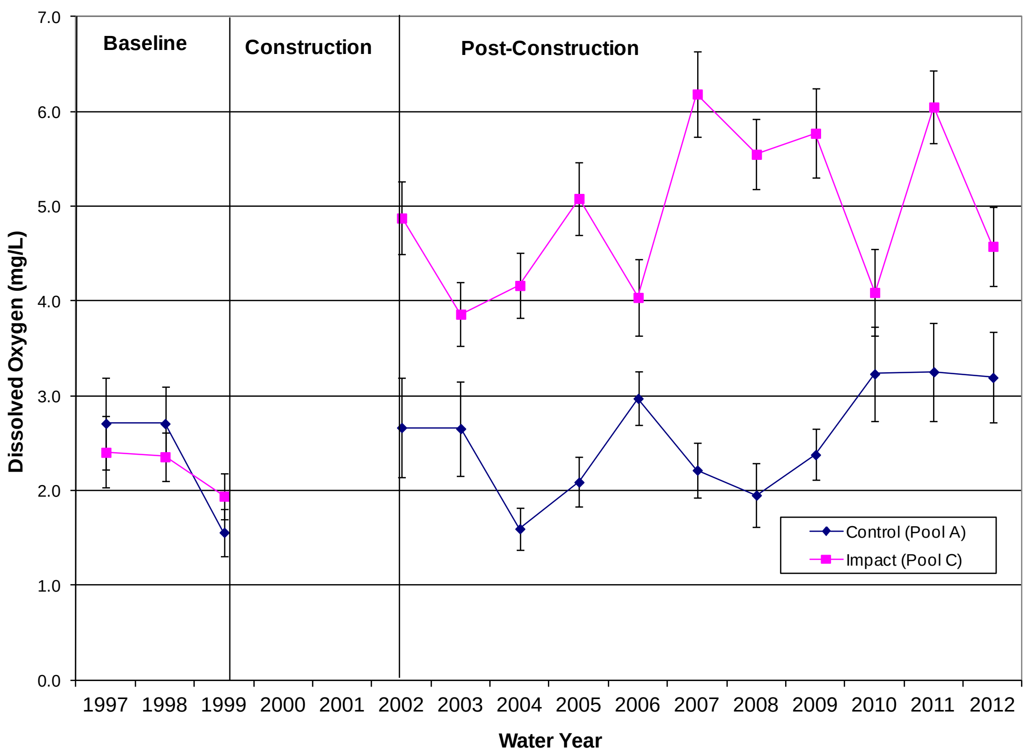


Figure 9-15. Mean DO concentrations (mg/L) in the Kissimmee River for each water year during the baseline and post-construction periods.

PHOSPHORUS AND NITROGEN

Expectation

A quantitative expectation has not been established for phosphorus and nitrogen, although river restoration is anticipated to create conditions favorable for greater nutrient deposition and assimilation in the floodplain, thereby reducing downstream nutrient loading to Lake Okeechobee.

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. Because nutrients were not monitored before channelization, concentrations in the natural river cannot be estimated with any certainty. 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). Therefore, although quantitative performance measures have not been established for phosphorus, restoring the river to its natural condition may help reduce loading from lateral tributaries and the headwater lakes once a more natural hydroperiod and a stable wetland ecosystem become established. In the meantime, phosphorus concentrations may increase periodically as the nutrient runs off former pastures and the floodplain transitions from terrestrial to wetland vegetation.

This section presents phosphorus loads and concentrations monitored at the five C-38 water control structures. Data collected since completion of Phase I restoration construction are compared to baseline data obtained prior to construction. Because nitrogen inputs to Lake Okeechobee are also a concern, a summary of nitrogen loading from the Kissimmee River is also included. To aid interpretation of the loading data, a graph of annual discharges from each structure is shown in **Figure 9-16**.

To estimate phosphorus and nitrogen loading along the C-38 canal, baseline and post-construction total phosphorus (TP) and total nitrogen (TN) concentrations have been monitored routinely at each of the canal's water control structures along with daily estimates of discharge. TP and TN 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). TP concentrations were also monitored with 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 nutrient loads were computed from measured or interpolated TP and TN concentrations and daily discharges and then summed annually. Because nutrient loads can vary greatly between wet years and dry years, annual nutrient loads were divided by annual discharges to obtain flow-weighted mean (FWM) TP and TN concentrations at each structure. These annual FWM concentrations provide a more useful metric for evaluating trends.

For comparison with post-restoration results, 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 9-17**). These amounts comprised 44 and 71 percent of the average load at S-65E, respectively. These values serve as the baseline levels 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 9-18**). 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 9-17**) and the FWM TP concentration was 43 ppb (**Figure 9-18**).

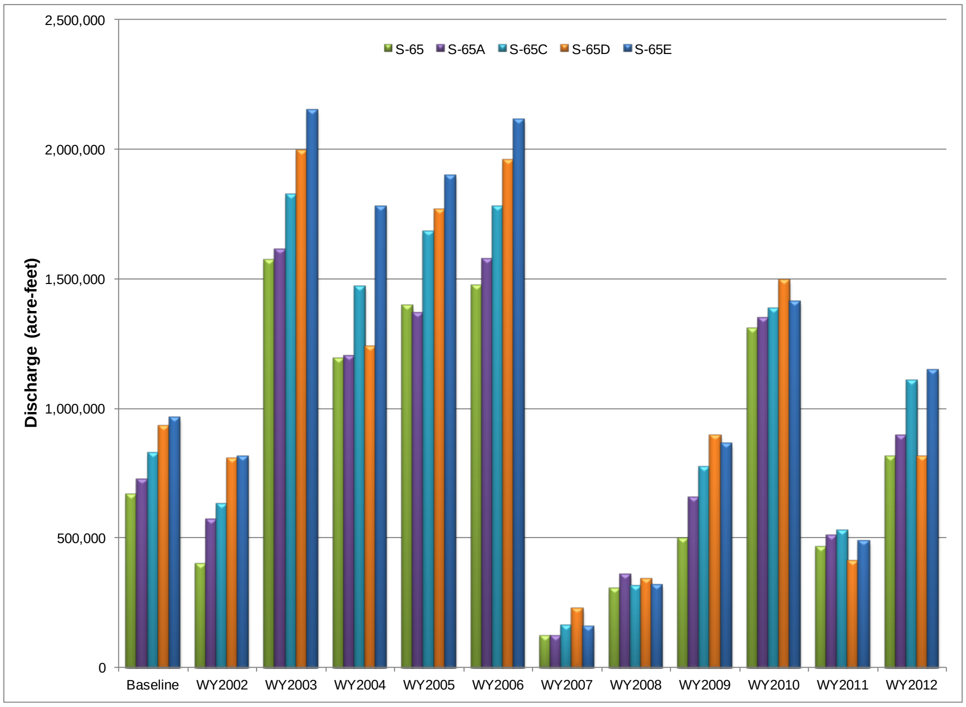


Figure 9-16. Annual discharges from C-38 structures for WY2002–WY2012 in comparison to average annual discharges during the baseline (calendar years 1974–1995). WY2002, WY2007, WY2008, and WY2011 were drought years, and WY2005 was wet due to hurricanes.

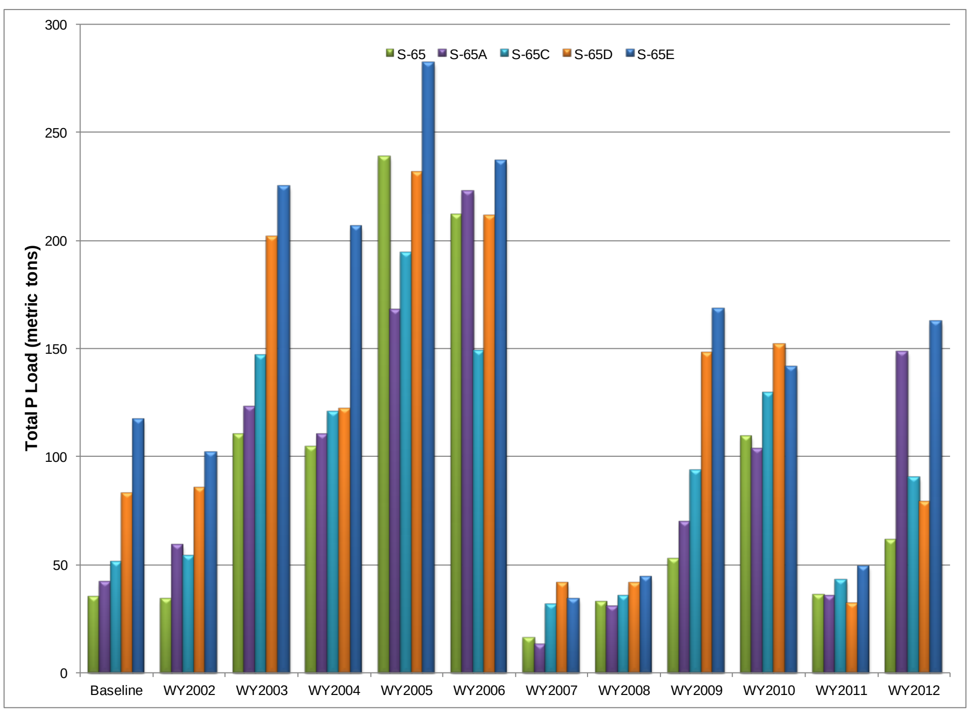


Figure 9-17. Annual total phosphorus (TP) loads from C-38 structures for WY2002–WY2012 in comparison to average annual baseline loads during calendar years 1974–1995. WY2002, WY2007, WY2008, and WY2011 were drought years and WY2005 was wet due to hurricanes.

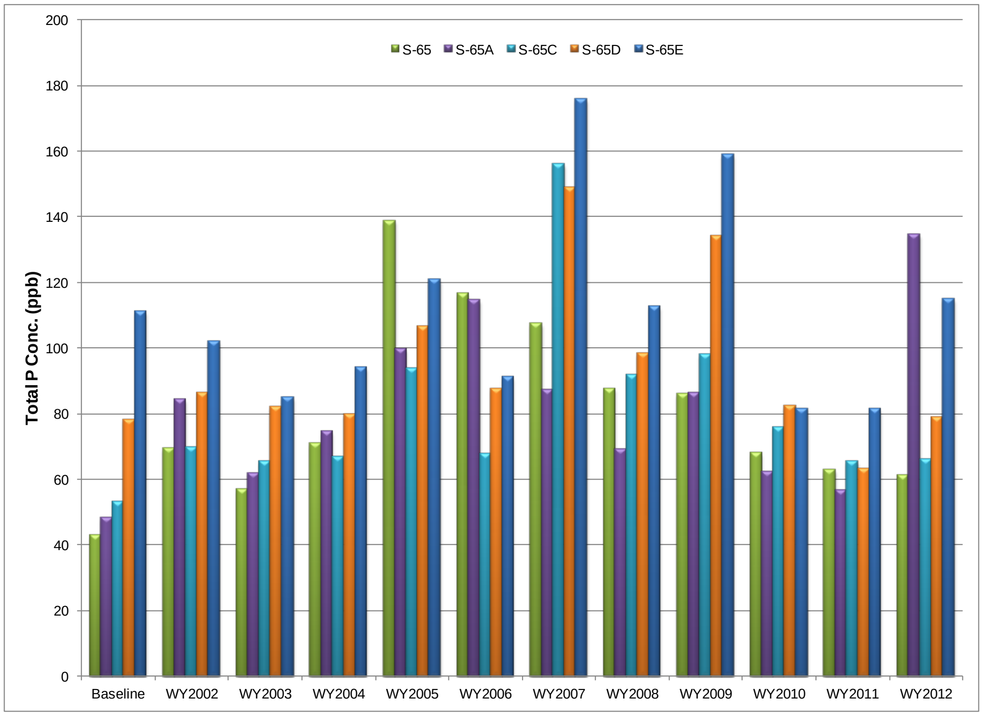


Figure 9-18. Annual flow-weighted mean (FWM) TP concentrations in parts per billion (ppb) at C-38 structures for WY2002–WY2012 in comparison to average annual baseline concentrations during calendar years 1974–1995.

After Phase I was completed in WY2002, the interim regulation schedule allowed intermittent inundation of the floodplain in the restoration area above S-65C. However, periodic dry conditions, especially in WY2007, WY2008 and WY2011, limited hydrologic interaction between the river channel and floodplain. Under these interim hydrologic conditions, wetland vegetation returned to a large extent, but the composition of wetland community types has not yet attained the proportions that are expected once the entire KRRP is completed (2011 SFER – Volume I, Chapter 11). Therefore, in the transitional years since WY2002, the river–floodplain system was unlikely to have sequestered phosphorus at its highest potential efficiency.

The significance of loading trends is difficult to determine because loading is highly dependent on discharge (see **Figures 9-16** and **9-17**). Because of discharge variations, loads at the C-38 structures varied greatly from year to year. In most of the last 11 years, they exceeded their 1974- 1995 baseline averages (**Figure 9-17**). Most of the TP entering the restoration area came from the Upper Kissimmee Basin, but in WY2012 the S-65A sub-basin contributed most of this load (**Figure 9-17**). The high TP load at S-65A was due to high concentrations and discharge during the October 7–10, 2011, storm event, which was centered on the S-65A sub-basin. This storm raised WY2012 TP loading from the Kissimmee Basin (163 mt at S-65E) above the average annual load for the last 11 years (150 mt) in what otherwise was a below-average year. Over the longer term, TP loading in the last six years (WY2007–WY2012) has been lower than loading in the previous five years, which included the hurricane years of WY2005 and WY2006 (**Figure 9-17**).

FWM TP concentrations have been higher at all structures since the baseline period. However, they have shown a general decline since WY2005–WY2007 (**Figure 9-18**). This decline, particularly at S-65, can be attributed in part to the time elapsed since the disturbance caused by three hurricanes that crossed the Kissimmee Basin in WY2005.

The graph of annual loads of total nitrogen (**Figure 9-19**) looks very similar to the graph of annual discharges (**Figure 9-16**), indicating that TN loads are highly dependent on discharge. Annual FWM TN concentrations have ranged from 0.96 to 1.55 mg/L since WY2002 (**Figure 9-20**). These concentrations were usually similar among the C-38 structures or declined slightly from upstream to downstream. The only general trend apparent over the last 11 years is the slight decline at each structure since WY2007–WY2009. In WY2012, TN concentrations at the five structures fell within a narrow range of 1.12 to 1.20 mg/L. Unlike TP, the concentration of TN at S-65A was not unusually high.

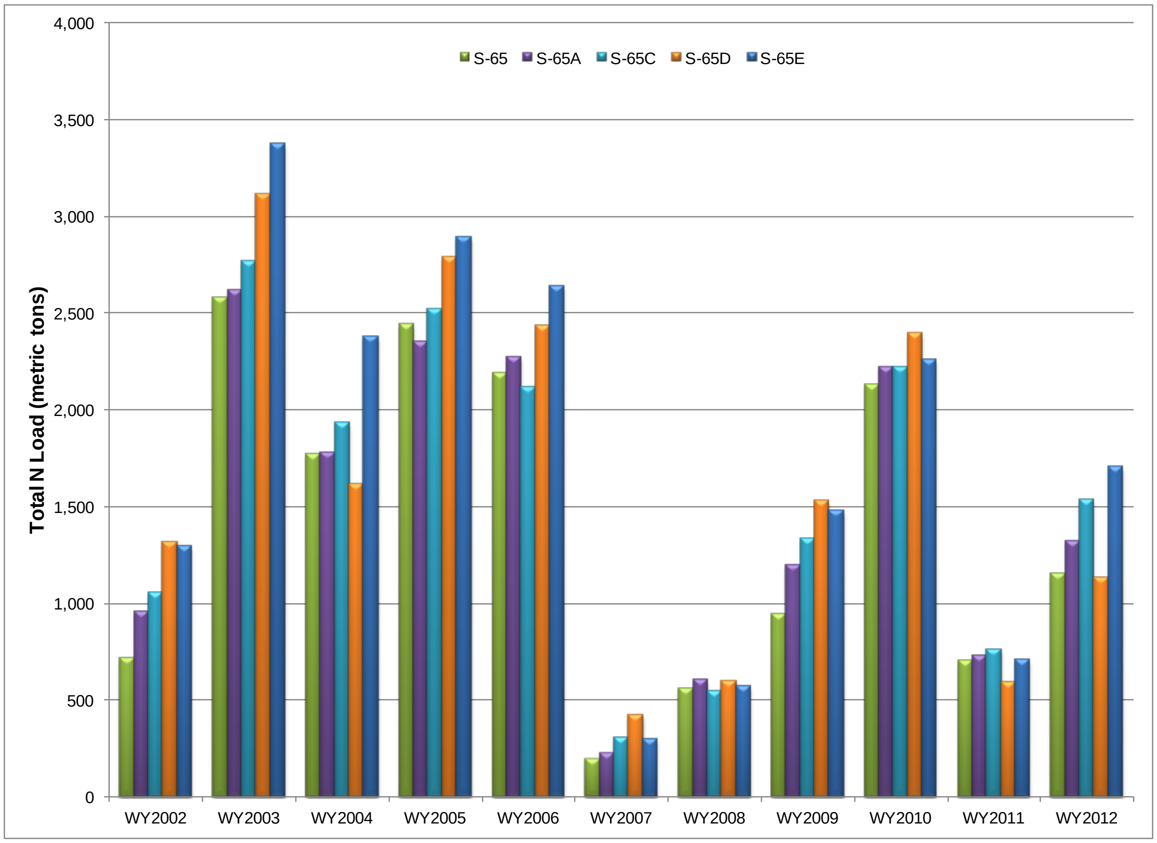


Figure 9-19. Annual total nitrogen (TN) loads from C-38 structures for WY2002–WY2012. WY2002, WY2007, WY2008, and WY2011 were drought years and WY2005 was wet due to hurricanes.

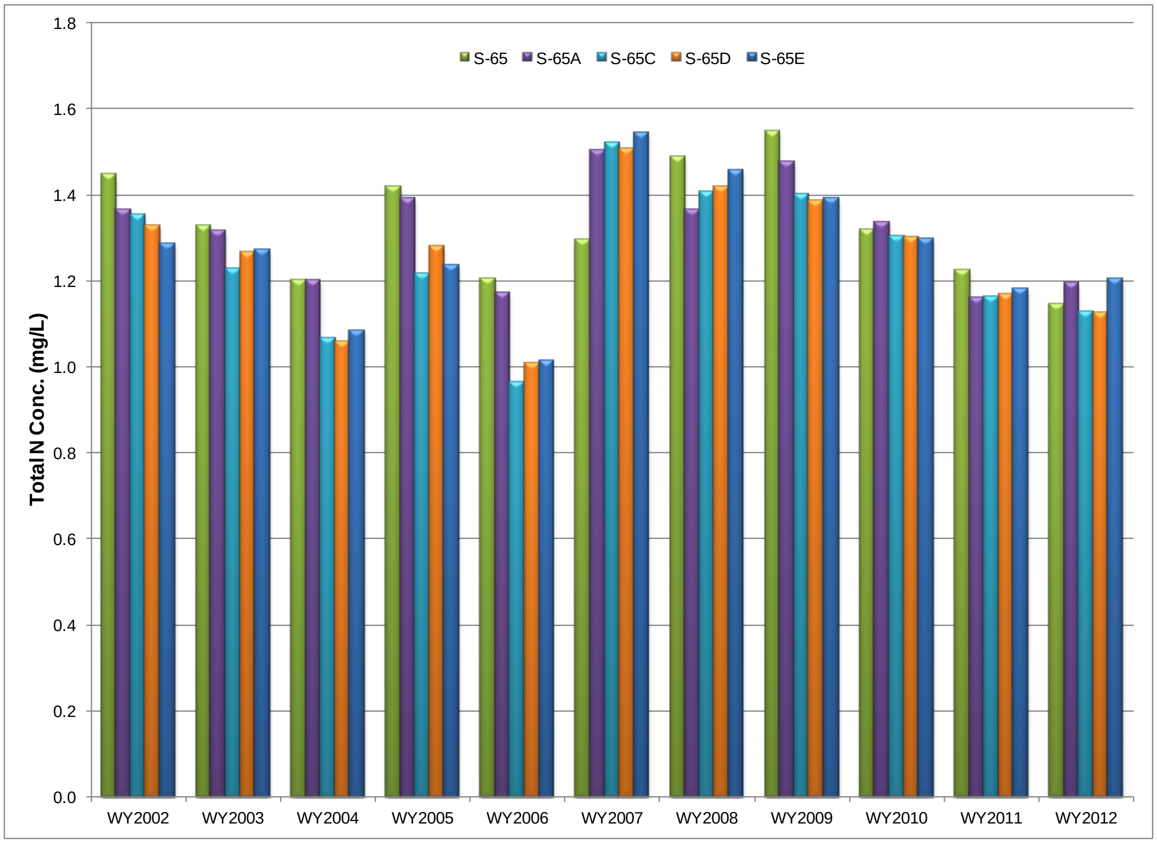


Figure 9-20. Annual flow-weighted mean (FWM) TN concentrations in milligrams per liter (mg/L) at C-38 structures for WY2002–WY2012.

Two events occurred in WY2012 that are of particular interest to phosphorus runoff and downstream transport. The first was a runoff event in July that illustrates watershed concerns in the vicinity of S-65. The second was an extreme storm event in October that had a major impact on hydrology and phosphorus runoff in the Kissimmee Basin. (Also see the *Kissimmee Basin Hydrologic Conditions in Water Year 2012* section for further information on both of these events.)

Preceding the July event, discharge at S-65 was kept at low levels to maintain flow to the river while allowing the headwater lakes to rise to the summer pool elevation permitted by the regulation schedule. Nearly 3 inches of rain fell at S-65A on July 15–16, prompting an increase in discharge at S-65A to provide flood control for the S-65A sub-basin. Because the runoff from the S-65A sub-basin was more than enough to maintain flow in the river restoration area, discharge at S-65 was stopped for five days (July 16–20) to conserve water in the headwater lakes. During this time, the TP concentration at S-65 tripled, reaching a value of 298 ppb for the week ending July 20 and increasing to 387 ppb in the following week (**Figure 9-21**). Although no observations or samples were obtained of any runoff into the lake above S-65, the increase appears to be locally influenced because TP concentrations monitored at two stations in the main body of Lake Kissimmee were much lower (49 and 60 ppb on July 26). Therefore, the source of phosphorus appears to be storm runoff that entered the south end of the lake and pooled above the S-65 structure. Because the structure was closed, this runoff was not diluted by water that would have been pulled from the main body of the lake if the structure had been open. When the structure was opened, the high TP water in the lake's south end was released downstream.

Based on analysis of SFWMD data (Jones, unpublished), this scenario has apparently occurred at other times over the last two decades. This is important to recognize because data collected at S-65 represent discharge from the Upper Kissimmee Basin, which contributes the most phosphorus of any Lake Okeechobee sub-watershed (see Chapter 8 of this volume). In addition, TP loads and concentrations at S-65 have increased over the nearly four decades of monitoring. Even though TP concentrations have fallen from their peak in WY2005, they are still higher than they were in the 1974–1995 baseline period (**Figure 9-18**). Consequently, identification of sources that might influence TP at S-65 is critical. It is especially important to distinguish between local runoff that discharges into a mixing zone above S-65 and other potential sources further north that may affect ambient TP concentrations in Lake Kissimmee and other lakes upstream. In the past, the SFWMD has obtained a few water quality samples indicating that local runoff strongly influences TP in the south end of Lake Kissimmee. More monitoring of this runoff would be helpful for determining its impact on water quality at S-65.

The most important hydrologic event of WY2012 was the storm of October 7–10, 2011, which brought heavy rains to South Florida, especially the Kissimmee Basin (see Chapter 2 of this volume). The Pool A sub-basin received the highest rainfall (12.6 inches), which exceeded the 100-year, 5-day design storm (Konyha, in prep.). Peak discharges at S-65 and S-65C were the highest ever measured at these locations. The entire Phase I restoration area was flooded to an average depth of 5.1 ft (average for October 10–16; SFWMD Environmental Conditions Report – October 18, 2011). Water on the Kissimmee River floodplain took 42 days to return to pre-storm levels (Konyha, in prep.). The Pool A floodplain was inundated as well. As designed, excess flow that could not be handled by S-65A passed through culverts and weirs on the tieback levees east and west of the structure, but also overtopped these levees for a short time. Flooding throughout the Pool A sub-basin caused erosion and breaching of roads and berms. Runoff lasted for 21 days (to October 30) in most of the Kissimmee Basin and was of somewhat shorter duration in the S-65A sub-basin (Konyha, in prep.). The S-65A sub-basin contains agricultural operations and other land uses that could not tolerate standing water. Consequently, efforts were made to drain this water as quickly as possible.

This storm resulted in a large discharge of phosphorus from Pool A into the restoration area. The TP mass at S-65A (101 mt for the month of October) was much larger than the amount transported through S-65 (27 mt), indicating the degree of disturbance caused by flooding in all parts of the S-65A sub-basin. Also, the TP load at S-65A was twice that at S-65C (51 mt) even though October discharge at S-65A was less than discharge at S-65C.

The load was extremely high at S-65A due to both water volume and TP concentration. Concentrations of TP ranged up to 328 ppb during the 30 days following the storm (**Figure 9-21**). These concentrations reflected increases at other SFWMD monitoring stations in the area. The highest TP value was collected on October 11 in the south end of Lake Kissimmee near an agricultural outfall. This value (436 ppb) was nearly 10 times higher than the average for other in-lake sites (47 ppb).

Another indication of the magnitude of this storm was its effect on annual TP loads. October loads accounted for 44 percent of the load at S-65 and 68 percent of the load at S-65A in WY2012. At S-65E, the drainage outlet of the Kissimmee Basin, the October load was 108 mt, or 66 percent of the basin's annual load. This 108 mt was 32 percent of the entire surface water load (339 mt) to Lake Okeechobee for WY2012.

Perhaps of most interest is the difference in TP load between S-65A and S-65C. As mentioned above, the S-65C load was 50 mt less than the S-65A load in October. This difference was not made up later in the year; the annual WY2012 load at S-65A was 149 mt, which was 59 mt higher than the annual load at S-65C (**Figure 9-17**). Therefore, much of the TP from S-65A was retained in Pool BC. Data collected following this storm suggest that the restored Kissimmee River floodplain can assimilate large amounts of phosphorus during flood events.

To better understand the process of phosphorus movement and assimilation, 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 potential interaction of sediment and soil phosphorus with the overlying water. In WY2011, the SFWMD initiated a survey to fill this information need. In WY2012, investigators collected sediment and soil samples from the river channel and floodplain, measured the content of phosphorus, nitrogen and related constituents, examined their spatial distribution and association with various landscape types and vegetation communities, and estimated soil phosphorus storage capacity. The final report on this survey is planned for WY2013.

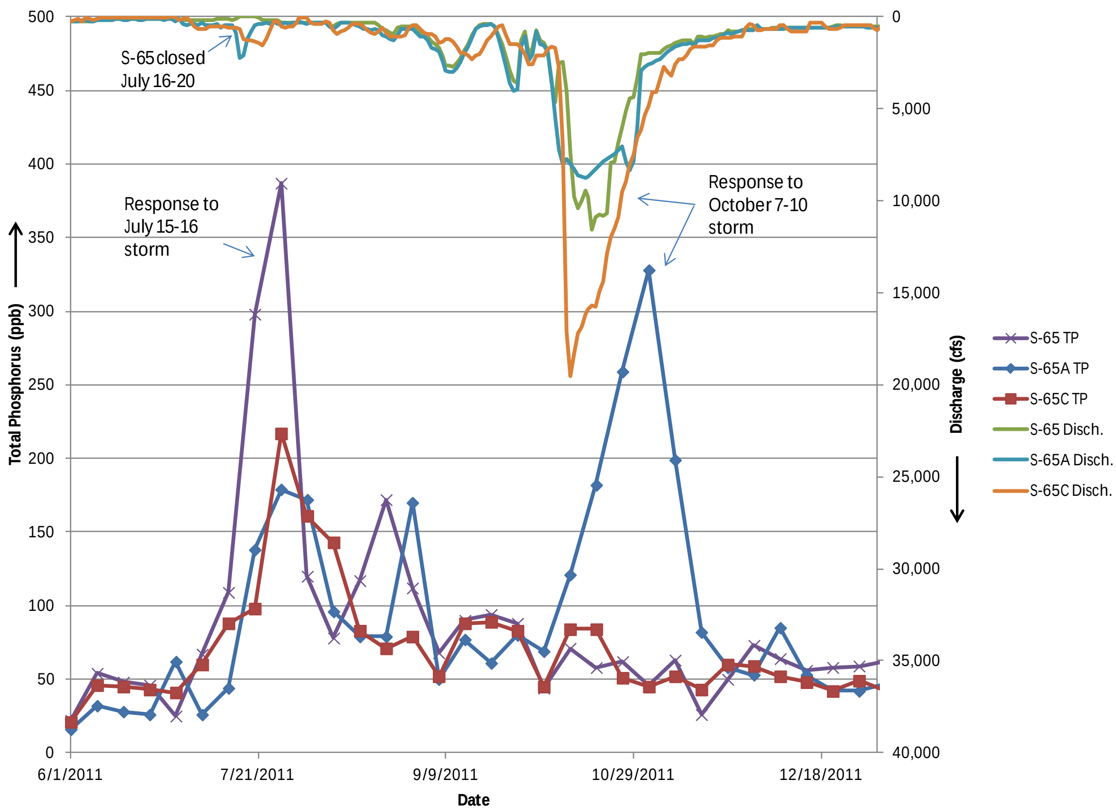


Figure 9-21. Response of discharge (cfs) and total phosphorus concentration (ppb) to July and October 2011 storm events at the S-65, S-65A, and S-65C water control structures in the C-38 Canal.

WADING BIRDS AND WATERFOWL

Birds are integral to the Kissimmee River–floodplain ecosystem and highly valued by the public. While quantitative prechannelization data are sparse, available data and anecdotal accounts indicate that the system supported an abundant and diverse bird assemblage (National Audubon Society, 1936–1959; Florida Game and Fresh Water Fish Commission, 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 2011–2012, and compare recent data to restoration expectations.

Wading Bird Nesting Colonies

Expectation

No expectation has been established for wading bird nesting colonies.

As part of the KRREP, the SFWMD performed systematic aerial surveys on March 6, April 9, and June 5, 2012, 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 floodline. Nesting colonies were also monitored, when encountered, during separate aerial surveys of foraging wading birds on January 17, February 13, March 13, April 17, and May 14, 2012. 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 S-65C colony on April 25 to obtain a more accurate nest count and determine the presence of less visible dark-colored species. Seven colonies were surveyed during 2012 (**Figure 9-22**), of which four were within 3 km of the Kissimmee River restoration project area. The other three colonies were on Lakes Mary Jane, Kissimmee, and Istokpoga.

The four colonies active within or near the Kissimmee River floodplain included the relatively large S-65C colony and three much smaller colonies: Melaleuca Island, River Ranch, and Orange Grove. Nesting effort along the Kissimmee River was dominated by the terrestrial cattle egret (*Bubulcus ibis*) (1,202 nests), while nesting by aquatic wading bird species was more limited (160 nests) (**Table 9-6**).

The colonies on Lakes Mary Jane and Istokpoga were dominated by aquatic species, while nesters on Lake Kissimmee were mostly cattle egrets. The second largest colony to form this year after S-65C was in Lake Kissimmee on Rabbit Island, which has supported the largest number of aquatic wading birds (i.e., excluding cattle egrets) in both the Upper and Lower Kissimmee basins in recent years. The number of aquatic species nests at the Rabbit Island colony in 2012 was down from 2011 by 408 nests (-43%), largely due to lower numbers of nesting white ibis (*Eudocimus albus*), which were down by 384 nests (-71%). Cattle egret nests in this colony increased by 295 (84%). Lake Mary Jane, the third largest colony this season, had an increase in cattle egrets (235 nests) and white ibis (119 nests) over last year, when neither of these species nested in the lake. The total number of aquatic species nests on the Lake Mary Jane island was up by 92 (23%) over 2011. Bumblebee Island in Lake Istokpoga, the fourth significant colony, had a decrease in nests of both cattle egrets (306 nests, -80%) and white ibis (50 nests, -100%), with an overall decrease for all aquatic species on the island of 45 nests (-15%) (**Table 9-6**).

Compared to 2011, the number of aquatic bird nests in all observed colonies was down by 293 nests (-17%), while the number of cattle egret nests was up by 675 (46%) (**Table 9-6**). The peak number of nests of all aquatic species combined was observed during the April survey, while the peak number of cattle egret nests was observed during June.

Table 9-6. Peak numbers of wading bird nests inside or within two miles of the Kissimmee River 100-year floodline (between the S-65 and S-65D structures) and within Lakes Mary Jane, Kissimmee, and Istokpoga.

Kissimmee River										
Year*	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	SMDH	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
2012	1,202	2	-	18	32	-	-	108	-	1,362
Total	**4,210**	**393**	**-**	**26**	**126**	**59**	**28**	**108**	**-**	**4,962**
Lake Mary Jane										
Year*	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	WOST	BCNH	Total
2010	-	250	-	-	-	-	-	100	1	**351**
2011	-	200	-	-	-	-	-	200	-	400
2012	235	176	119	25	-	-	-	172	-	727
Total	**235**	**626**	119	25	-	-	-	**472**	**1**	**1,478**
Lake Kissimmee										
Year*	CAEG	GREG	WHIB	SNEG	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**
2012	645	250	156	39	87	-	-	-	-	**1,177**
Total	**1,935**	**899**	**1,927**	**114**	**271**	**42**	**87**	**10**	**3**	**5,288**
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
2012	75	175	-	-	75	-	-	-	-	325
Total	**559**	**700**	**160**	**-**	**195**	**-**	**-**	**-**	**-**	**1,614**

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 heron combined)
SMDH = small dark heron (little blue heron and tricolored heron combined)

*Surveys were conducted March–June 2004, March–June 2005, February–June 2006, May–July 2007, January–May 2008, February–April 2009, February–May 2010, February-May 2011, and March, April and June 2012.

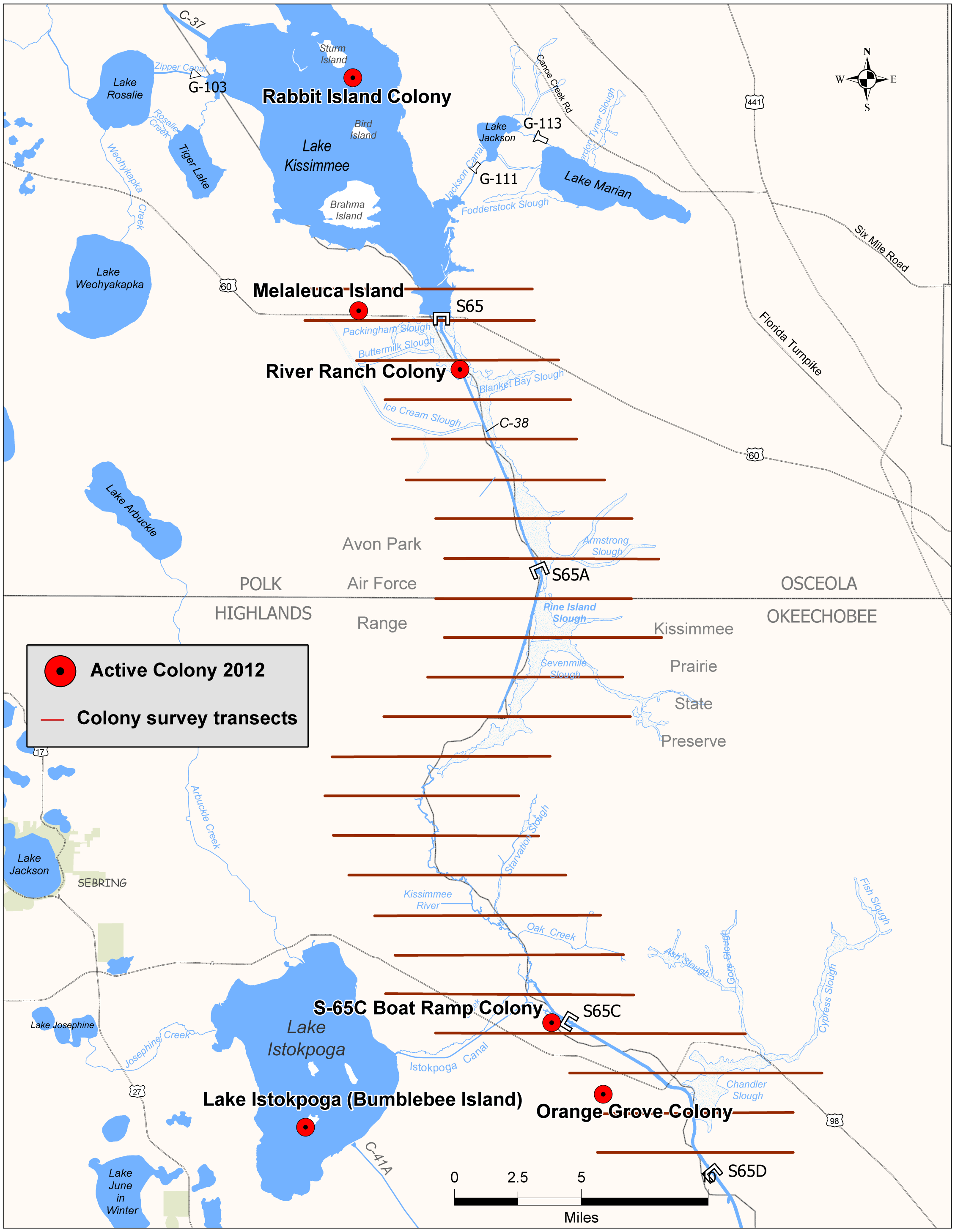


Figure 9-22. Aerial survey transect routes and nesting colony sites within the Kissimmee River floodplain and surrounding wetland-upland complex during 2012. The Lake Mary Jane colony (not shown) is approximately 30 miles to the north-northeast of Lake Kissimmee and 16 miles southeast of Orlando.

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 bird abundance. Prior to the restoration project, dry season abundance of long-legged wading birds in the Phase I restoration area averaged [(± standard error (S.E.)] 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 9-23**).

Mean monthly wading bird abundance within the restored portions of the river during the 2011–2012 season (44.4 birds/km^2) was more than double last year's estimate of 19.9 birds/km^2, bringing the three-year running average back above the restoration target of 30.6 birds/km^2. Wading bird numbers were low in November due to high water levels following the record-setting rainfall in October (see *Kissimmee Basin Hydrologic Conditions in Water Year 2012* section). Numbers gradually increased from December through March and were slightly above their respective monthly averages. The March abundance estimate was extremely high at over 105 birds/km^2, during which time a record-setting single foraging flock was observed consisting of at least 2,123 wading birds, with an additional 237 white pelicans (*Pelecanus erythrorhynchos*). This flock was the largest single congregation of waterbirds observed since restoration began in 2001. Wading bird abundance declined by roughly half in April to 46.8 birds/km^2 then dropped to only 2.1 birds/km^2, the lowest monthly abundance of wading birds recorded since restoration began, in May when the floodplain was essentially dry.

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

Table 9-7. Post-restoration abundance as three-year running averages (± S.E.) 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.

Period	Three-year Running Average ± S.E.
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
2010–2012	37.6 ± 9.0

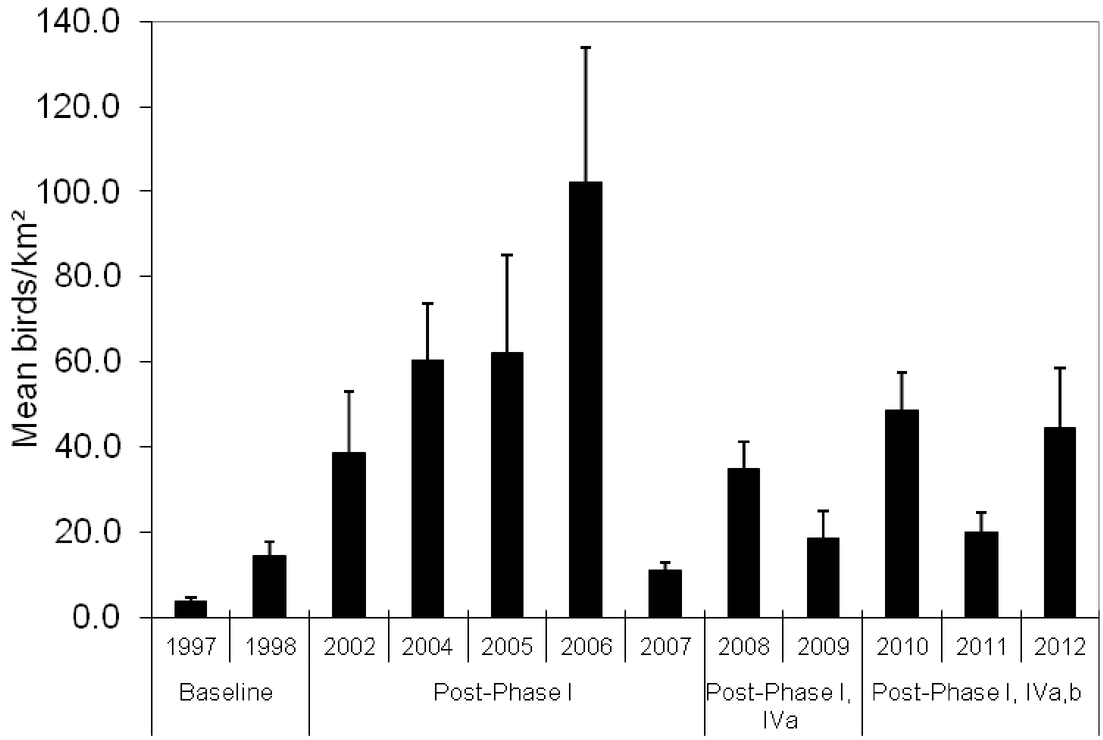


Figure 9-23. Baseline and post-Phases I, IVA, and IVB mean abundance ± S.E. of long-legged wading birds (excluding cattle egrets) per square kilometer (birds/km^2) during the dry season (December–May) within the 100-year floodline of the Kissimmee River.

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 (*A. crecca*), mottled duck (*A. fulvigula*), and hooded merganser (*Lophodytes cullulatus*), were detected during baseline aerial surveys. During the same period, casual observations of wood ducks (*Aix sponsa*) were made during ground surveys for other projects (SFWMD, 2005a). Mean annual abundance ± S.E. was 0.4 ± 0.1 ducks/km^2 in the Phase I area before restoration construction, well below the restoration expectation of 3.9 ducks/km^2. The three-year running average of waterfowl abundance has exceeded this expectation every year since restoration began in 2001 (**Table 9-8**, **Figure 9-24**). Waterfowl abundance during the 2011–2012 survey (13.6 ducks/km^2) was greater than the previous year's mean of 8.5 ducks/km^2, bringing the three-year running average well above the restoration target. Blue-winged teals dominated numerically, followed in order of abundance by green-winged teals, mottled ducks, and hooded mergansers.

Table 9-8. Post-restoration abundance as three-year running averages ± S.E. of waterfowl during the winter (November–March) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River.

Period	Three-year Running Average ± S.E.
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
2010–2012	10.0 ± 1.8

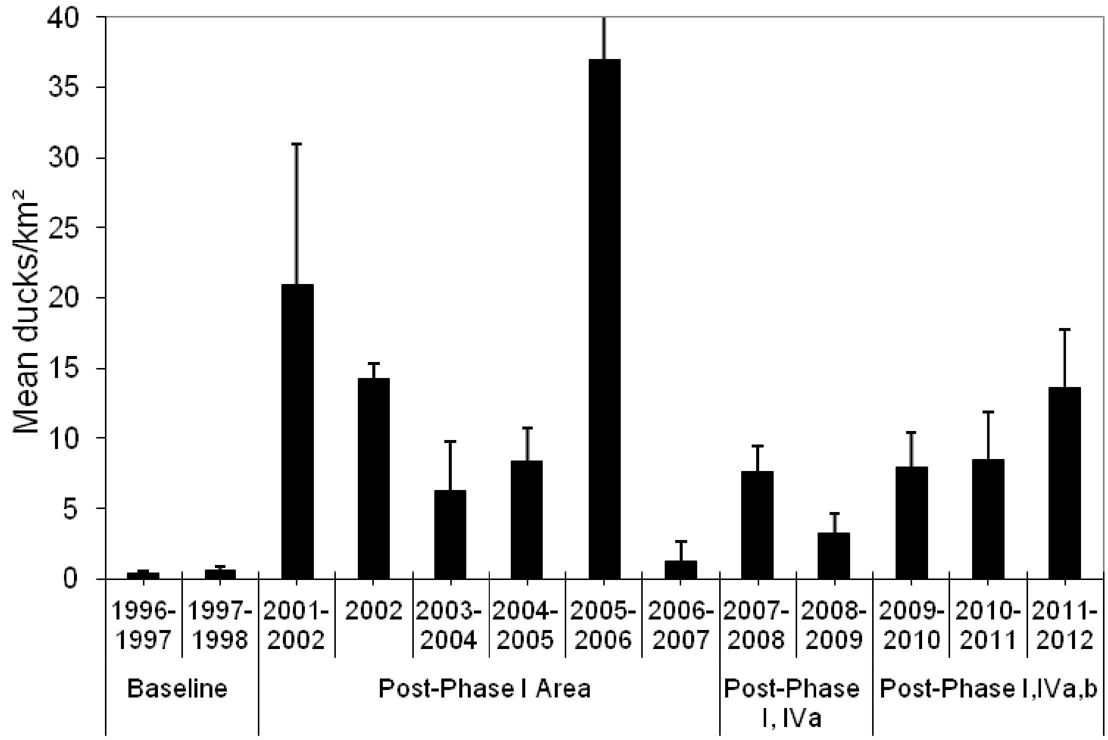


Figure 9-24. Baseline and post-Phases I, IVA, and IVB mean abundance ± S.E. of waterfowl [ducks per square kilometer (ducks/km^2)] during winter (November–March) within the 100-year floodline of the Kissimmee River. Baseline abundance was measured in the Phase I area prior to restoration. Measurement of post-restoration abundance began approximately nine months following completion of Phase I.

The American wigeon (*Anas americana*), northern pintail (*A. acuta*), northern shoveler (*A. 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. 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 since restoration began in 2001.

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 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 30 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 the operational component of the KRRP. It has produced the following products:

- 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 local and regional considerations that must be resolved before a drawdown is implemented
- Extensive public outreach and involvement at the federal, state, local, and individual stakeholder level

The study is expected to be completed by the end of 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 AND KISSIMMEE UPPER BASIN MONITORING AND ASSESSMENT PROJECT

The KCOL and Kissimmee Upper Basin Monitoring and Assessment Project, initiated in October 2010, addresses deficiencies in ecological data identified over the past 10 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 KBMOS. The project scope has been reduced due to fiscal constraints, but still includes numerous important deliverables for KCOL and C&SF Project water bodies: (1) updated bathymetric maps and stage-area-volume tables, (2) littoral vegetation maps, (3) a hydroperiod tool that uses topographic survey data to measure and analyze depth and duration of inundation in lake littoral zones, and (4) nutrient budgets for each lake basin and sub-basin. To date, littoral vegetation mapping has been completed for all 19 C&SF water bodies and bathymetric mapping is complete for 17 of them. Hydroperiod tool implementation is ongoing with the pilot set of lakes nearing completion.

To support the nutrient reduction plan for Lake Tohopekaliga (Camp Dresser & McKee, 2011), hydrologic, chloride, phosphorus, and nitrogen budgets were developed (James, 2012). These budgets indicate that the major tributaries – Shingle Creek and C-31 (St. Cloud Canal) – contribute just 36 percent of the lake inflow. Unmonitored minor tributaries and direct rainfall contribute 47 and 17 percent, respectively (**Figure 9-25a**). The outlet at S-61 accounts for 68 percent of the water output, while evaporation and seepage make up another 19 and 13 percent (**Figure 9-25b**). The minor tributaries contribute 61 percent of the TP load compared to 35 percent for the major tributaries (**Figure 9-25c**). The lake's outlet removes 72 percent of the TP lost from the lake, while settling and seepage each make up 14 percent removed (**Figure 9-25d**).

Based on the large contribution from the minor tributaries, which drain watersheds close to the lakeshore, it is reasonable to assume that Best Management Practices (BMPs) and other local control measures will have significant effects toward reducing nutrient loads to the lake. Such improvements have been observed in the S-154 sub-basin, a small watershed close to Lake Okeechobee, in which BMPs have been implemented intensively (Zhang et al., 2011). Because the turnover time for Lake Tohopekaliga is short (about 6 months), any load reductions should result in noticeable and rapid improvement of the lake's water quality.

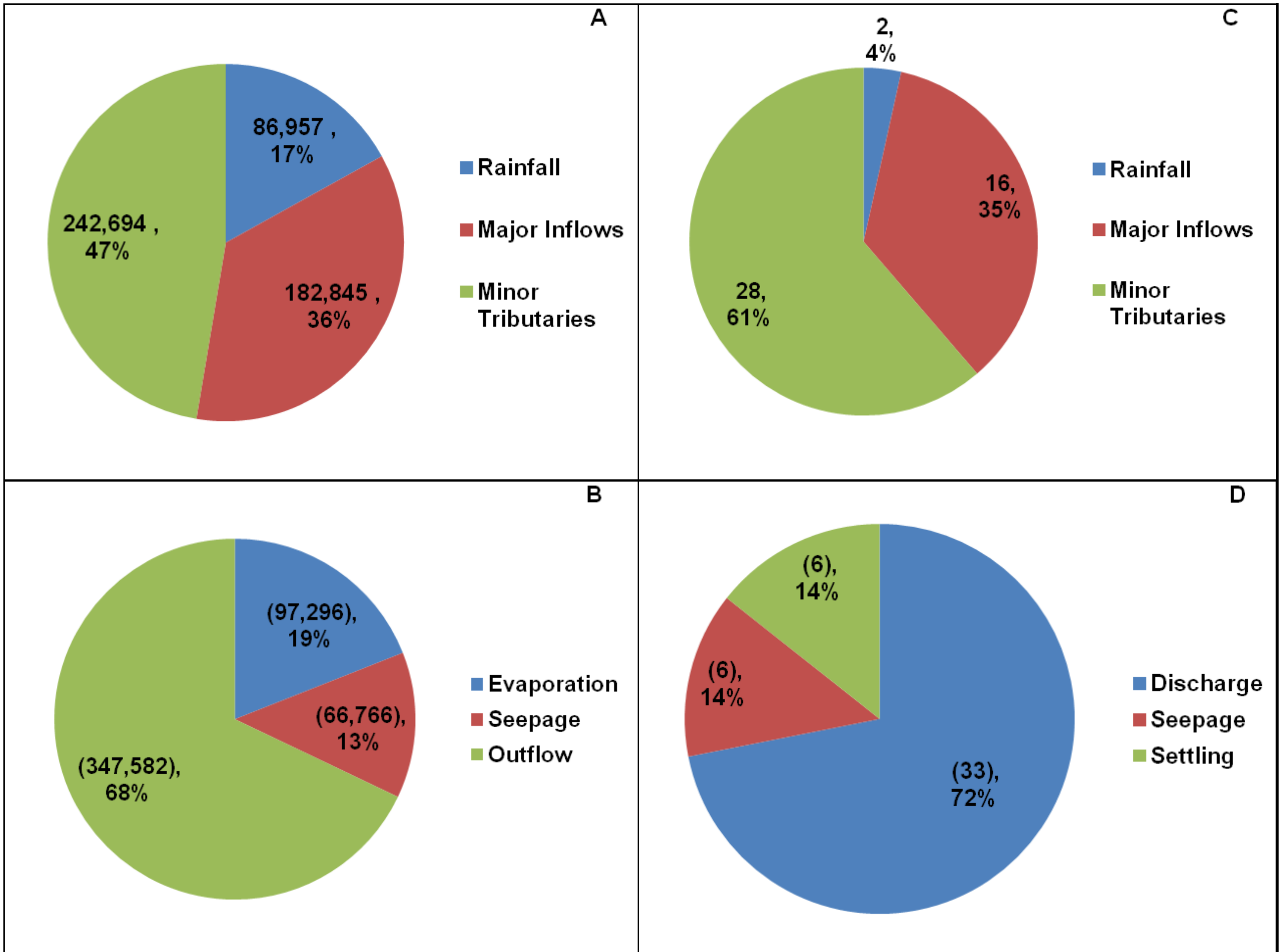


Figure 9-25. Water (A) inflows and (B) outflows (in acre-feet), and total phosphorus (C) inputs and (D) outputs (in metric tons) for Lake Tohopekaliga averaged over calendar years 1996–2011.

THREE LAKES WILDLIFE MANAGEMENT AREA RESTORATION

The Three Lakes Wildlife Management Area Hydrologic Restoration Project is a joint initiative between the SFWMD and the Florida Fish and Wildlife Conservation Commission (FWC) to restore wetlands and historical flow patterns to the Three Lakes Wildlife Management Area. This wildlife management area is located in the Upper Kissimmee Basin, just north of the S-65 water control structure, on the east side of Lake Kissimmee near Lake Marian (**Figure 9-26**). 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 9-26. 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.

Phases 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 this structure was rendered "inactive" in 2007 by the USACE. Phase IV, construction of the replacement G-113 structure, is scheduled for completion by September 2012. No additional work toward restoration of Fodderstack Slough is expected in the near future.

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