Chapter 2: South Florida Hydrology and Water Management

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SUMMARY

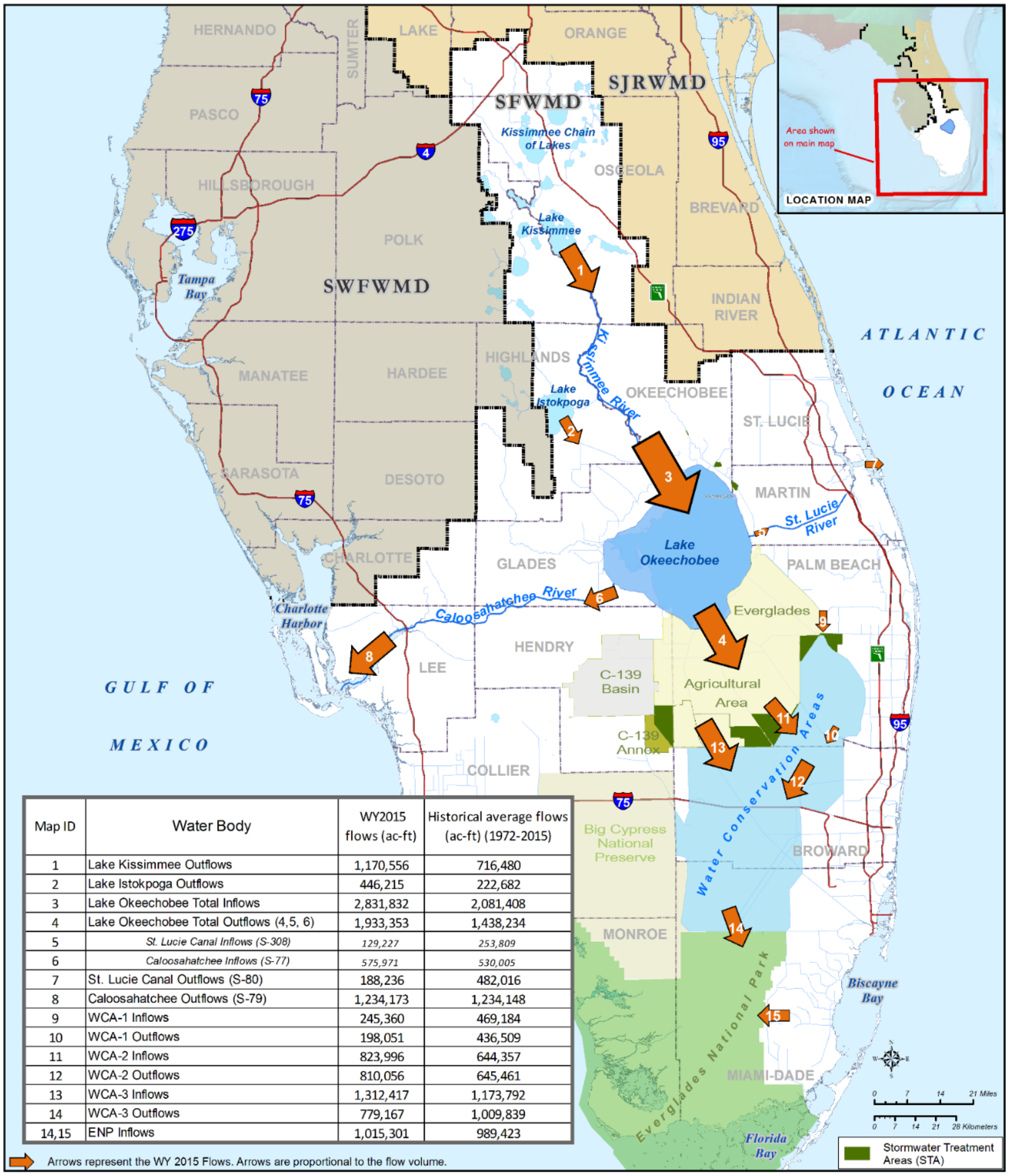
Given hydrology's significance to the entire South Florida ecosystem and all aspects of regional water management, this chapter presents hydrologic data and analysis for Water Year 2015 (WY2015) (May 1, 2014–April 30, 2015). Similar information from previous water years is available in Chapter 2 of the respective *South Florida Environmental Report* (SFER) – *Volume I.* This year's chapter includes a brief overview of the regional water management system, hydrologic impact of WY2015 tropical systems, two major rainfall events in August 2014 and February 2015, WY2015 hydrology of several subregions and major hydrologic units within the South Florida Water Management District (SFWMD or District) boundaries. Appendices 2-1 through 2-6 of this volume provide supplementary information for this chapter. The broad influences of water year hydrology on various aspects of the regionwide system are covered in most other Volume I chapters. The El Niño-Southern Oscillation (ENSO) climatic phenomenon is linked to South Florida hydrology. The last quarter of 2014 showed warming sea surface temperature (SST) of the tropical Pacific west of Peru and the warming continued into 2015 increasing the chance of El Niño for 2015.

Although the WY2015 District areal average rainfall of 51.09 inches is only 1.66 inches below the historical average, there was high spatial variation. The year was both a wet and a dry year depending upon the region of the District. Generally, the northern part of the District was wetter and the southern part was drier. Upper Kissimmee (+6.71 inches) and Lower Kissimmee (+12.99 inches) were very wet followed by Lake Okeechobee (+1.98 inches), which was wetter than average. Martin/St. Lucie rain area had average rainfall (+0.08 inches). But, the rest of the District and Everglades National Park (ENP) were drier than normal with some areas extremely dry: ENP (-10.54 inches), East Everglades Agricultural Area (-8.84 inches), Palm Beach (-7.27 inches), Water Conservation Area 3 (WCA-3) (-5.68 inches), East Caloosahatchee (-5.14 inches), West Everglades Agricultural Area (-4.89 inches), Big Cypress Basin (-3.98 inches), WCA-1 and WCA-2 (-3.53 inches), Southwest Coast (-3.3 inches), Broward (-3.04 inches), and Miami-Dade (-2.28 inches). The drought continued into summer 2015 in the southeast and ENP.

Lake Okeechobee—the main storage of the regional water management system—was at a stage of 13.05 feet (ft) National Geodetic Vertical Datum of 1929 (ft NGVD29) on May 1, 2014. The lake stage reached the minimum of 12.3 ft NGVD29 on June 11, 2014, and started rising to the water year maximum stage of 16.01 ft NGVD29 by October 22, 2014, due to wet conditions in the watershed. The lake stage followed a gradual decline through the dry season with some reversal, reaching 13.87 ft NGVD29 by the end of WY2015. During WY2015, there was no concern of water supply from Lake Okeechobee.

[1] **Acknowledgments:** The authors acknowledge Luis Cadavid's contribution in providing regular and temporary regulation schedules and Lake Okeechobee water management decisions.

Figure 2-1 presents WY2015 surface water flows for major hydrologic components in the regional system, along with historical average flows shown for comparison. **Table 2-1** compares WY2015 flows to the last water year's flows and historical average flows. Generally, inflows and outflows in the northern part of the District were well above the historical average. WY2015 flows were lower than WY2014 except for outflows from Lake Kissimmee and Lake Istokpoga, and inflows to Lake Okeechobee and WCA-3.



Map ID	Water Body	WY2015 flows (ac-ft)	Historical average flows (ac-ft) (1972-2015)
1	Lake Kissimmee Outflows	1,170,556	716,480
2	Lake Istokpoga Outflows	446,215	222,682
3	Lake Okeechobee Total Inflows	2,831,832	2,081,408
4	Lake Okeechobee Total Outflows (4,5, 6)	1,933,353	1,438,234
5	*St. Lucie Canal Inflows (S-308)*	*129,227*	*253,809*
6	*Caloosahatchee Inflows (S-77)*	*575,971*	*530,005*
7	St. Lucie Canal Outflows (S-80)	188,236	482,016
8	Caloosahatchee Outflows (S-79)	1,234,173	1,234,148
9	WCA-1 Inflows	245,360	469,184
10	WCA-1 Outflows	198,051	436,509
11	WCA-2 Inflows	823,996	644,357
12	WCA-2 Outflows	810,056	645,461
13	WCA-3 Inflows	1,312,417	1,173,792
14	WCA-3 Outflows	779,167	1,009,839
14,15	ENP Inflows	1,015,301	989,423

Figure 2-1. WY2015 and historical average inflow and outflow (in acre-feet, or ac-ft) into major hydrologic units of the regional water management system. [Note: The three arrows depicted from Lake Okeechobee represent lake outflows in inset].

Table 2-1. Summary of flows for WY2015, the percent of historical average they represent, and their comparison to WY2014. [Note: Structures used to calculate inflows and outflows into the major hydrological units are presented in Appendix 2-5 of this volume.]

Location	WY2015 total flow (ac-ft)	Percent of Historical Average	WY2014 Total Flow (ac-ft)
Northern Everglades			
Lake Kissimmee Outflows	1,170,556	163	765,563
Lake Istokpoga Outflows	446,215	200	319,317
Lake Okeechobee Inflows	2,831,832	134	2,695,257
Lake Okeechobee Outflows	1,933,353	134	2,527,633
Flows into St. Lucie Canal from Lake Okeechobee	129,227	51	444,651
Flows into St. Lucie Estuary through St. Lucie Canal	188,236	39	675,722
Lake Okeechobee Releases to St. Lucie Estuary [a]	80,250		418,559
C-44 basin runoff into St. Lucie Estuary [a]	107,986		257,154
Flows into Caloosahatchee Canal from Lake Okeechobee	575,971	109	1,225,613
Flows into Caloosahatchee Estuary through Caloosahatchee Canal	1,234,173	100	2,521,600
Lake Okeechobee Releases to Caloosahatchee Estuary[a]	486,598		1,146,488
Basin runoff into Caloosahatchee Estuary [a]	747,575		1,377,052
Southern Everglades			
Water Conservation Area 1 Inflows	245,360	52	380,269
Water Conservation Area 1 Outflows	198,051	45	471,206
Water Conservation Area 2 Inflows	823,997	128	1,078,408
Water Conservation Area 2 Outflows	810,056	126	965,358
Water Conservation Area 3 Inflows	1,312,417	112	1,248,362
Water Conservation Area 3 Outflows	779,167	78	1,452,583
Everglades National Park Inflows	1,015,301	103	1,590,971

a. calculated

INTRODUCTION

THE SOUTH FLORIDA WATER MANAGEMENT SYSTEM: A REGIONAL OVERVIEW

The ecological and physical characteristics of South Florida have been shaped by years of hydrologic variation—ranging from extreme drought to flood, sometimes within a relatively short time period. The regional hydrology is driven by rainfall, rainfall-generated runoff, groundwater recharge and discharge, and evapotranspiration. Surface water runoff is the source for direct and indirect recharge of groundwater, lake and impoundment storage, and replenishments of wetlands. Excess surface water is discharged to the peninsula's coasts. Most of the municipal water supply is from groundwater that is sensitive to surface recharge through direct rainfall, runoff, or canal recharge. The general hydraulic gradient is north-to-south, where excess surface water flows from the Upper Kissimmee Basin in the north to the Everglades in the south, with water supply and coastal discharges to the east and west. The current hydraulic and hydrologic system includes lakes, impoundments, wetlands, canals, and water control structures managed under water management schedules and operational rules.

The development of South Florida requires a complex water management system to manage floods, droughts, and hurricane impacts. Excess water is stored in lakes, detention ponds, wetlands, impoundments, and aquifers, or is discharged to the coast to estuaries and the ocean. Information regarding the operation of the South Florida water management system is summarized in Abtew et al. (2011). As a major component of this system, Lake Okeechobee's storage capacity is over 3.54 million acre-feet (ac-ft) at an average lake level of 14.02 ft NGVD29—the largest of any hydrologic feature in South Florida. The lake is critical for flood control during wet seasons and water supply during dry seasons. Lake outflows are received by the Everglades Agricultural Area (EAA), St. Lucie River and Estuary, Caloosahatchee River and Estuary, and sometimes the Everglades Stormwater Treatment Areas (STAs). In drought conditions, some water is sent south for water supply. Further details of these subregional flows are presented in the *Water Levels and Flows* section of this chapter.

Over an 18,000 square mile area, the District manages the region's water resources for flood control, water supply, water quality, and natural systems' needs under water management schedules based on specific criteria. The major hydrologic components are the Upper Kissimmee Chain of Lakes, Lake Istokpoga, Lake Okeechobee, EAA, Caloosahatchee and St. Lucie River basins, Upper East Coast (UEC), Lower East Coast (LEC), WCAs, Lower West Coast (LWC), and ENP. The Kissimmee Chain of Lakes (Lake Myrtle, Alligator Lake, Lake Mary Jane, Lake Gentry, Lake East Tohopekaliga, Lake Tohopekaliga, and Lake Kissimmee) is a principal source of inflow to Lake Okeechobee. Various groundwater aquifers are part of the water resources, with most of their water levels responding relatively quickly to changes in rainfall and surface water conditions.

Generally, the region is wet with an average annual rainfall of 53 inches. For water management purposes, the District has divided the region into 14 rainfall areas plus ENP (**Figure 2-2**). Rainfall for each area is reported daily, and multiple and overlapping gauges are used to compute average rainfall over each area. Real-time rainfall observations over the rainfall areas aid real-time water management decisions. Due to the relatively low gradient of regional topography, pumping is necessary to move water in the system. Across the region, the average pumping volume for Fiscal Years (October 1–September 30) 1995-1996 through 2013-2014 was 2.89 million ac-ft (**Table 2-2**). Fiscal Year 2013-2014 pumping was 3,445,573 ac-ft. In many cases, the same water is pumped in and out, as is the case with most of the Everglades STAs. The number of pump stations has increased from 20 to over 70 since 1996, with additional temporary pumps that vary in number from time to time. Some pumps are installed but not yet certified/registered and fully operational.

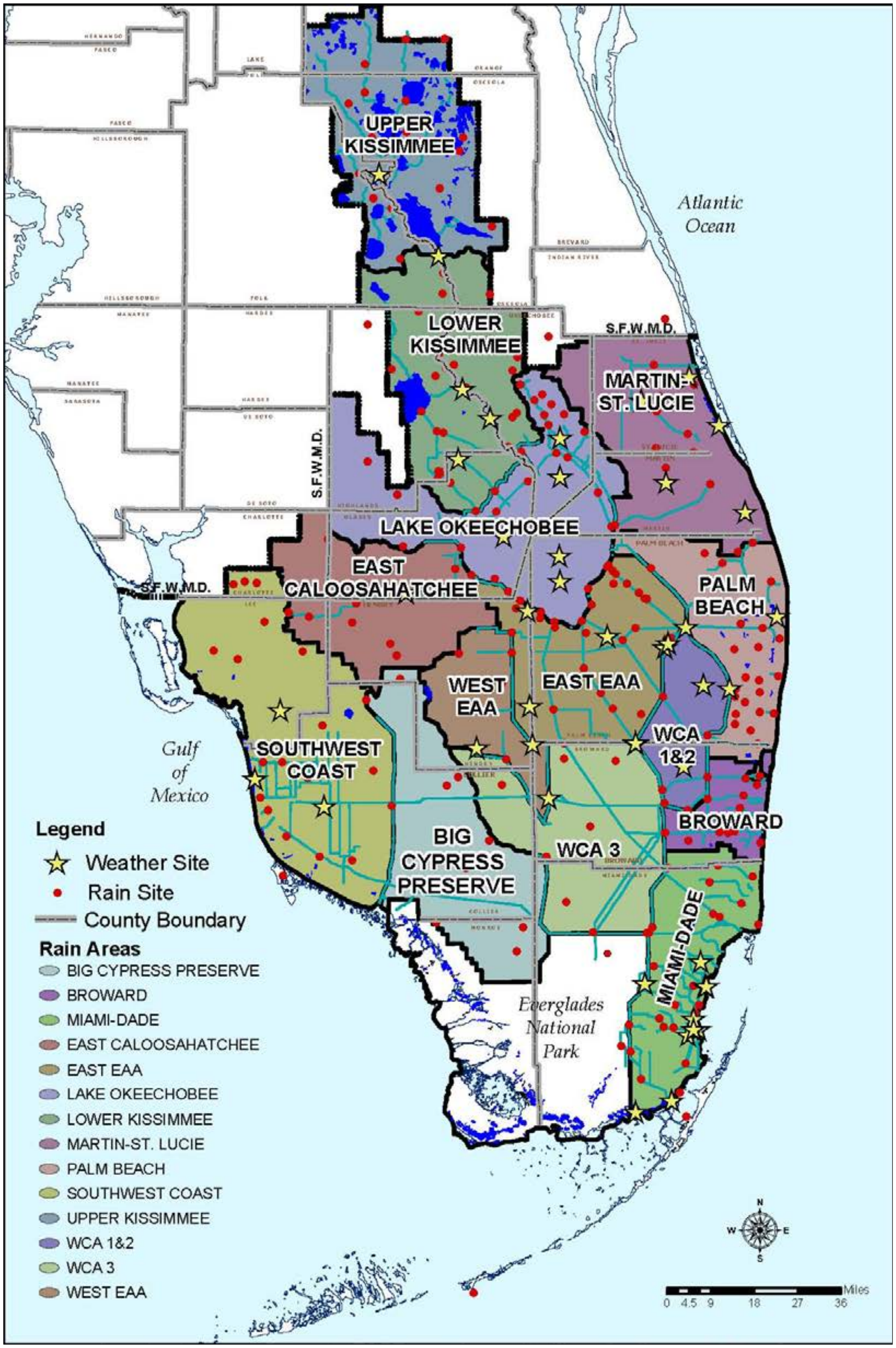


Figure 2-2. SFWMD rainfall areas.

Table 2-2. SFWMD water pumping volumes for Fiscal Year 1995-1996 through Fiscal Year 2013-2014.

Fiscal Year	Volume of Water Pumped (ac-ft)
1995-1996	2,480,000
1996-1997	1,840,000
1997-1998	2,020,000
1998-1999	2,090,000
1999-2000	2,517,000
2000-2001	2,131,000
2001-2002	3,131,000
2002-2003	3,339,000
2003-2004	3,404,000
2004-2005	3,938,000
2005-2006	3,583,000
2006-2007	1,281,000
2007-2008	3,767,700
2008-2009	3,660,000
2009-2010	3,031,622
2010-2011	1,584,057
2011-2012	3,254,308
2012-2013	4,419,510
2013-2014	3,445,573
Average	**2,890,356**

STORAGE OF LAKES AND IMPOUNDMENTS

Storage is required for both flood control and water supply in the regional water management system. The amount of storage volume available varies significantly from year to year due to large variations in rainfall and runoff both temporally and spatially. The impact of variation in rainfall amount and timing is reduced by managing available storage. Regulation schedules provide guidance for water level/storage management of lakes and impoundments. The regulation schedule for each water body is covered in the following sections where WY2015 water levels are discussed. Temporary modifications from normal regulation schedules for WY2015 are also presented if any. Regulation schedule deviations include environmental needs, such as Everglade snail kite (*Rostrhamus sociabilis plumbeus*) needs, and construction and maintenance activities.

The combined average storage of the major lakes and impoundments is over 5.2 million ac-ft; Lake Okeechobee provides about 68 percent of this storage volume. During wet conditions and high flow periods, storage between the actual stage and maximum regulatory stage is limited and water has to be released. The successful operation of the system depends on timely water management decisions and the constant movement of water. Excess water is mainly discharged to the Gulf of Mexico, St. Lucie Estuary, Atlantic Ocean, and Florida Bay. Stage-storage relationships of lakes and impoundments are critical information for managing water levels and storage and computing average hydraulic residence time. Appendix 2-2 in the 2007 SFER – Volume I (Abtew et al. 2007a) presents the compiled charts for stage-storage for the major lakes and impoundments and stage-area relationships where data are available.

SELECTED HYDROLOGIC COMPONENTS

During WY2015, the northern part of the District received above average rainfall and the southern part received below average rainfall. Conceptual descriptions of these areas are summarized in this section, while specific hydrology and structure flow information for each is presented in the *Water Management in Water Year 2015* section of this chapter.

Upper and Lower Kissimmee Basins

The Upper Kissimmee Basin comprises the Kissimmee Chain of Lakes with a drainage area of 1,596 square miles (Guardo 1992). Historically, the Kissimmee Chain of Lakes is hydraulically connected to the Kissimmee River; during the wet season, the lakes overflow into surrounding marshes and then into the river (Williams et al. 2007). Water from the Upper Kissimmee Basin is discharged into the Lower Kissimmee Basin as the outflow of Lake Kissimmee. The Lower Kissimmee Basin has a drainage area of 727 square miles (Abtew 1992). Flows are through the restored segments of the Kissimmee River and C-38 canal. Along the reaches of the river, there are four water control structures (S-65A, S-65C, S-65D, and S-65E) that regulate the river stage. At the terminal of the Kissimmee River, discharge from the S-65E structure flows into Lake Okeechobee as the main source of inflows to the lake. Overall, the Kissimmee Basin is an integrated system consisting of several lakes with interconnecting canals and flow control structures (see also Chapter 9 of this volume).

Lake Okeechobee

Lake Okeechobee is the largest lake in the southeastern United States. It is relatively shallow with an average depth of 8.9 ft and surface area of 436,300 acres at the average water surface elevation of 14.02 ft NGVD29. Water levels are regulated through numerous water control structures operated according to a seasonally varying regulation schedule. The lake serves multiple functions for flood control, water supply, recreation, and environmental restoration efforts. Chapter 8 of this volume discusses the status of Lake Okeechobee.

Everglades Agricultural Area

The EAA is an agricultural irrigation and drainage basin where, generally, ground elevation is lower than the surrounding area. During excess rainfall, runoff has to be pumped out of the area; during dry times, irrigation water supply is needed. Irrigation water supply during dry seasons comes mainly from Lake Okeechobee, with the WCAs as secondary sources. On average, about 900,000 ac-ft of water is discharged from and through the EAA to the south and southeast, historically mostly discharging into the Everglades Protection Area (EPA) (Abtew and Khanal 1994, Abtew and Obeysekera 1996). Four primary canals (Hillsboro Canal, North New River Canal, Miami Canal, and West Palm Beach Canal) and three connecting canals (Bolles Canal, Cross Canal, and Ocean Canal) facilitate runoff removal and irrigation water supply. Currently, runoff/drainage from the EAA is discharged to the Everglades STAs for treatment and released to the EPA. Additional information on the EAA and Everglades STAs is presented in Chapters 4 and 5B of this volume, respectively.

Upper East Coast

The main canal in the UEC is the St. Lucie River (C-44 Canal). It runs from Lake Okeechobee to the St. Lucie Estuary. Inflows to the St. Lucie River are runoff from the basin and releases from Lake Okeechobee by operation of the S-308 structure according to regulation procedures described by the United States Army Corps of Engineers (USACE) (2008). Downstream of S-308 is a gated spillway, S-80, that also receives inflows from the local watershed to the west and discharges to the estuary. The C-23 canal discharges into the North Fork of the St. Lucie River at structure S-48. The C-24 canal discharges into the same fork at S-49. The C-25 canal discharges into the southern part of the Indian River Lagoon at structure S-50.

Lower East Coast

The LEC includes urban areas in Palm Beach, Broward, and Miami-Dade counties. The purposes of the major canals in the LEC are flood control, prevention of overdrainage in the area, water supply, prevention of saltwater intrusion into groundwater, and conveyance of runoff to ENP when available. The system is also intended to improve water supply and distribution to ENP. It was designed to supply water during a 10-year drought and deliver minimum water needs to Taylor Slough and the C-2, C-4, C-1, C-102, C-103, and C-113 basins. The stages in canals are usually allowed to recede before supplemental water is introduced. Flow releases during major flood events are made according to established guidelines (USACE 1995). Lake Okeechobee is connected to the LEC through the major canals. During dry periods, flows from the WCAs and Lake Okeechobee are released to raise canal and groundwater levels. During wet periods, the canal network is used to move runoff to the ocean as quickly as possible.

Lower West Coast

The main canal in the LWC is the Caloosahatchee River (C-43 Canal). It runs from Lake Okeechobee to the Caloosahatchee Estuary. Inflows to the Caloosahatchee River are runoff from the basin and releases from Lake Okeechobee by operation of the S-77 structure according to regulation procedures described by USACE (2008). Downstream of S-77 is a gated spillway, S-78, that also receives inflows from the local watershed. The outflow from the Caloosahatchee River (downstream of S-78) is discharged into the estuary via S-79, a gated spillway and lock operated by USACE. The operations of S-79 include managing stormwater runoff from the Caloosahatchee Watershed. The LWC includes large areas outside the drainage basin of the Caloosahatchee River.

WATER YEAR 2015 EXTREME RAINFALL EVENTS

AUGUST 4, 2014, AND FEBRUARY 28, 2015, HEAVY RAINFALL EVENTS

According to the Weather Channel, more than 6.5 inches of rainfall fell in about 5 hours on the city of Naples on August 4, 2014 (**Figure 2-3**). It was a record wet day for Naples in 29 years. The heaviest rain was 3.94 inches in an hour at Naples airport between 12:53 to 1:53 pm. Road flooding and stalled cars were reported. The District area received over 1 inch of rainfall on that day. As a result of a front that stalled on South Florida, February 28, 2015, was another 1-inch rainfall day, with high rainfall causing flooding in some locations. According to the National Weather Service, the stalled front drenched eastern and southern Palm Beach and Broward counties (**Figure 2-4**). Areas that had high rainfall were Stuart (9.6 inches), Pembroke Pine in Broward (8.84 inches), Jupiter (7.07 inches), Royal Palm Beach (5.92 inches), and Boca Raton (5.66 inches).

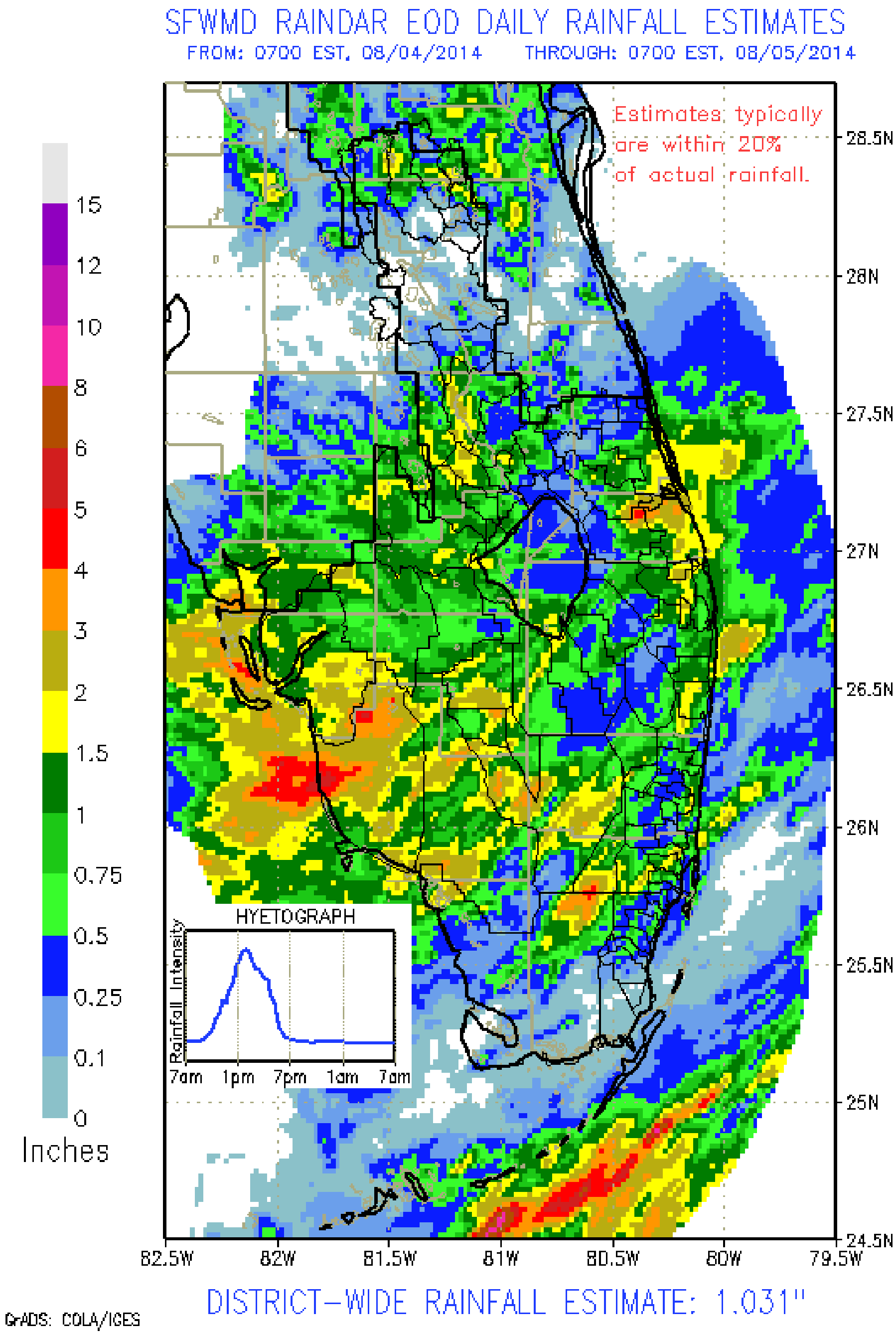


Figure 2-3. August 4, 2014, high rainfall event in Naples.

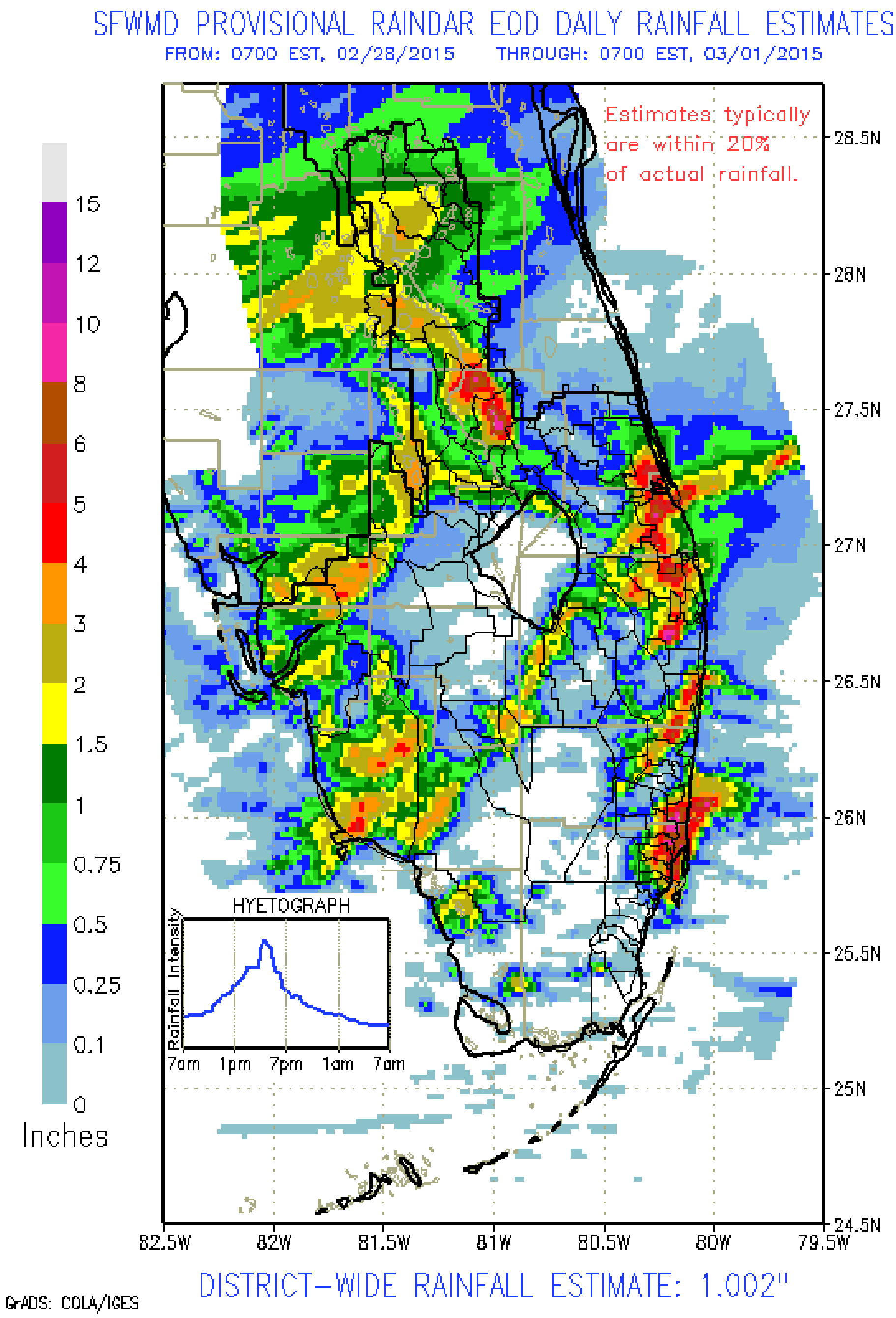


Figure 2-4. February 28, 2015, high rainfall event in South Florida.

WATER YEAR 2015 HURRICANE SEASON

WY2015 (2014 hurricane season) Atlantic, Gulf of Mexico, and Caribbean tropical activities were quieter with total number of events at the lower end of the prediction. A total of eight named storms occurred with six hurricanes, with two becoming major hurricanes reaching category three status (**Figure 2-5**). In May 2014, the National Oceanic and Atmospheric Administration's prediction was a 70 percent chance of eight to 13 named storms with three to six becoming hurricanes, including one to two major hurricanes (http://www.noaanews.noaa.gov/stories2014/20140522_hurricaneoutlook_atlantic.html). On the average, the number of named storms is 12 with six hurricanes, including three major hurricanes based on data from 1981 to 2010. The reduced number of forecasted storms was based on projected development of El Niño, which causes wind shear that reduces the intensity and number of storms. According to the National Oceanic and Atmospheric Administration, a combination of atmospheric conditions as strong vertical wind shear, increased atmospheric stability, stronger sinking motion, and drier air across the Atlantic helped reduce the number of storms. Sahara dust over tropical regions and a dome of high pressure over the western Atlantic (Bermuda High) was credited for the quieter season and the favorable path of hurricanes, turning north before reaching the coast (Sun Sentinel, November 21, 2014).

A tropical system related rainfall contribution was from a named storm, Hurricane Arthur (July 1–5, 2014). Hurricane Arthur started just east of South Florida as a tropical storm on July 1. By July 3, it strengthened to a hurricane and grazed the North Carolina coast and made landfall in Nova Scotia, Canada (**Figure 2-5**). It contributed some rainfall to South Florida on July 1–2 (**Figure 2-6**).

Late in the hurricane season, a tropical system from the Pacific crossed into the Gulf of Mexico as a disturbance and contributed to South Florida rainfall in conjunction with a dry cold front. On October 17, 2014, a tropical depression that developed near the coast of southern Mexico made landfall as Tropical Storm Trudy southeast of Marquelia, Mexico on October 18, 2014. The remnants of this storm moved to the east to the Gulf of Mexico as Depression Nine on October 21 over the Bay of Campeche and later became Tropical Storm Hanna (Brown 2014). Although the disturbance was very far from South Florida, the moisture bands extended over 1,000 miles and collided with a nor'easter off the coast of New Jersey and New York, with the impact reaching South Florida. Extreme rainfall and urban street flooding occurred on October 21 in Palm Beach County, with the rest of South Florida getting varying amount of rain (The Sun Sentinel, The Palm Beach Post, The Miami Herald, October 22, 2014). **Figure 2-7** depicts rainfall contribution from the system.

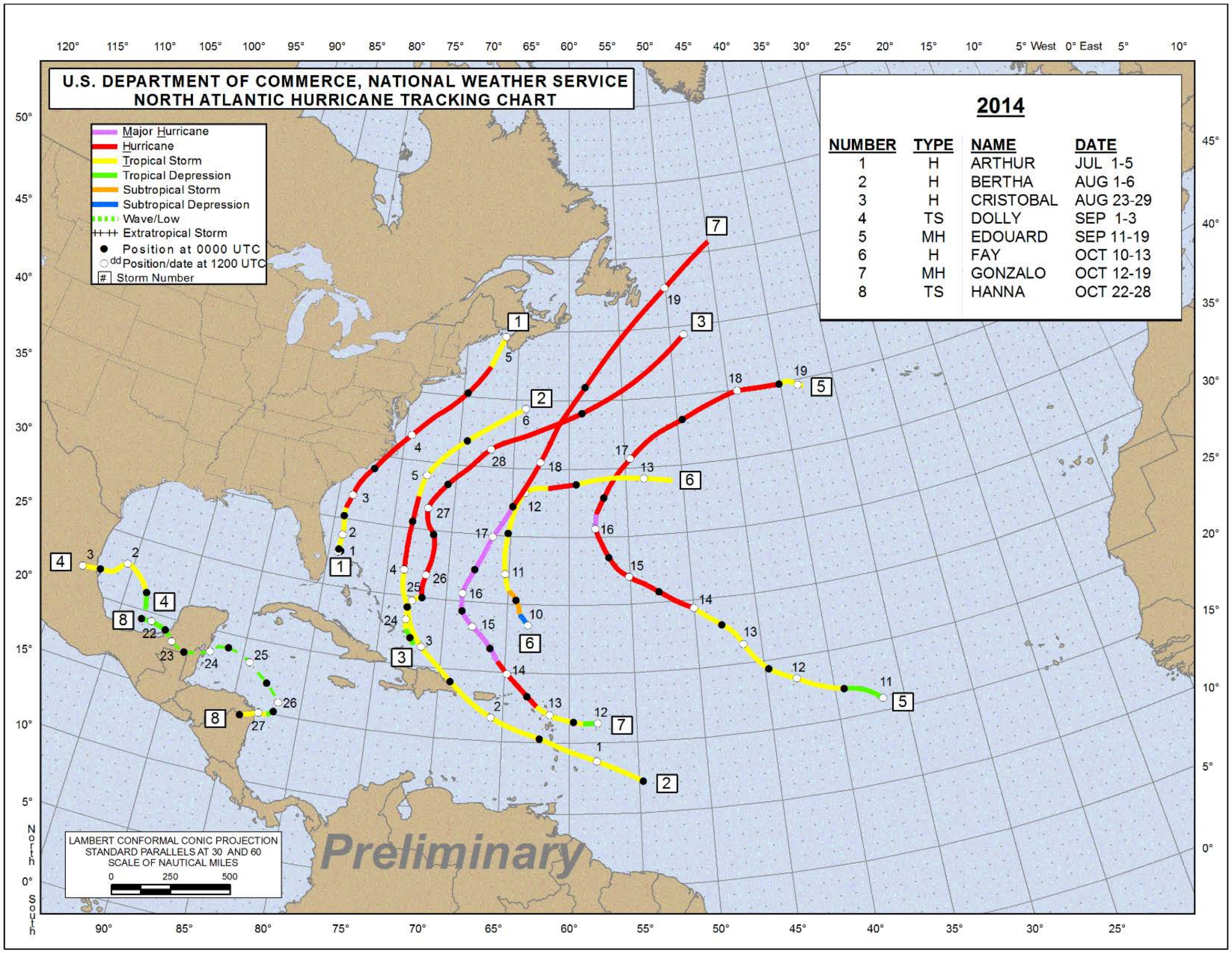


Figure 2-5. 2014 tropical systems tracks and durations (http://www.nhc.noaa.gov/tafb_latest/tws_atl_latest.gif).

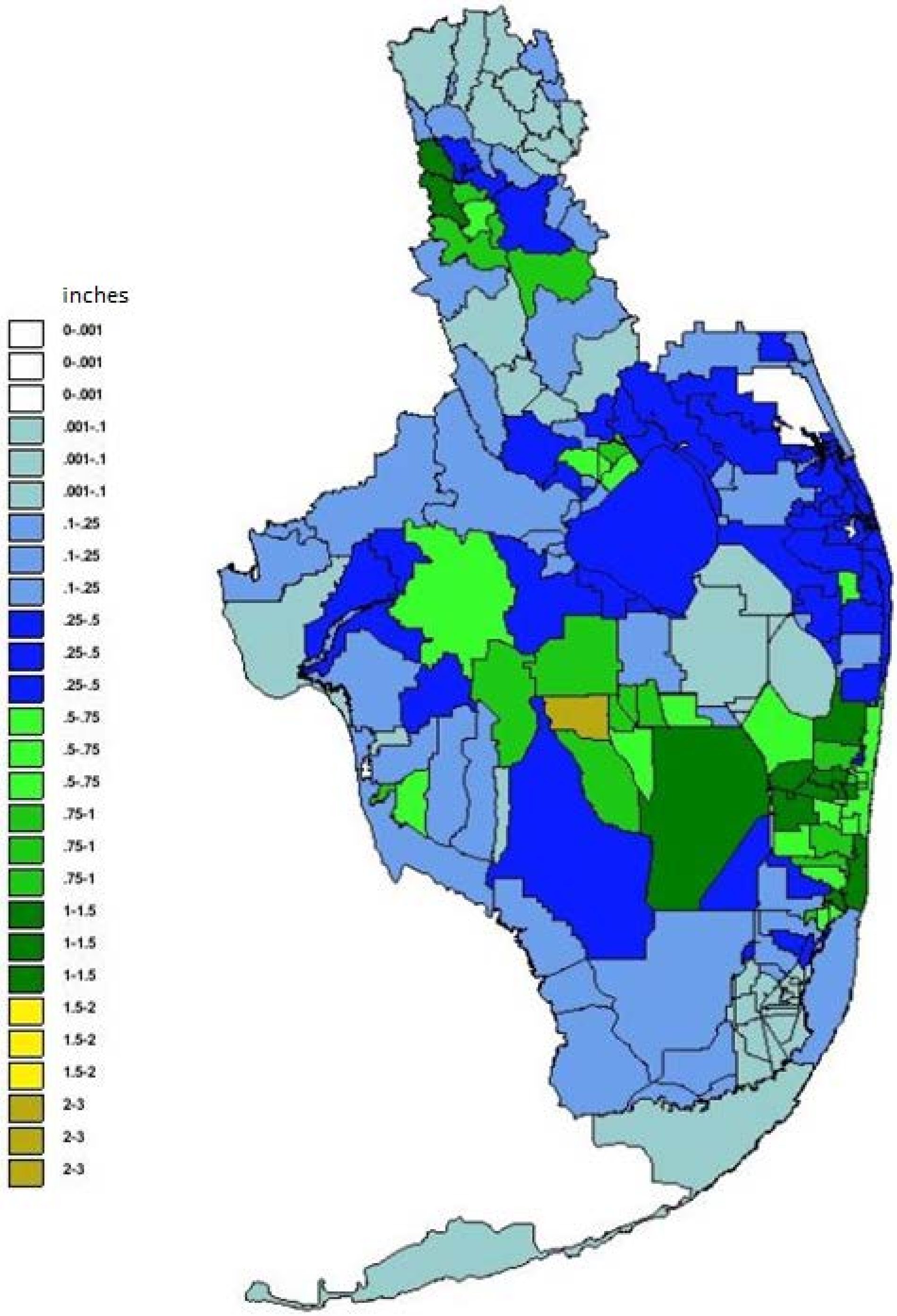


Figure 2-6. Hurricane Arthur related Raindar rainfall estimate from July 1–3, 2014.

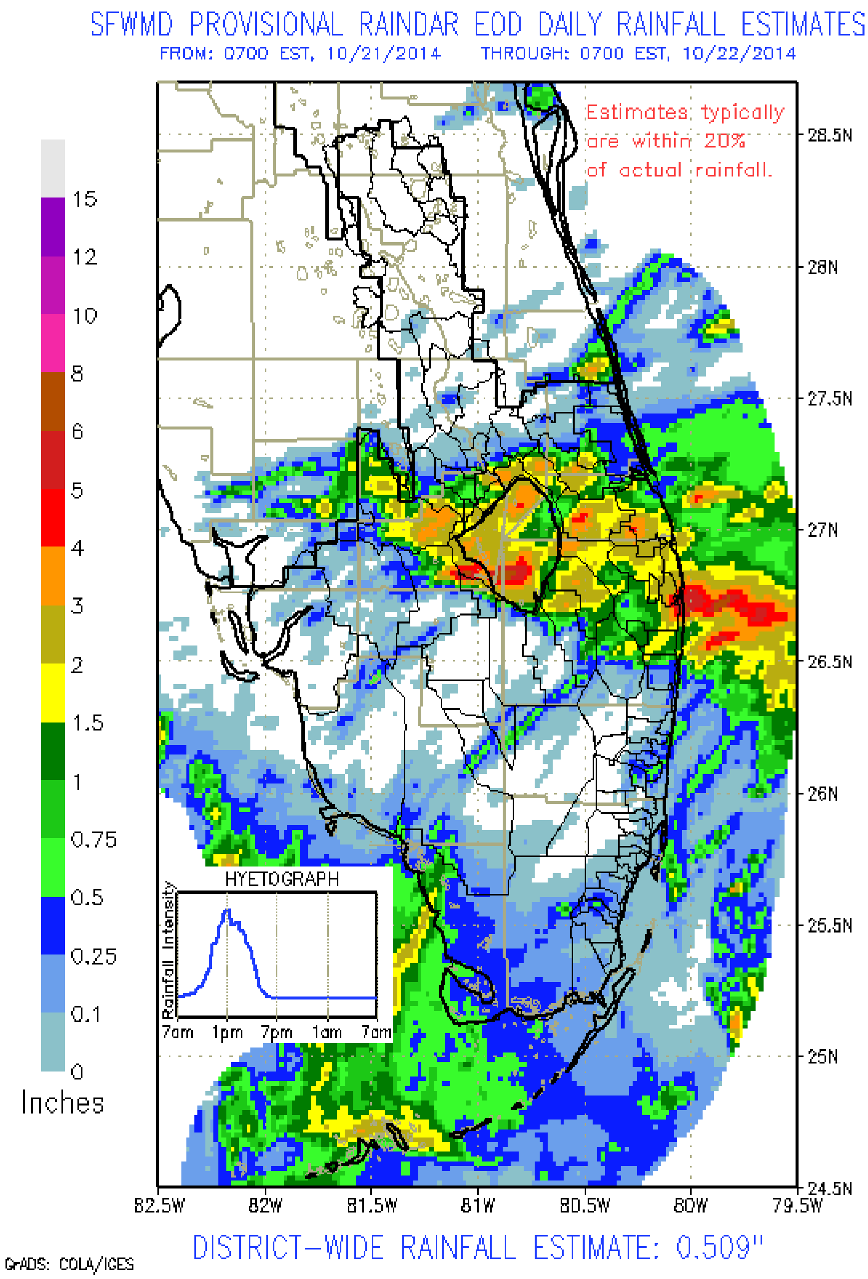


Figure 2-7. Tropical system related rainfall, October 21, 2014.

2014 AND 2015 EL NIÑO SOUTHERN OSCILLATION

The Pacific SST warming condition that started in August 2014 continued in 2015. The warming continued into spring 2015, increasing the chance of a 2015 El Niño or strong El Niño that could continue to the end of the year (**Figure 2-8**). Positive SST anomalies were observed across tropical Pacific west of Peru. **Figure 2-8** depicts a cumulative SST tracking index where positive values indicate the presence of El Niño and negative values indicate La Niña; values closer to zero indicate a neutral condition (Abtew et al. 2009, Abtew and Trimble 2010). Strong El Niño is indicated by above 5 degrees Celsius (^{o} C) cumulative SST and strong La Niña is indicated by cumulative SST of less than -5^{o} C. El Niño conditions create wind shear that weakens Atlantic tropical systems and also influence the path of tropical storms to curve to the north and east away from the land mass of the eastern United States. As a result of the expected El Niño in 2015, the initial prediction of number of storms is lower than the median 12 named storms with seven forecasted, median of 6.5 hurricanes with three forecasted, and median of two major hurricanes with one forecasted (Klotzbach and Gray 2015). The hydrology of South Florida during an El Niño year is characterized by high rainfall during the following dry season. La Niña conditions create favorable conditions for Atlantic tropical storms. South Florida dry season rainfall during La Niña years is likely to be below average and cause droughts (Abtew and Trimble 2010).

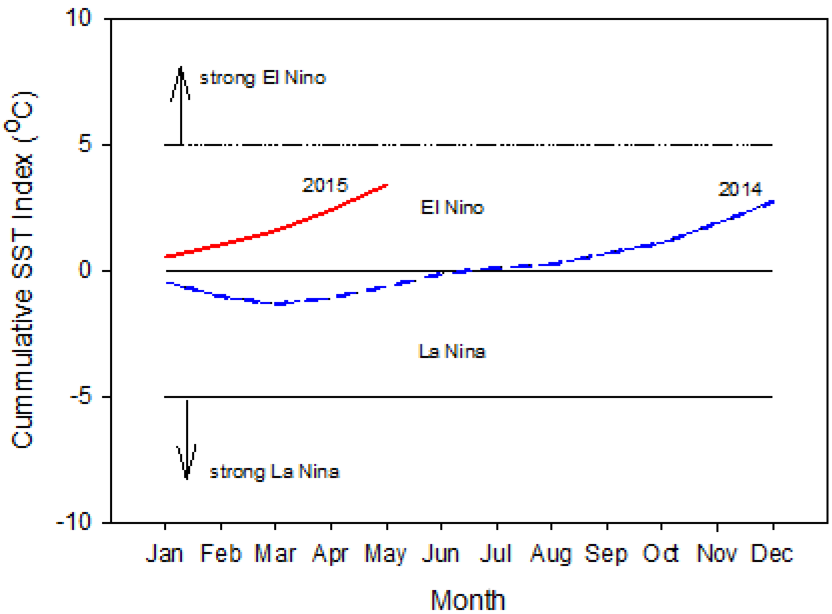


Figure 2-8. Calendar Years 2014 and 2015 ENSO developments.

WATER YEAR 2015 HYDROLOGY

RAINFALL AND EVAPOTRANSPIRATION

Following the two below average rainfall years of WY2011 and WY2012, hydrologic conditions of South Florida improved with average rainfall in WY2013 and wetter than average in WY2014. WY2015 District areal average rainfall of 51.09 inches is only 1.66 inches below the historical average, but there was high spatial variation. The year was both a wet and a dry year, depending upon the region of the District. Generally, the northern part of the District was wetter and the southern part was drier. Upper Kissimmee (+6.71 inches) and Lower Kissimmee (+12.99 inches) were very wet followed by Lake Okeechobee (+1.98 inches), which was wetter than average. Martin/St. Lucie rain area had average rainfall (+0.08 inches). However, the rest of the District and ENP were drier than normal with some extremely dry: ENP (-10.54 inches), East EAA (-8.84 inches), Palm Beach (-7.27 inches), WCA-3 (-5.68 inches), East Caloosahatchee (-5.14 inches), West EAA (-4.89 inches), Big Cypress Basin (-3.98 inches), WCA-1 and WCA-2 (-3.53 inches), Southwest Coast (-3.3 inches), Broward (-3.04 inches), and Miami-Dade (-2.28 inches). The drought continued into summer 2015 in the southeast and ENP.

The temporal and spatial distribution of the rainfall was uneven where there was wet conditions in the north and severe deficit rainfall conditions in the south. **Table 2-3** depicts monthly rainfall for each rainfall area for WY2015. **Table 2-4** presents dry and wet return periods of monthly rainfall in each rainfall area during WY2015, showing each month's state in each area. As shown in **Table 2-4**, on the average, six and a half months experienced drier than average rainfall. East EAA, West EAA, WCA-3, and Miami-Dade rain areas had eight months of below average rainfall. July and September 2014 were wet months. February 2015 was wet in most rain areas. April 2015 was a wet month in all rain areas. WY2015 tropical storm activity was low; there was relatively small contribution of tropical systems related rainfall in July and October 2014. District rainfall areas daily rainfall data was acquired from the operations rain gauge network (https://my.sfwmd.gov/sfwmd/common/images/weather/site_frm.html). ENP rainfall was acquired from the 24 ENP rain gauge network for which data is available in the District's corporate environmental database, DBHYDRO (www.sfwmd.gov/dbhydro).

Regionally, the balance between rainfall and evapotranspiration maintains the hydrologic system in either a wet or dry condition. ETp is potential evapotranspiration or actual evaporation for lakes, wetlands, and any feature that is wet year round. In South Florida, most of the variation in evapotranspiration is explained by solar radiation (Abtew 1996, Abtew and Melesse 2013). Regional estimates of average ETp from open water and wetlands that do not dry out range from 48 inches in the District's northern section to 54 inches in the Southern Everglades (Abtew et al. 2003, Abtew 2005). Available ETp data from the closest site to a rainfall area was used to estimate ETp for the area. In WY2015, ETp was higher than WY2014 reflecting relatively drier conditions during this period. **Table 2-5** shows monthly ETp for each rainfall area, ENP, and District average. **Table 2-6** summarizes WY2014, WY2015, and historical average annual rainfall; WY2015 ETp; and WY2015 rainfall anomalies. Appendix 2-1 of this volume compares WY2014 and WY2015 monthly rainfall, historical average rainfall, and WY2015 ETp for each rainfall area.

Table 2-3. WY2015 monthly rainfall (inches) for each rainfall area. [Note: Data from each rainfall area is from the District's operations rainfall database, which accumulates daily rainfall data from 7:00 a.m. of the previous day through 6:59 a.m. of the data registration day, both in Eastern Standard Time. ENP rainfall is average of 24 stations in ENP.]

Year	Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East EAA	West EAA	WCA-1 and WCA-2	WCA-3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	District average	ENP
2014	May	3.55	5.12	3.96	3.79	3.91	1.84	3.07	4.05	3.60	3.72	3.24	3.82	3.07	2.88	3.61	2.37
2014	June	8.52	10.03	8.14	6.65	5.85	6.61	6.85	9.57	7.79	7.70	10.27	6.44	8.97	7.44	8.09	9.12
2014	July	7.69	7.75	6.94	8.39	11.10	8.88	8.82	8.00	8.55	10.22	10.62	6.51	8.49	8.04	8.22	7.29
2014	Aug	4.87	6.65	5.57	5.62	6.52	6.67	7.91	5.01	7.40	6.19	6.43	7.64	7.90	9.00	6.72	6.00
2014	Sept	9.39	9.65	7.04	8.79	9.57	11.41	8.45	9.37	9.10	10.70	6.97	7.73	9.02	9.86	8.90	5.85
2014	Oct	1.11	1.51	3.28	1.74	1.31	2.71	1.17	2.55	4.39	1.79	4.34	1.20	1.47	1.47	2.07	2.24
2014	Nov	5.91	3.78	2.41	1.88	2.20	1.88	2.52	2.18	1.66	2.37	1.88	2.63	2.80	3.31	2.89	1.60
2014	Dec	1.26	0.74	0.65	0.62	0.62	1.07	0.83	1.53	1.20	2.30	1.47	0.34	0.56	0.33	0.87	0.89
2015	Jan	3.20	1.90	0.96	0.45	1.04	0.47	0.76	1.24	0.74	1.86	1.24	0.57	0.84	0.52	1.14	0.56
2015	Feb	5.13	4.20	2.94	2.68	1.86	2.42	1.29	4.65	4.37	2.67	2.28	2.26	1.70	2.80	3.07	1.67
2015	Mar	0.76	1.17	0.85	1.13	1.60	1.17	0.81	1.49	1.20	0.77	1.22	1.38	1.20	1.81	1.20	1.10
2015	Apr	5.41	4.94	5.21	2.90	4.48	3.30	3.08	4.58	4.27	4.80	4.87	5.02	4.12	3.36	4.31	5.99
Sum		**56.80**	**57.44**	**47.95**	**44.64**	**50.06**	**48.43**	**45.56**	**54.22**	**54.27**	**55.09**	**54.83**	**45.54**	**50.14**	**50.82**	**51.09**	**44.68**

Table 2-4. WY2015 monthly rainfall dry and wet return periods for each rainfall area (derived from Ali and Abtew 1999).

Year	Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East EAA	West EAA	WCA 1,2	WCA 3	Martin/St.Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast
2014	May	<average	≈ 5-yr wet	≈average	<5-yr dry	<5-yr dry	10-yr dry	<5-yr dry	<average	<5-yr dry	<5-yr dry	<5-yr dry	<average	<5-yr dry	≈5-yr dry
2014	Jun	< 5-yr wet	> 5-yr wet	< 5-yr wet	<5-yr dry	5-yr dry	<5-yr dry	<5-yr dry	< 10-yr wet	<average	<average	< 5-yr wet	<5-yr dry	≈average	<5-yr dry
2014	Jul	≈average	< 5-yr wet	>average	< 5-yr wet	≈ 10-yr wet	> 5-yr wet	> 5-yr wet	5-yr wet	< 5-yr wet	10-yr wet	> 10-yr wet	<5-yr dry	≈average	<average
2014	Aug	5-yr dry	>average	<5-yr dry	5-yr dry	<5-yr dry	average	< 5-yr wet	<5-yr dry	> 5-yr wet	<5-yr dry	<average	≈average	<average	>average
2014	Sep	> 5-yr wet	>20-yr wet	< 5-yr wet	< 5-yr wet	5-yr wet	> 10-yr wet	≈ 5-yr wet	< 5-yr wet	>average	5-yr wet	<average	>average	< 5-yr wet	< 5-yr wet
2014	Oct	5-yr dry	≈5-yr dry	<average	5-yr dry	<5-yr dry	>average	> 10-yr dry	< 10-yr dry	<5-yr dry	> 10-yr dry	<5-yr dry	<5-yr dry	5-yr dry	5-yr dry
2014	Nov	> 10-yr wet	10-yr wet	≈ 5-yr wet	<5-yr dry	< 5-yr wet	<5-yr dry	<average	<average	<5-yr dry	<5-yr dry	<5-yr dry	> 5-yr wet	> 5-yr wet	10-yr wet
2014	Dec	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	≈5-yr dry	<5-yr dry	<5-yr dry	>average	<5-yr dry	5-yr dry	≈5-yr dry	≈5-yr dry
2015	Jan	≈ 5-yr wet	≈average	<5-yr dry	<10-yr dry	<5-yr dry	<10-yr dry	<5-yr dry	<5-yr dry	<10-yr dry	<average	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
2015	Feb	≈ 10-yr wet	10-yr wet	< 5-yr wet	≈ 5-yr wet	<5-yr dry	>average	<5-yr dry	<10-yr wet	≈ 5-yr wet	< 5-yr wet	>average	>average	<5-yr dry	< 5-yr wet
2015	Mar	10-yr dry	<5-yr dry	<10-yr dry	5-yr dry	<5-yr dry	<5-yr dry	<10-yr dry	<5-yr dry	5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry	<5-yr dry
2015	Apr	> 10-yr wet	> 10-yr wet	> 10-yr wet	>average	> 5-yr wet	< 5-yr wet	< 5-yr wet	5-yr wet	< 5-yr wet	5-yr wet	5-yr wet	10-yr wet	<10-yr wet	< 5-yr wet
dry months		5	3	5	8	8	6	8	7	7	7	8	7	6	6
extreme dry															
wet months		7	8	7	4	4	6	4	5	5	5	4	5	6	6
extreme wet			1												
≈ average															

dry = < average

extreme dry>= 20 yr dry

wet = > average

extreme wet >= 20-yr

Table 2-5. WY2015 monthly ETp for each rainfall area (inches).

Year	Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	East Everglades Agricultural Area	West Everglades Agricultural Area	Water Conservation Areas 1,2	Water Conservation Area 3	Martin/St Lucie	Palm Beach	Broward	Miami-Dade	East Caloosahatchee	Big Cypress Preserve	Southwest Coast	Everglades National Park	District
2014	May	5.98	6.06	6.16	5.74	5.71	5.76	5.91	6.09	5.74	5.91	5.91	6.29	5.71	6.03	6.35	5.93
2014	June	5.15	5.26	5.13	5.14	5.04	5.19	4.60	5.44	5.14	4.60	4.60	5.71	5.04	5.02	5.26	5.08
2014	July	5.36	5.01	4.92	4.92	4.61	4.75	4.19	4.75	4.92	4.19	4.19	5.04	4.61	4.76	5.37	4.73
2014	Aug	5.09	5.18	5.94	5.15	5.19	5.18	4.90	5.54	5.15	4.90	4.90	5.31	5.19	5.02	5.62	5.19
2014	Sept	4.02	3.90	4.18	3.80	4.03	3.92	3.96	4.22	3.80	3.96	3.96	4.19	4.03	3.64	4.04	3.97
2014	Oct	4.58	4.38	4.74	4.25	4.29	4.00	4.33	4.23	4.25	4.33	4.33	4.83	4.29	4.34	4.12	4.37
2014	Nov	3.12	2.99	3.59	3.06	3.25	2.87	3.40	2.98	3.06	3.40	3.40	3.53	3.25	3.40	3.46	3.24
2014	Dec	2.79	2.86	3.41	2.91	3.11	2.78	3.42	2.95	2.91	3.42	3.42	3.40	3.11	3.32	3.39	3.13
2015	Jan	3.28	3.12	3.60	3.07	3.28	3.04	3.48	3.25	3.07	3.48	3.48	3.53	3.28	3.38	3.45	3.31
2015	Feb	3.35	3.33	3.89	3.53	3.69	3.47	3.68	3.66	3.53	3.68	3.68	3.85	3.69	3.80	4.11	3.63
2015	Mar	4.80	4.48	5.15	4.66	4.89	4.67	5.03	4.78	4.66	5.03	5.03	5.03	4.89	5.02	5.48	4.86
2015	Apr	5.22	4.96	5.60	5.26	5.04	5.19	4.87	5.15	5.26	4.87	4.87	5.46	5.04	5.05	5.45	5.13
Sum	**(inches)**	**52.73**	**51.53**	**56.33**	**51.49**	**52.12**	**50.81**	**51.76**	**53.03**	**51.49**	**51.76**	**51.76**	**56.17**	**52.12**	**52.78**	**56.10**	**52.56**

Table 2-6. WY2015, WY2014, and historical average annual rainfall, WY2015 ETp, and WY2015 rainfall deviation from historical average (inches) for each rainfall area.

Rainfall Area	WY2015 Rainfall	WY2014 Rainfall	Historical Average Rainfall	WY2015 ETp	WY2015 Rainfall Deviation
Upper Kissimmee	56.8	52.54	50.09	52.73	6.71
Lower Kissimmee	57.44	53.33	44.45	51.53	12.99
Lake Okeechobee	47.95	47.94	45.97	56.33	1.98
East EAA	44.64	50.68	53.48	51.49	-8.84
West EAA	50.06	48.75	54.95	52.12	-4.89
WCA-1 and WCA-2	48.43	53.92	51.96	50.87	-3.53
WCA-3	45.56	54.1	51.24	51.76	-5.68
Martin/St. Lucie	54.22	56.8	54.14	53.03	0.08
Palm Beach	54.27	62.03	61.54	51.49	-7.27
Broward	55.09	65.1	58.13	51.76	-3.04
Miami-Dade	54.83	59.53	57.11	51.76	-2.28
East Caloosahatchee	45.54	57.41	50.68	56.17	-5.14
Big Cypress Basin	50.14	54.79	54.12	52.12	-3.98
Southwest Coast	50.82	60.42	54.12	52.78	-3.3
Everglades National Park [a]	44.68	50.08	55.22	56.1	-10.54
SFWMD Spatial Average	**51.09**	**55.14**	**52.75**	**52.56**	-1.66

a. ENP historical average rainfall estimates from Sculley (1986).

WILDFIRES

One of drought's impacts on the South Florida environment is creating conditions that promote and spread wildfires. The size and number of wildfires are generally correlated to dry conditions. Generally, drought years have above average total number of acres burned and number of acres burned per fire. For instance, the area burned by wildfire in 1989, 1990, 2001, and 2007 drought years was high. **Figure 2-9** depicts the number of acres burned per water year in the SFWMD area from wildfires that were 10 acres or larger from WY1982 to WY2015. Mostly, major droughts correspond to larger areas burned by wildfire. The number of acres burned in WY2015 was 60,778 acres. The average area burned in a year is 105,577 acres.

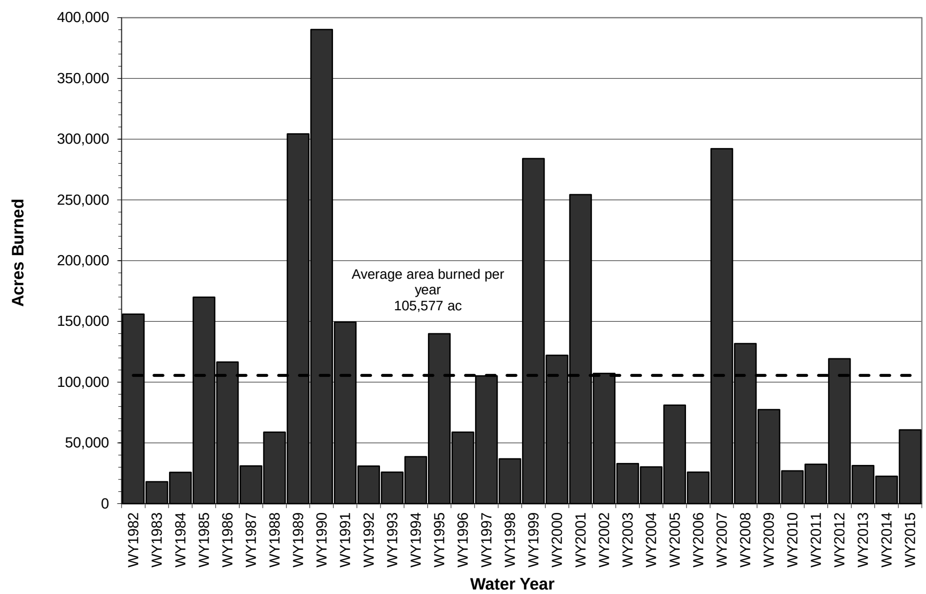


Figure 2-9. Number of acres burned per water year in the SFWMD area from wildfires that were 10 acres or larger (WY1982–WY2015).

GROUNDWATER

The District is divided into four major water resource planning regions (see Appendix 2-2, Figure 1). Each has aquifers that provide water for agricultural, commercial, industrial, and domestic use. The LEC principal groundwater source is the surficial Biscayne aquifer. The UEC principal source of groundwater is the surficial aquifer. The LWC relies on three aquifer systems for water supply: the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system. The Lower Tamiami aquifer is part of the surficial aquifer system; the sandstone and the mid-Hawthorne aquifers are part of the intermediate aquifer system (SFWMD 2006). The Kissimmee Basin is served by a surficial or shallow aquifer and a deep aquifer, the Floridan aquifer system.

In general, WY2015 groundwater levels reflect regional rainfall conditions. Kissimmee basin was wet and groundwater levels rose by the end of the water year. Beginning and end of water year levels for UEC groundwater levels were about the same. LEC and LWC levels decreased by end of the water year. Representative groundwater level fluctuation observations from the United States Geological Survey are shown in Appendix 2-2 for the stations shown in Figure 1 of that appendix.

WATER MANAGEMENT IN WATER YEAR 2015

OVERVIEW

District-wide water management operations depend largely on the spatial and temporal distribution of rainfall across the South Florida region and antecedent conditions. Although water management of SFWMD facilities is performed according to prescribed operation plans, there are various constraints that are considered while developing and implementing shorter-term operating strategies. Flood control operations are conducted in the wet season and tropical storm events occur in this season. Inflow and outflow operations were regularly conducted to bring water levels of the major water bodies closer to the respective regulation schedules. The water management system was operated both in flood control and water supply mode based on weather and antecedent conditions. From the wet season, July and September were wet and, from the dry season, generally, February and April were wet. Upper and Lower Kissimmee and Lake Okeechobee rain areas were wet. For the remaining areas, rainfall was generally far below the historical average with half or more of the months being drier. The dry season months were drier than average, except for February and April 2015 (**Table 2-4**).

Water management is performed by using previously established regulation schedules that integrate different purposes. Regulation schedules are rule curves designed to manage the regional storage. In order to broadly satisfy flood control and water supply needs on a long-term basis, daily water level regulation schedules for each of the regional water bodies were developed by USACE and SFWMD in cooperation with other agencies and stakeholders. The regulation schedules for the regional lakes and WCAs are published in detail in the 2007 SFER – Volume I, Appendix 2-6 (Abtew et al. 2007b). At times, deviations from the regular regulation schedules are made for a specific lake or WCA to manage water under particular infrastructural, environmental, or weather-related conditions. For WY2015, temporary operational modifications were established for some of the Kissimmee Chain of Lakes in the Upper Basin to protect and enhance snail kite breeding habitat.

Initiated in May 2008, the current regulation schedule for Lake Okeechobee, known as LORS2008 (USACE 2008), incorporates current and future (outlook) climatic information in the decision making process. The regulation schedule has three main bands (**Figure 2-10**): High Lake Management Band, Operational Band, and Water Shortage Management Band. The Operational Band is further divided into high, intermediate, low, base flow, and beneficial use categories. In the High Lake Management Band, large flood control releases may be required and outlet canals may be maintained above their optimum water management elevations. In the Operational Band, substantial flood control releases may be implemented; outlet canals should be maintained within their optimum water management elevations. In the Water Shortage Management Band, outlet canals may be maintained below optimum water management elevations and water supply releases from the lake are restricted according to the severity of prolonged dry climate conditions. More information on LORS2008 is also presented in the *Lake Okeechobee* section of this chapter.

Water supply releases are made for various beneficial uses that include water supply for municipal and industrial use, irrigation for agriculture, deliveries to ENP, salinity control, estuarine management and other environmental releases. Releases are made to the St. Lucie Canal and Caloosahatchee River to maintain navigation depths if sufficient water is available in Lake Okeechobee. The outflows from Lake Okeechobee are received by the St. Lucie Canal, Caloosahatchee River, EAA, Lower East Coast and, in some cases, the WCAs and Everglades STAs. **Figure 2-10** depicts Lake Okeechobee daily water level, regulation schedule, and water management decisions. Based on the lake water level and other relevant factors, various water management decisions are depicted on the figure. Release from the lake through S-308 into the St. Lucie Canal, which discharges into the St. Lucie Estuary through S-80; releases from the lake through S-77 and into the Caloosahatchee River, which discharges into the Caloosahatchee Estuary through S-79; and regulatory releases to WCAs are also shown on the figure. Further details of these subregion flows are provided in the *Water Levels and Flows* section of this chapter and Appendices 2-5 and 2-6 of this volume.

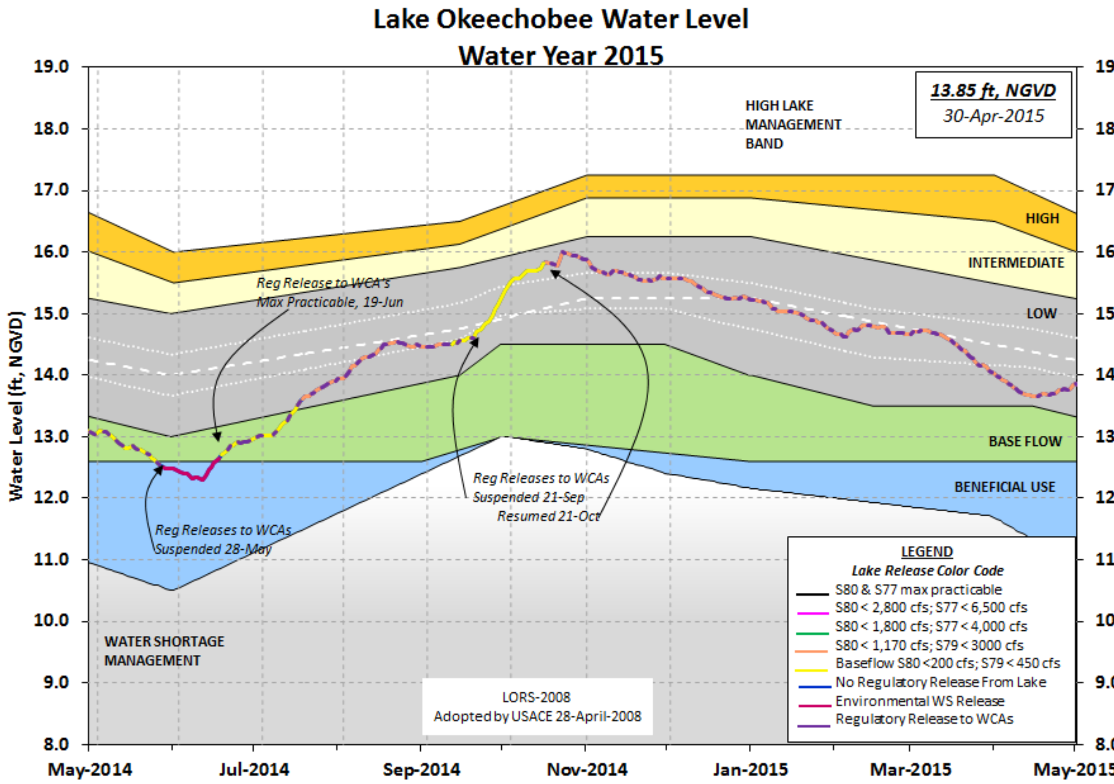


Figure 2-10. Daily Lake Okeechobee water levels, regulation schedule, and water management decisions. [Note: cfs – cubic feet per second; ft, NGVD – feet National Geodetic Vertical Datum of 1929; max – maximum; and WS – water supply.]

During WY2015, water managers, scientists, and engineers from the District, USACE, and other federal and state agencies met weekly to discuss the state of the regional system and possible operational scenarios. Reports on the ecological and hydrological status of various areas (e.g., Kissimmee Basin, Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, Everglades STAs, Everglades, water supply, and groundwater conditions) were presented. How well the objectives of the Central and South Florida Flood Control Project (water supply, flood control, and protection of fish and wildlife) were met were also discussed. The meeting starts with the previous week's weather report and coming week's rainfall predictions, followed by climate forecast. The previous week's Lake Okeechobee operations and the rest of the water management system were reported in each meeting. Operational recommendations were given to District managers for approval and then submitted to USACE in a Weekly Environmental Conditions for Systems Operations memoranda.

In WY2015, there was no major tropical system event. In July and October 2014, there was a modest amount of tropical system related rainfall. There were non-tropical high rainfall events on August 4, 2014, and February 28, 2015. Lake Okeechobee was at 13.05 ft NGVD29 on May 1, 2014, at the start of WY2015. The lake level rose to a maximum of 16.01 ft NGVD29 by October 22, 2014, from runoff generated by rainfall of preceding months. Sixty-three percent of the water year inflow to the lake was received from May through October 2014. Since the dry season was wet in the lake watershed, 40 percent of the lake inflows were in the dry season (see Appendix 2-5, Table 2).

WATER LEVELS AND FLOWS

For parts of WY2015 wet and dry seasons, most water control structures were operated for water supply during dry conditions and flood control operations during the wet season and other high rainfall events. Period of record daily mean water levels (stage) graphs for the lakes, impoundments, and ENP are shown in Appendix 2-3. All water levels are expressed in ft NGVD29 in these and related publications. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages. WY2015 water levels were generally higher than the historical average in the north and lower in the south and ENP. WY2015 average water levels were generally lower than WY2014 average levels in the south and ENP. The average Lake Okeechobee water level was 0.10 ft lower than WY2014 but 0.36 ft higher than the historical average. Comparison of monthly historical averages, WY2014, and WY2015 water levels are shown in Appendix 2-4. Water levels are also a measure of the amount of stored water. Relationships of water levels (stage) and storage for lakes and impoundments are presented in the 2007 SFER – Volume I, Appendix 2-2 (Abtew et al. 2007a).

WY2015 surface water flow statistics were also compared to WY2014 and historical flow records (**Table 2-8**). WY2015 flows were higher than historical flows for Lake Okeechobee watershed but lower for the lower part of the District and ENP. In comparison to WY2014 flows, except Lake Okeechobee watershed and WCA-3A inflows, others were generally lower for WY2015. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments and canals. Monthly flows by structure are shown in Appendix 2-5. Comparison of historical, WY2014, and WY2015 monthly flows are shown in Appendix 2-6. Maps showing water control structures, canals, water bodies, and hydrologic units are available in previous SFERs.

Table 2-7. WY2015, WY2014, and historical stage statistics for regional major lakes and impoundments.

Lake or Impoundment	Beginning of Record	Historical Mean Stage (ft NGVD29)	WY2015 Mean Stage (ft NGVD29)	WY2014 Mean Stage (ft NGVD29)	Historical Maximum Stage (ft NGVD29)	Historical Minimum Stage (ft NGVD29)
Alligator Lake	1993	62.61	61.86	63.03	64.33	58.13
Lake Myrtle	1993	60.86	61.06	61.00	65.22	58.45
Lake Mary Jane	1993	60.09	60.32	60.05	62.16	57.19
Lake Gentry	1993	60.71	60.97	60.92	61.97	58.31
East Lake Tohopekaliga	1993	56.63	56.70	56.56	59.12	54.41
Lake Tohopekaliga	1993	53.72	53.80	53.72	56.63	48.37
Lake Kissimmee	1929	50.39	50.94	50.67	56.64	42.87
Lake Istokpoga	1993	38.78	38.98	38.91	39.78	35.84
Lake Okeechobee	1931	14.02	14.38	14.48	18.77	8.82
Water Conservation Area 1	1953	15.68	16.49	16.31	18.16	10.00
Water Conservation Area 2A	1961	12.51	12.30	12.69	15.64	9.33
Water Conservation Area 3A	1962	9.59	9.74	10.23	12.79	4.78
Everglades National Park, Slough	1952	6.01	6.28	6.63	8.08	2.01
Everglades National Park, Wet Prairie	1953	2.17	2.51	3.24	7.10	-2.69

Table 2-8. WY2015, WY2014, and historical flow statistics for major impoundments, lakes, and canals.

Lake, Impoundment, or Canal	Beginning of Record	Historical Mean Flow (ac-ft)	WY2015 Flow (ac-ft)	Percent of Historical Mean	WY2014 Flow (ac-ft)	Historical Maximum Flow (ac-ft)	Historical Minimum Flow (ac-ft)
Lake Kissimmee Outflow	1972	716,480	1,170,556	163%	765,563	2,175,297	16,195
Lake Istokpoga Outflow	1972	222,682	446,215	200%	319,317	637,881	26,559
Lake Okeechobee Inflow	1972	2,106,045	2,831,832	134%	2,695,257	4,905,838	377,671
Lake Okeechobee Outflow	1972	1,438,234	1,933,353	134%	2,527,633	3,978,904	176,568
St. Lucie (C-44 Canal) Inflow at S-308	1972	253,809	129,227	51%	444,651	1,117,159	4,061
St. Lucie (C-44 Canal) Outflow at S-80	1972	482,016	188,236	39%	675,800	1,192,782	0
Caloosahatchee River (C-43 Canal) Inflow at S-77	1972	530,005	575,971	109%	1,225,613	2,175,765	42,301
Caloosahatchee River (C-43 Canal) Outflow at S-79	1972	1,234,148	1,234,148	100%	2,521,600	3,615,526	86,895
Water Conservation Area 1 Inflow	1972	469,184	245,360	52%	380,269	1,307,517	152,641
Water Conservation Area 1 Outflow	1972	436,509	198,051	45%	471,206	1,433,399	14,812
Water Conservation Area 2 Inflow	1972	644,357	823,996	128%	1,078,408	1,754,710	113,225
Water Conservation Area 2 Outflow	1972	645,461	810,056	126%	965,358	1,729,168	93,564
Water Conservation Area 3A Inflow	1972	1,173,792	1,312,417	112%	1,248,362	2,177,198	393,233
Water Conservation Area 3A Outflow	1972	1,005,017	779,167	78%	1,452,583	2,581,129	245,951
Everglades National Park Inflow	1972	989,508	1,015,301	103%	1,590,971	2,838,481	165,372
Upper East Coast C-23 Canal Outflow at S-48	1995	126,082	104,992	83%	169,437	297,214	33,644
Upper East Coast C-24 Canal Outflow at S-49	1972	129,715	104,548	81%	107,679	274,827	10,591
Upper East Coast C-25 Canal Outflow at S-50	1972	135,584	120,838	89%	225,688	249,159	21,154

Kissimmee Chain of Lakes

The Upper Kissimmee Basin is an integrated system of several lakes with interconnecting canals and flow control structures (Abtew et al. 2011). The major lakes are shallow with depths from 6 to 13 ft (Guardo 1992). The Upper Kissimmee Basin structures are operated according to regulation schedules. The details of the water control plan for the Kissimmee River are presented in the Master Water Control Manual for Kissimmee River – Lake Istokpoga (USACE 1994). Average stage for WY2015, WY2014, and historical observation statistics for the Kissimmee Chain of Lakes are shown in **Table 2-7**. Historical daily water levels are shown in Appendix 2-3. Monthly historical average, WY2015, and WY2014 water levels for the lakes are shown in Appendix 2-4. In WY2015, the Upper Kissimmee Basin produced far above average flow volume (1,170,556 ac-ft), 163 percent of the historical average, as a result of a wet year in the watershed. Monthly inflows and outflows by structure are shown in Appendix 2-5. Appendix 2-6 depicts monthly historical average, WY2015, and WY2014 flows for each water body or canal.

Alligator Lake

The outflows from Lakes Alligator, Center, Coon, Trout, Lizzie, and Brick are controlled by two structures: S-58 and S-60. S-58 is located in the C-32 canal that connects lakes Trout and Joel, and S-60 is located in C-33 canal between Alligator Lake and Lake Gentry. Culvert S-58 maintains stages in Alligator Lake upstream from the structure, while the S-60 spillway is operated to main the optimum lakewide stage. These lakes are regulated between elevations 61.5 and 64.0 ft NGVD29 on a seasonally varying schedule. Daily water level observations for Alligator Lake over the last 22 years show that the most significant change in water levels occurred during the 2000–2001 drought, with water levels showing a big drop (Appendix 2-3, Figure 1). **Figure 2-11**, panel a, shows WY2015 daily average stage at the headwater of S-60, daily rainfall, and flood regulation schedule for Alligator Lake. Generally water levels were at the regulation schedule except in early part of the wet season. WY2015 average stage (61.86 ft NGVD29) was lower than WY2014 but higher than the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 1.

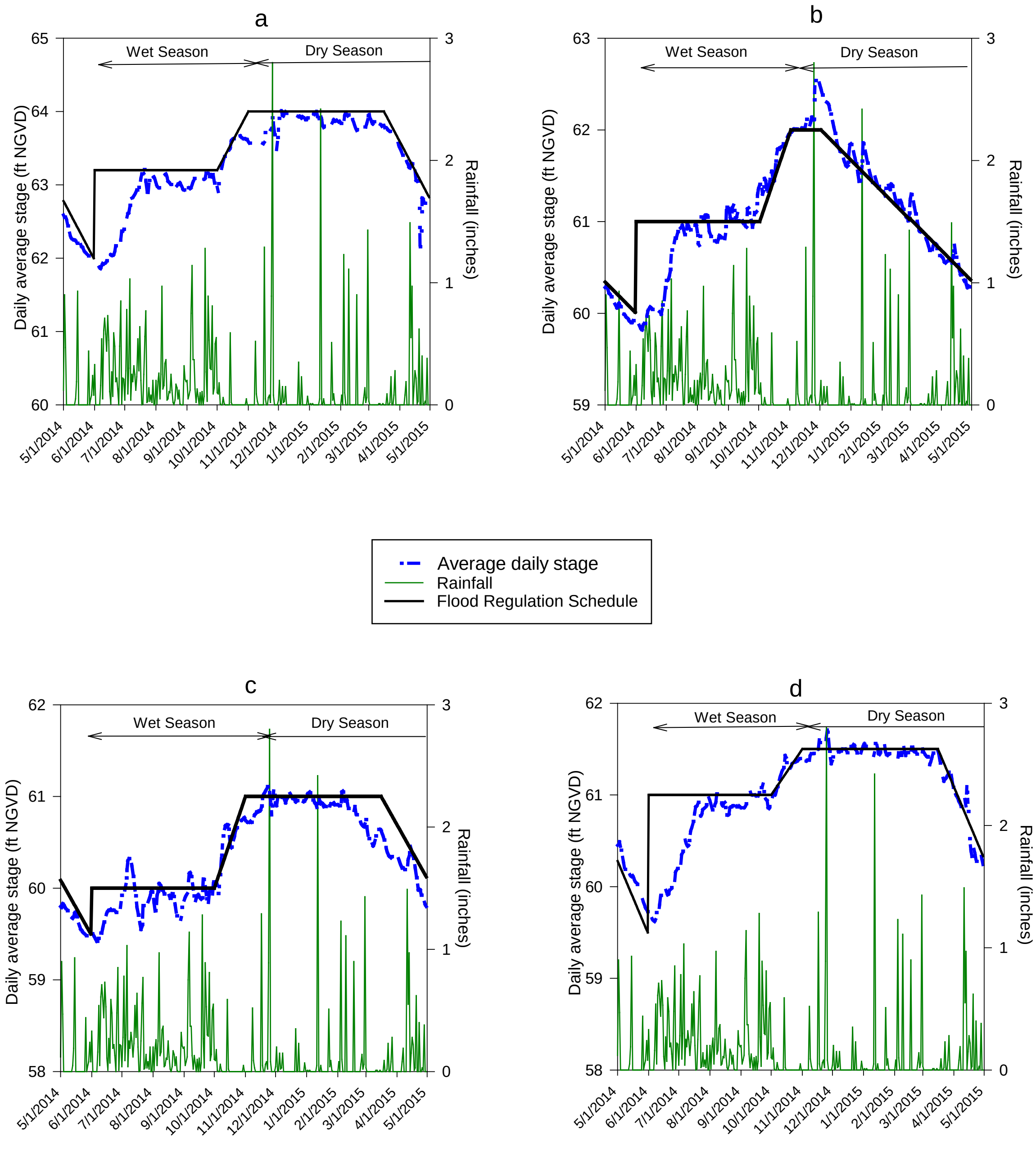


Figure 2-11. Average daily water levels (stage), regulation schedule, and rainfall for (a) Alligator Lake, (b) Lake Myrtle, (c) Lake Mary Jane, and (d) Lake Gentry.

Lakes Joel, Myrtle, and Preston

Lakes Joel, Myrtle, and Preston are regulated by structure S-57. The S-57 culvert is located in the C-30 canal that connects Lakes Myrtle and Mary Jane. The lakes are regulated between 59.5 and 62.0 ft NGVD29 on a seasonally varying schedule. **Figure 2-11**, panel b, shows the WY2015 daily average stage at the headwater of S-57, daily rainfall, and regulation schedule for Lake Myrtle. Generally water levels were at the regulation schedule except in early part of the wet season. Water levels rose above the regulation schedule in November 2014 as a result of six inches of rainfall on the basin for the month. Daily water level observations for Lake Myrtle over the last 22 years show that the most significant drop in water level occurred in 2000–-2001 and 2010–2011 drought years (Appendix 2-3, Figure 2). WY2015 average stage for Lake Myrtle (61.06 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 2.

Lakes Hart and Mary Jane

Lakes Hart and Mary Jane are regulated by structure S-62. The S-62 spillway is located in the C-29 canal that discharges into Lake Ajay. The lakes are regulated between elevations of 59.5 and 61.0 ft NGVD29 according to a seasonally varying schedule. **Figure 2-11**, panel c, shows WY2015 daily average stage at the headwater of S-62, daily rainfall, and flood regulation schedule for Lake Mary Jane. The stages generally followed the regulation. Flow releases were made based on water supply needs and flood control. Daily water level observations for Lake Mary Jane over the last 22 years show that the most significant drop in water level occurred in May 2001 during a severe drought year (Appendix 2-3, Figure 3). WY2015 average stage for Lake Mary Jane (60.32 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 3.

Lake Gentry

Lake Gentry is regulated by the S-63 structure, located in the C-34 canal at the south end of the lake. The stages downstream of S-63 are further lowered by S-63A before the canal discharges into Lake Cypress. The lake is regulated between elevations of 59.0 and 61.5 ft NGVD29 according to a seasonally varying schedule. **Figure 2-11**, panel d, shows WY2015 daily average stage at the headwater of the S-63 spillway, daily rainfall, and flood regulation schedule for Lake Gentry. Water levels were at the regulation schedule except in early part of the wet season. Daily water level observations for Lake Gentry over the last 22 years show the most drop in water level occurred in May 2001 during a severe drought year (Appendix 2-3, Figure 4). WY2015 average stage for Lake Gentry (60.97 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 4.

East Lake Tohopekaliga

East Lake Tohopekaliga and Lake Ajay are regulated by structure S-59, located in the C-31 canal between East Lake Tohopekaliga and Lake Tohopekaliga. The lakes are maintained between 54.5 and 58.0 ft NGVD29 on a seasonally varying schedule. A weir structure was built downstream of the S-59 spillway to control the tailwater elevation at S-59. The weir crest is at an elevation of 51.0 ft NGVD29. The weir is often submerged and therefore, the tailwater influences the headwater of S-59. **Figure 2-12**, panel a, shows WY2015 daily average stage at the headwater of S-59, daily rainfall, regulation schedule, and ecological regulation schedule for East Lake Tohopekaliga. The stages mostly followed the ecological regulation schedule. Flow releases were based on water supply needs, flood control, and maintaining the regulation schedule whenever possible. Daily water level observations for East Lake Tohopekaliga in the last 22 years are shown in Appendix 2-3, Figure 5. WY2015 average stage for Lake East Tohopekaliga (56.70 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 5.

Lake Tohopekaliga

Lake Tohopekaliga is regulated by structure S-61, located in the C-35 canal at the south shore of the lake. The lake is regulated between the elevations of 51.5 and 55.0 ft NGVD29 on a seasonally varying schedule. The S-61 structure is used to maintain the optimum stage in Lake Tohopekaliga. **Figure 2-12**, panel b, shows WY2015 daily average stage at the headwater of S-61, daily rainfall, regulation schedule, and ecological regulation schedule for Lake Tohopekaliga. The stages followed the ecological regulation schedule. Daily water level observations for Lake Tohopekaliga over the last 22 years show the most significant drop in water level occurred in June 2004 during the lake drawdown (Appendix 2-3, Figure 6). WY2015 average stage for Lake Tohopekaliga (53.80 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 6.

Lakes Kissimmee, Hatchineha, and Cypress

Lakes Kissimmee, Hatchineha, and Cypress are regulated by the S-65 spillway and lock structure located at the outlet of Lake Kissimmee and the head of the Kissimmee River (C-38 canal). Lake Kissimmee covers approximately 35,000 acres and is regulated between 48.5 and 52.5 ft NGVD29 on a seasonally varying schedule. **Figure 2-12**, panel c, shows the daily average stage at the headwater of S-65, daily rainfall, regulation schedule, and ecological regulation schedule for Lake Kissimmee during WY2015. The stages followed the ecological regulation schedule. Releases were made based on downstream water needs and flood control. Appendix 2-3, Figure 7 shows daily water level for 1929–2015. WY2015 average stage for Lake Kissimmee (50.94 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Monthly historical average, WY2015, and WY2014 water levels for the lake are shown in Appendix 2-4, Figure 7.

The Upper Kissimmee Basin received above average rainfall (+6.71 inches) resulting in far above average discharge out of Lake Kissimmee (1,170,556 ac-ft, 163 percent of the historical average). There was discharge from Lake Kissimmee to the Kissimmee River throughout the water year except for two days in June 2014. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments. WY2015 monthly flows are shown in Appendix 2-5, Table 1. Monthly historical average, WY2014, and WY2015 flows are presented in Appendix 2-6, Figure 1.

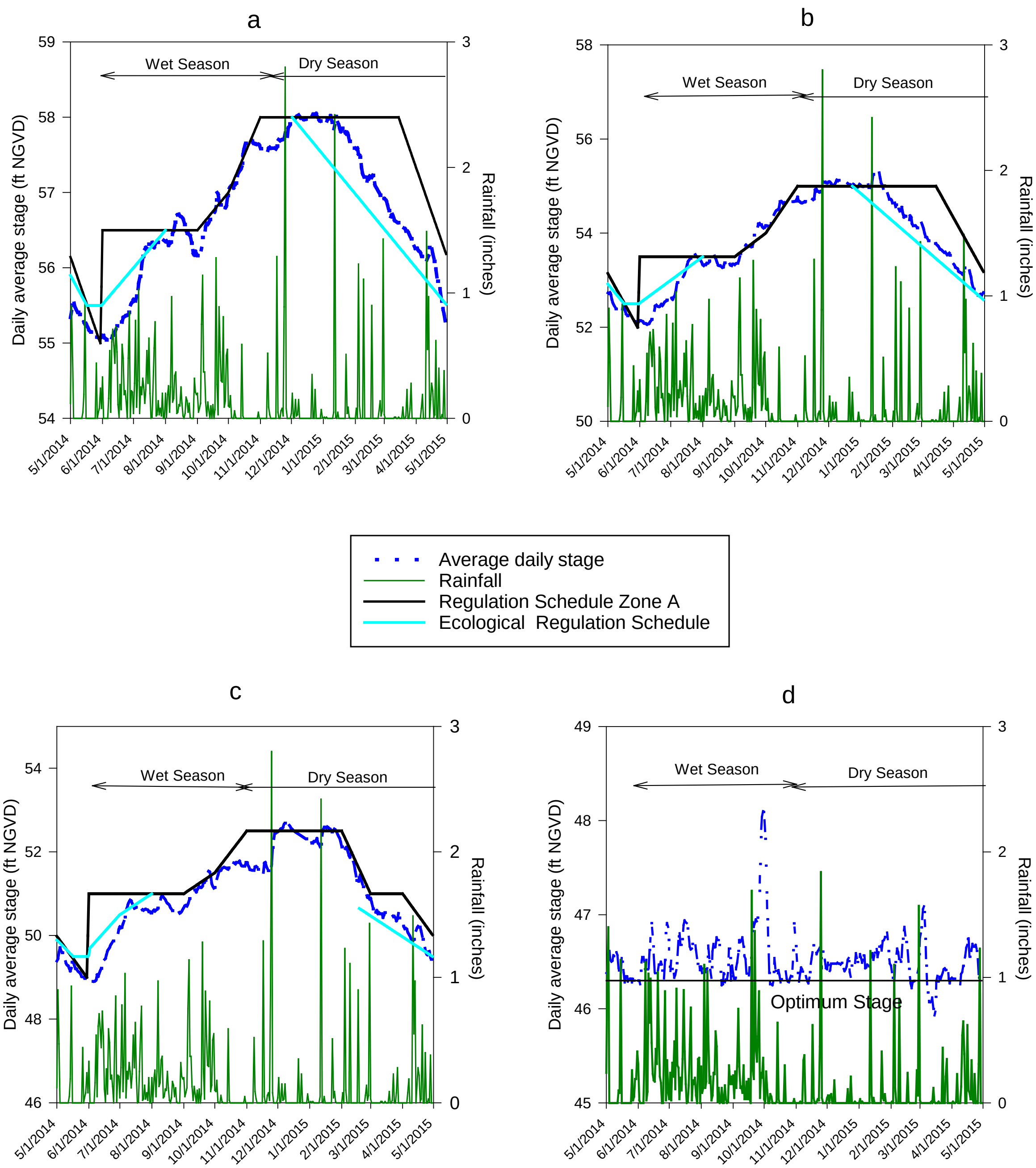


Figure 2-12. Average daily water levels (stage), regular regulation schedule, temporary modifications, and rainfall for (a) East Lake Tohopekaliga, (b) Lake Tohopekaliga, (c) Lake Kissimmee, and (d) Pool A.

Lower Kissimmee System

The Lower Kissimmee System consists of the Kissimmee River (C-38 canal) and four structures (S-65A, S-65C, S-65D, and S-65E) that form four pools (A, C, D, and E). These structures are operated according to optimum stages. Optimum stages for S-65A, S-65C, S-65D, and S-65E are 46.3, 34.4, 26.8, and 21.0 ft NGVD29, respectively (Abtew et al. 2011). WY2015 conditions in the Kissimmee River system are covered in detail in Chapter 9 of this volume.

Pool A

Stages in Pool A are controlled by the S-65A gated spillway and lock, and the pool is downstream of the S-65 structure. In addition to S-65A, a culvert structure is located through the east tieback levee at the natural channel of the Kissimmee River. During water supply periods, minimum releases are made to satisfy water demands and maintain navigation downstream. The culvert also provides water to the oxbows of the natural river channel. **Figure 2-12**, panel d, shows the daily average stage at the headwater of S-65A, daily rainfall, and optimum stage for Pool A during WY2015. There was a brief spike in water level of 2 ft at the end of September and beginning of October 2014 when upstream discharge from Lake Kissimmee through the S-65 structure was high. Most of the year, stages remained higher than the optimum stage of 46.3 ft NGVD29 for the water year reflecting the wet conditions in the watershed.

Pool C

Stages in Pool C are controlled by the S-65C gated spillway and lock, which is downstream of the S-65A structure. In addition to S-65C, there is a culvert structure that is located through the east tieback levee at the natural channel of the Kissimmee River. During WY2015, minimum and maximum headwater stages at S-65C were 32.82 and 35.58 ft NGVD, respectively, with mean stage of 34.48 ft NGVD29.

Pool D

Stages in Pool D are controlled by the S-65D gated spillway and lock downstream of S-65C. During WY2015, headwater stages at S-65D ranged from 27.47 to 27.67 ft NGVD29 with mean stage of 27.47 ft NGVD29.

Pool E

Stages in Pool E are controlled by the S-65E gated spillway and lock, which is downstream of the S-65D. During WY2015, minimum and maximum headwater stages at S-65E were 20.83 and 21.19 ft NGVD29, respectively with mean stage of 21 ft NGVD29.

Lake Istokpoga

Lake Istokpoga has a surface area of approximately 27,700 acres. Stages in Lake Istokpoga are maintained in accordance with a regulation schedule that varies seasonally. The S-68 spillway, located at the south end of the lake, regulates the lake stage and discharges water to the C-41A canal (the Slough Canal). The C-41 canal (Harney Pond Canal), the C-40 canal (Indian Prairie Canal), and the C-39A canal (State Road 70 Canal) provide secondary conveyance capacity for the regulation of floods in the Lake Istokpoga Water Management Basin. The C-40 and C-41 canals flow into Lake Okeechobee, whereas the C-41A canal flows into the Kissimmee River, which flows into Lake Okeechobee. Details of Lake Istokpoga water control plan are available in the Master Water Control Manual for Kissimmee River – Lake Istokpoga Basin (USACE 1994).

Figure 2-13, panel a, shows the daily average stage at the headwater of S-68, daily rainfall, and regulation schedules for Lake Istokpoga during WY2015. Appendix 2-3, Figure 8, shows daily water levels for the period from 1993 to 2015. Stages were close to the regulation schedule. WY2015 average stage for Lake Istokpoga (38.98 ft NGVD29) was higher than WY2014 and the historical average (**Table 2-7**). Minimum releases, based on water supply needs, were made during drier periods and flood control releases during wet periods. WY2015 flows (446,215 ac-ft) were twice as much as the historical average and 140 percent of WY2014. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments. Monthly historical average, WY2014, and WY2015 water levels are shown in Appendix 2-4, Figure 8. WY2015 monthly flows are shown in Appendix 2-5, Table 1. Monthly historical average, WY2014, and WY2015 flows are presented in Appendix 2-6, Figure 2.

Lake Okeechobee

Lake Okeechobee's water level is regulated to provide (1) flood control, (2) navigation, (3) water supply for agricultural irrigation, municipalities and industry, the EPA and the Everglades STAs, (4) regional groundwater control, (5) salinity control, (6) enhancement of fish and wildlife, and (7) recreation (Abtew et al. 2011). The regulation schedule accounts for varying and often conflicting purposes. The lake was regulated under a different regulation schedule in previous water years (Abtew et al. 2007b). An updated regulation schedule was adopted on April 28, 2008, for Lake Okeechobee, which was implemented on May 1, 2008 (USACE 2008). Details of the current regulation schedule are discussed below and shown in **Figure 2-14**.

Lake Okeechobee has an approximate surface area of 436,300 acres at the historical average stage of 14.02 ft NGVD29 (1931–2015). At the beginning of WY2015, the lake stage was 13.05 ft NGVD29 and the average stage was 14.38 ft NGVD29 for the water year, 0.36 ft higher than the historical average. Stage at the end of the water year was 13.87 ft NGVD29. **Figure 2-13**, panel b, shows the daily average stage and daily rainfall for Lake Okeechobee during WY2015. Appendix 2-3, Figure 9, shows daily water levels for Lake Okeechobee for the period of record, 1931–2015. WY2015 average stage for Lake Okeechobee (14.38 ft NGVD29) was lower than WY2014 but higher than the historical average (**Table 2-7**). Monthly historical average, WY2014, and WY2015 water levels are shown in Appendix 2-4, Figure 9. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages.

WY2015 inflows into Lake Okeechobee (2,831,832 ac-ft) were high, 134 percent of the historical average inflows (2,106,045 ac-ft). WY2015 outflows of 1,933,353 ac-ft, which was also 134 percent of historical annual outflows (1,438,234 ac-ft) since 1972. During the dry season (November 2014 to April 2015), surface water inflows into the lake was 1,037,031 ac-ft, 49 percent for the water year. At the same time, 1,350,632 ac-ft was discharged from the lake to control the rise in stage reflecting the relatively wet year in the watershed. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments. WY2015 monthly inflows and outflows are shown in Appendix 2-5, Tables 2 and 3, respectively. Monthly historical average, WY2014, and WY2015 inflows and outflows are shown in Appendix 2-6, Figures 3 and 4, respectively.

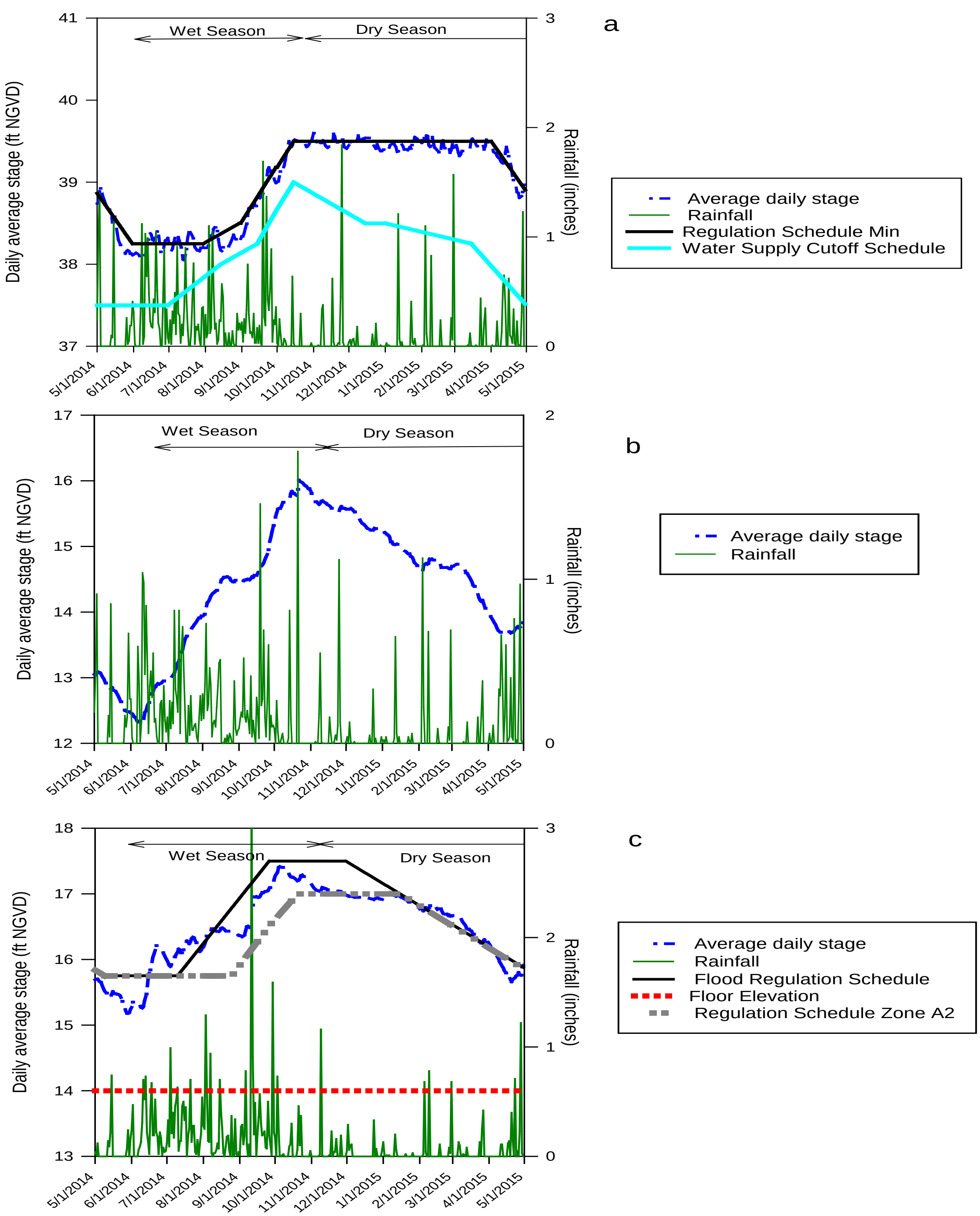


Figure 2-13. Average daily water levels (stage), regulation schedule, and rainfall for (a) Lake Istokpoga, (b) Lake Okeechobee, and (c) WCA-1.

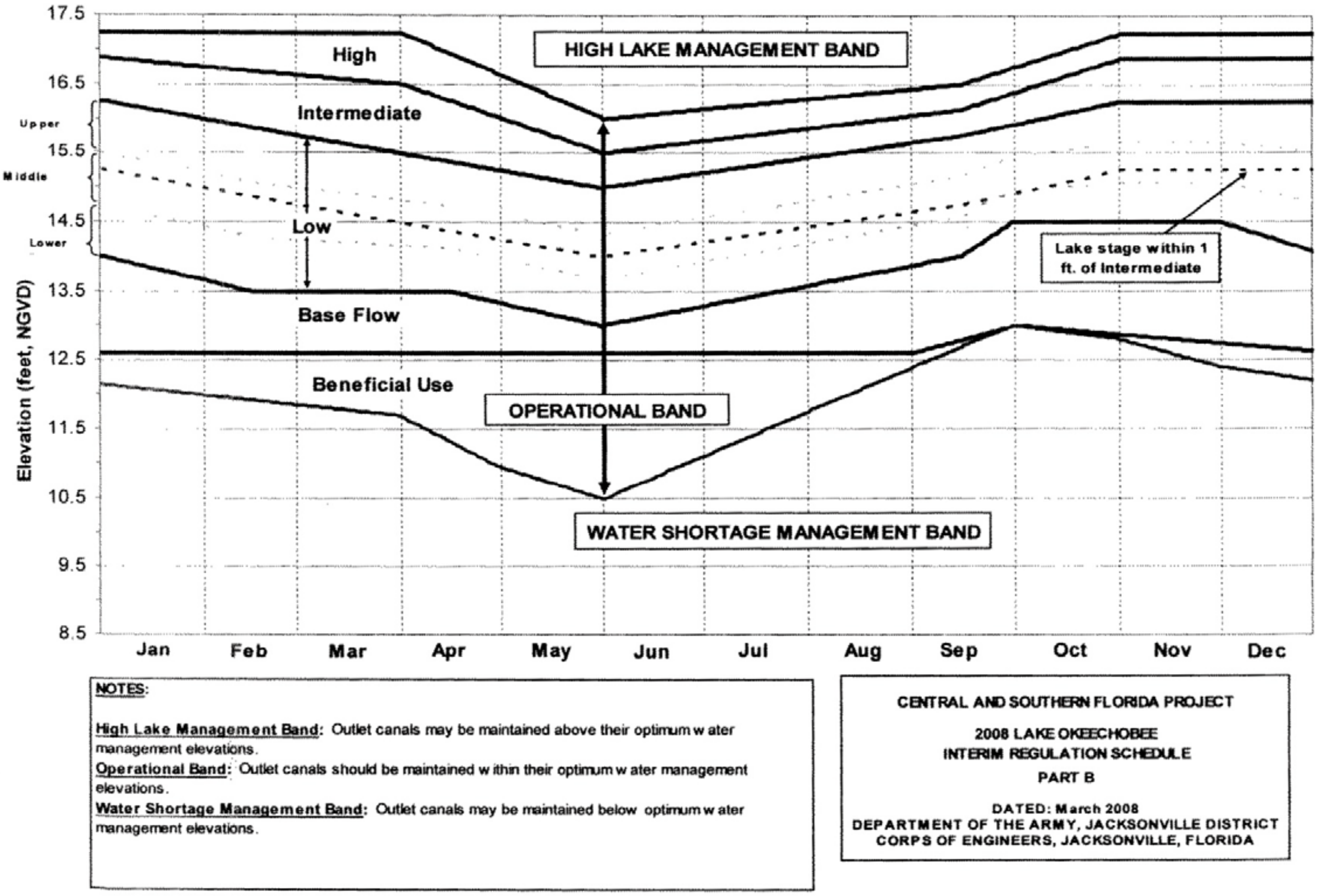


Figure 2-14. Lake Okeechobee's current regulation schedule (LORS2008).

As previously noted in the *Water Management in Water Year 2015* section of this chapter, the current regulation schedule for Lake Okeechobee is divided into three major bands: High Lake Management Band, Operational Band, and Water Shortage Management Band (**Figure 2-14**). The regulation schedule was developed by USACE based on several key considerations including the lake's ecology and environmental needs, Caloosahatchee and St. Lucie estuaries' environmental needs, Everglades environmental needs, and structural integrity of the Herbert Hoover Dike, and potential danger from hurricanes. While this regulation schedule attempts to balance the multipurpose needs of flood control, water supply, navigation, enhancement of fish and wildlife resources, and recreation, the dominant objective is public health and safety related to dike structural integrity. Notably, LORS2008 has expanded operational flexibility throughout the year and allows Lake Okeechobee to be managed at lower levels than the previous regulation schedule. It is implemented through a decision tree that consider lake water level, WCA water levels, tributary hydrologic conditions, multi-season climatic and hydrologic outlook, and downstream estuary conditions. The decision tree for establishing allowable lake releases to the WCAs and tide (estuaries) is shown in Abtew et al. (2011).

Upper East Coast and St. Lucie Canal and Estuary

Inflows to the St. Lucie Canal are received from Lake Okeechobee by operation of S-308, a gated spillway, the Port Mayaca lock, and runoff from the basin (Abtew et al. 2011). The optimum water control elevations for the St. Lucie Canal vary between 14.0 and 14.5 ft NGVD29. When the lake stage is below 14.5 ft NGVD29 and the S-308 structure is open, runoff from the C-44 (St. Lucie Canal) basin flows back to the lake with the C-44 canal stage relatively higher. The outflow from the St. Lucie Canal that is not used in the basin for water supply or canal stage maintenance is discharged into the estuary via the S-80 structure. Runoff from the basin (C-44) is discharged to the estuary through S-80. WY2015 flows from Lake Okeechobee to the St. Lucie Canal were 129,227 ac-ft while inflow into the St. Lucie Estuary through S-80 was 188,236 ac-ft. Lake Okeechobee discharge through S-308 in to the St. Lucie Canal that is not used for water supply and is discharged to the estuary was estimated at 80,250 ac-ft. The estimated basin runoff discharged to the estuary was 107,986 ac-ft (**Table 2-8**). As salinity is an important measure of estuary viability, volume and timing of freshwater flow at S-80 is a key feature of water management activities.

The C-23 canal discharges into the North Fork of the St. Lucie River at structure S-48. The C-24 canal discharges into the same fork at S-49. The C-25 canal discharges into the southern part of the Indian River Lagoon at structure S-50. Structure S-80 discharges water from the St. Lucie Canal into the South Fork of the St. Lucie River. Rainfall in Martin/St. Lucie rainfall area was average for WY2015. Outflows from the C-23 canal (S-48), C-25 canal (S-50), and St. Lucie Canal (S-80) were lower than WY2014 (**Table 2-8**). WY2015 monthly flows for S-48, S-49, S-50, and S-80 are shown in Appendix 2-5, Table 4. Monthly historical average, WY2014, and WY2015 flows are shown in Appendix 2-6, Figures 5 through 8. Water management decision regulating releases through S-80 into the St. Lucie River is shown in **Figure 2-10**.

Lower West Coast

Inflows to the Caloosahatchee River (C-43 Canal) are runoff from the basin watershed and releases from Lake Okeechobee by operation of S-77, a gated spillway and lock structure (Abtew et al. 2011). Structure S-77 operations use regulation procedures described by USACE (2008). Environmental water supply releases from the lake to the Caloosahatchee River occurred at various times (**Figure 2-10**). WY2015 flows from Lake Okeechobee to the Caloosahatchee River were 575,971 ac-ft, which is 109 percent of the historical average but 47 percent of WY2014 flows. WY2015 monthly Lake Okeechobee flows through S-77 are shown in Appendix 2-5, Table 5.

Downstream of S-77, S-78 is a gated spillway that also receives runoff from the East Caloosahatchee Watershed, its local watershed. The optimum water control elevation for this portion of the Caloosahatchee Canal (upstream of S-78 and downstream of S-77) is between 10.6 and 11.5 ft NGVD29. The outflow from the Caloosahatchee Canal (downstream of S-78) is discharged into the estuary via S-79, a gated spillway and lock operated by USACE. The operations of S-79 include runoff from the West Caloosahatchee and Tidal Caloosahatchee watersheds. The optimum water control elevations near S-79 range between 2.8 and 3.2 ft NGVD29. Because salinity is an important measure of estuary viability, the volume and timing of freshwater flow at S-79 is an important feature of water management activities. Water management decision regulating releases through S-79 into the Caloosahatchee Estuary is shown in **Figure 2-10**. WY2015 discharge through S-79 to the coast, 1,234,173 ac-ft, is the same as the historical average (1972–2015) and 49 percent of WY2014. Lake Okeechobee inflow into the Caloosahatchee Canal that is not used for water supply in the basins or canal stage maintenance is discharged into the estuary via the S-79 structure passing through S-78 along the route. Runoff from the basin (West Caloosahatchee and Tidal Caloosahatchee) is also discharged to the estuary. Lake Okeechobee discharge through S-77 that passed through S-78, not used for water supply, but discharged to the estuary was estimated at 486,598 ac-ft. The estimated basin runoff discharged to the estuary was 747,575 ac-ft (**Table 2-8**). WY2015 monthly flows for S-77 and S-79 are shown in Appendix 2-5, Table 5. Monthly historical average, WY2014, and WY2015 outflows at S-79 are shown in Appendix 2-6, Figure 9. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments and canals.

Everglades Agricultural Area

Four major canals pass through the EAA: West Palm Beach Canal, Hillsboro Canal, North New River Canal, and Miami Canal. Flows from Lake Okeechobee and runoff from the EAA are discharged via these four canals to relieve flooding for the local drainage area and into the Everglades STAs for water quality improvement. Discharges to the east coast occur through the West Palm Beach Canal. At times, when conditions do not allow for the STAs to treat all runoff water, diversion to the WCAs could occur. The inflows from Lake Okeechobee to these canals are from structures S-351, S-352, and S-354. These structures are gated spillways with a maximum tailwater elevation not to exceed 12 ft NGVD29 for Lake Okeechobee operation. The optimum water control elevations for S-351 and S-354 range between 11.5 and 12.0 ft NGVD29. During WY2015, daily average tailwater elevations at S-351 ranged from 9.5 to 12.07 ft NGVD29; at S-354 from 9.36 to 12.06 ft NGVD29, and at S-352 from 9.48 to 10.95 ft NGVD29. The outflows from the four canals to the STAs are discharged through pump structures S-5A, S-319, S-6, G-370, G-372, and G-434. Outflows from STAs are inflows into WCAs. During the dry season and drier-than-normal wet seasons, water supply for agricultural irrigation is provided by these four primary canals, mainly through gravity release from Lake Okeechobee. During droughts, when Lake Okeechobee levels are low, forward pumping is required to withdraw water from the lake. At times, water is also supplied to the EAA from the WCAs. Farmers utilize a set of secondary and tertiary farm canals to distribute water from several gated culverts and pumps to their respective fields.

Everglades Protection Area

Water Conservation Area 1

The primary objectives of the WCAs are to provide (1) flood control; (2) water supply for agricultural irrigation, municipalities, industry, and ENP; (3) regional groundwater control and prevention of saltwater intrusion, (4) enhancement of fish and wildlife; and (5) recreation. A secondary objective is the maintenance of marsh vegetation in the WCAs, which is expected to provide a dampening effect on hurricane-induced wind tides (Abtew et al. 2011). WCA-1 covers approximately 141,440 acres with a daily average water level of 15.68 ft NGVD29 (1960–2015).

WCA-1 is regulated mainly by outflow structures S-10A, S-10C, S-10D and S-39; the regulation schedule for WCA-1 is provided by USACE (1996). The main inflow structures are the G-251, G-310, and S-362 pump stations. Water supply releases are made through the G-94 (A, B, C), G-300, G-301, and S-39 structures. S-39 is also used to discharge excess water to the coast through the Hillsboro Canal. The regulation schedule varies from high stages in the late fall and winter to low stages at the beginning of the wet season (Abtew et al. 2007b). The seasonal range allows runoff storage during the wet season and water supply during the dry season and fulfills ecological needs. Water levels in WCA-1 started at 15.69 ft NGVD29 on May 1, 2014, and ended the year at 15.91 ft NGVD29. Water level rose to a maximum of 17.41 ft NGVD29 in October 2014 and declined the rest of the water year with few reversals due to high rainfall events. The mean water year stage was 16.49 ft NGVD29, 0.18 ft higher than WY2014 and 0.81 ft higher than the historical average. Four gauges (1-8C, 1-7, 1-8T, and 1-9) are used for stage monitoring. Daily water levels were compiled from the four gauges based on their regulation schedule uses. Site 1-8C was used from January 1 to June 30, while the remaining sites (1-7, 1-8T, and 1-9) were used to calculate the average water level for the year, but only if the average was lower than that of site 1-8C. **Figure 2-13**, panel c, depicts WY2015 daily average water level, daily rainfall, and regulation schedule for WCA-1. Daily average historical water levels are shown in Appendix 2-3, Figure 10, for the period of record (1960–2015). Monthly historical average, WY2014, and WY2015 water levels are shown in Appendix 2-4, Figure 10. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages.

The main inflows into WCA-1 are from Stormwater Treatment Area 1 West (STA-1W) through the G-251 and G-310 pump stations and from Stormwater Treatment Area 1 East (STA-1E) via pump station S-362. There are three diversion structures that can flow in both directions (G-300, G-301, and G-338). The main outflow from WCA-1 is to WCA-2 through the S-10 structures and S-39. The two diversion structures (G-300 and G-301) are also used to discharge water from WCA-1 to the north to the L-8 and C-51 canals via the STA-1 inflow basin. S-39 discharges to the east via the Hillsboro Canal. The G-94A, B, and C structures are used to make water supply releases to the east urban area.

Historical flows through each structure have varying lengths of period of record because new structures come online, or because existing structures may no longer contribute to the inflow and outflow of a system. The structures related to the Everglades STAs are relatively recent additions. WCA-1 is regulated between 14 and 17.50 ft NGVD29. WY2015 inflows into WCA-1 (245,360 ac-ft) were 52 percent of the historical average. In WY2015, 60 percent of the inflow was from STA-1W through pump stations G-310 and G-251, and 40 percent was from STA-1E through pump station S-362. No backflows occurred through the G-94s or S-10s. No inflow occurred through G-338. There was no flood diversion inflow through G-300 and G-301. Monthly historical average, WY2014, and WY2015 inflows are shown in Appendix 2-6, Figure 10.

WY2015 outflows from WCA-1 (198,051 ac-ft), were 45 percent of the historical average, for the analysis period from 1972 to 2015. Outflows from WCA-1 were mainly into WCA-2A through the S-10 structures (50 percent) and to the east through S-39 and the Hillsboro Canal (44 percent); and some backflow through the G-300 and G-301 structure for water supply into L-8 or C-51 canal. For the first time, water was syphoned back into STA-1W from WCA-1 for the purpose of hydrating STA-1W cells (701 ac-ft). Capacity to provide water to the affected cells through the normal northern path was limited. Flow to the east through G-94A was 5 percent. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments. WY2015 monthly outflows are shown in Appendix 2-5, Table 7. Monthly historical average, WY2014, and WY2015 outflows are shown in Appendix 2-6, Figures 11.

Water Conservation Area 2

WCA-2 is located south of WCA-1. An interior levee across the southern portion of the area subdivides it into WCA-2A and WCA-2B, reducing water losses due to seepage into the extremely pervious aquifer that underlies WCA-2B and precludes the need to raise existing levees to the grade necessary to provide protection against wind tides and wave run-up. Combined, WCA-2A and WCA-2B have a total area of 133,400 acres, with 80 percent of the area in WCA-2A. The regulation schedule for WCA-2A is provided by USACE (1996). A regulation schedule is not used for WCA-2B because of high seepage rates. Releases to WCA-2B from S-144, S-145, and S-146 are terminated when the indicator stage gauge 99 in WCA-2B exceeds 11.0 ft NGVD29. Discharges from WCA-2B are made from spillway structure S-141 to the North New River Canal when the pool elevation in WCA-2B exceeds 11.0 ft NGVD29. For WY2015, the water level in WCA-2A started at 11.61 ft NGVD29 and reached a maximum of 14.23 ft NGVD29 in October 2014 and end at 11.79 ft NGVD29 by the end of the water year. Water level stayed above the regulation schedule throughout the water year. The average stage was 12.30 ft NGVD29. Appendix 2-3, Figure 11 shows the daily water level for 1961–2015. **Figure 2-15**, panel a, depicts WY2015 daily average water level, daily rainfall, and regulation schedule for WCA-2A. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages. Monthly historical average, WY2014, and WY2015 water levels are shown in Appendix 2-4, Figure 11.

WY2015 inflows into WCA-2 (823,997 ac-ft) were 128 percent of the historical average and 76 percent of the inflows in WY2014. The major inflows to WCA-2A were STA-2 discharges through pump station G-335 and G-436 (65 percent), STA-3/4 discharges through the S-7 pump station (23 percent), Outflow from WCA-1 through the S-10 structures (12 percent), and minor flows through S-142 and G-339.

WY2015 outflows from WCA-2 (810,056 ac-ft) were 126 percent of the historical average and 84 percent of WY2014 outflows. Outflows from WCA-2 were primarily into WCA-3A through structures S-11A, B, and C (81 percent) and discharge to canals 13 and 14 through structure S-38 (19 percent). This water year, there was no backflow into the EAA from WCA-2. There was no outflow through the North New River Canal through structure S-34 and no outflow through G-339. There was small discharge to WCA-3A through the S-142. WY2015 monthly inflows and outflows are shown in Appendix 2-5, Tables 8 and 9, respectively. Monthly historical average, WY2014, and WY2015 inflows and outflows are shown in Appendix 2-6, Figures 12 and 13, respectively. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments and canals.

Water Conservation Area 3

WCA-3 is located south and southwest of WCA-2A. Two interior levees across the southeastern portion of the area subdivide it into WCA-3A and WCA-3B. These levees reduce water losses due to seepage into the extremely pervious aquifer that underlies WCA-3B. WCA-3A and WCA-3B combined have a total area of 585,560 acres, with 83 percent of the area in WCA-3A. The regulation schedule for WCA-3A is provided in USACE (1996). A regulation schedule is not used for WCA-3B because of high seepage rates. Indicator gauge 3B-2 is used for WCA-3B. Flow releases into WCA-3B are from the S-142 and S-151 structures, while releases from WCA-3B are through S-31 or S-337. S-151 permits releases of water from WCA-3A to supply water needs to South Miami-Dade County and along the Miami canal (C-6), C-7 and C-8 during the dry season. Discharges from WCA-3B are rarely made from culvert L-29-1 for water supply purposes.

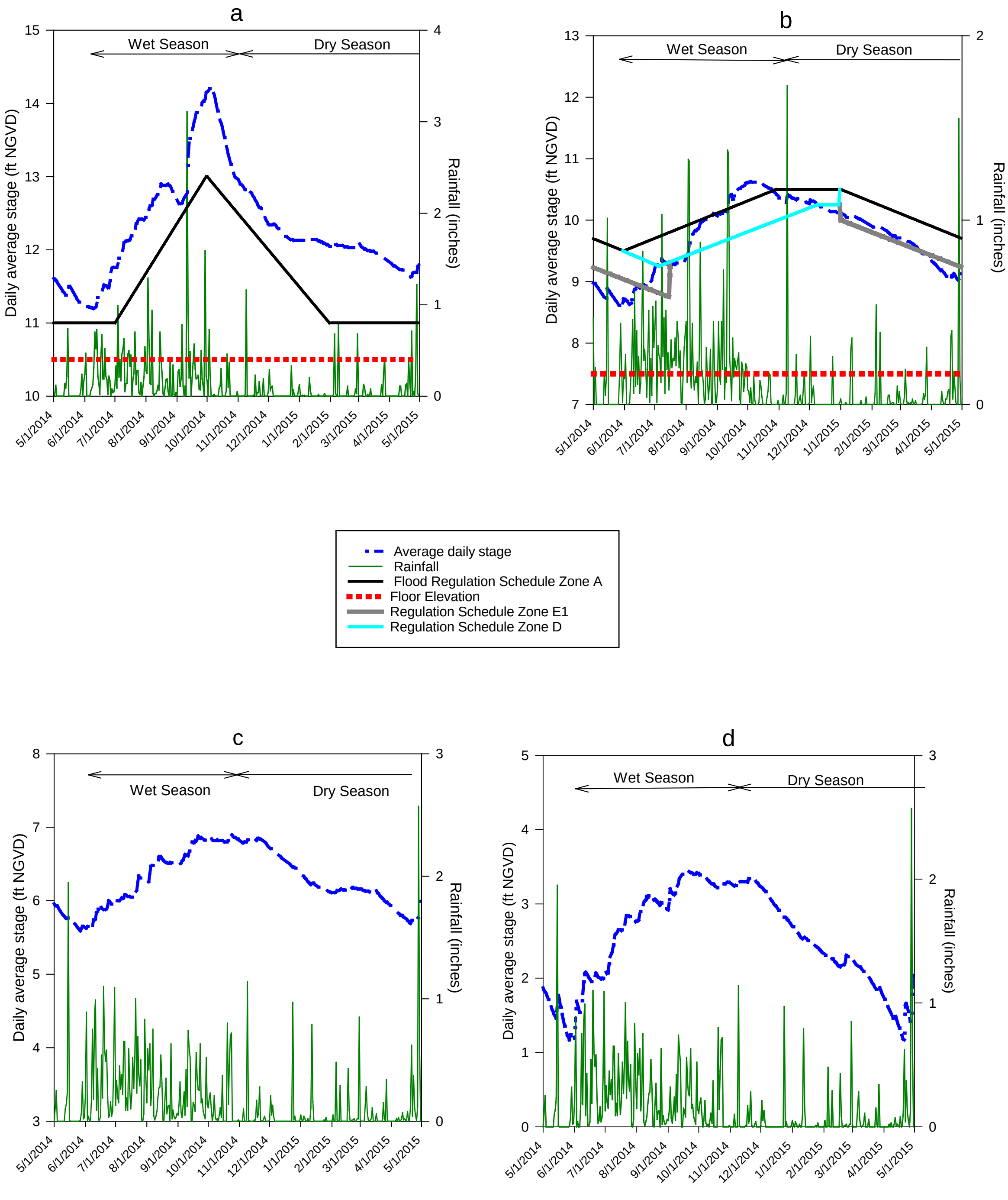


Figure 2-15. Average daily water levels (stage), regulation schedule, temporary deviation, and rainfall for (a) WCA-2A, (b) WCA-3A, (c) ENP gauge P-33, and (d) ENP gauge P-34.

Figure 2-15, panel b, depicts WY2015 daily average water level, daily rainfall, and regulation schedule for WCA-3A. The previous regulation schedule, which was known as the Interim Operational Plan for the Protection of the Cape Sable Seaside Sparrow, was replaced by a new regulation schedule known as Everglades Restoration Transition Plan as of October 19, 2012. Water levels in WCA-3 were above the flood regulation schedule in October 2014 and followed the regulation schedule Zone E1 for most of the period. The average stage was 9.74 ft NGVD29 with a maximum of 10.63 ft NGVD29 and minimum of 8.58 ft NGVD29 lower than WY2014 levels. Appendix 2-3, Figure 12, shows the daily water level for 1962–2015. Monthly historical average, WY2014, and WY2015 water levels are shown in Appendix 2-4, Figure 12. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages.

WY2015 inflows into WCA-3A (1,312,417 ac-ft) were 112 percent of historical average. The major inflows to WCA-3A in WY2015 were through S-11A, B, and C (50 percent) from WCA-2, and from STA-3/4 through structures S-8 (16 percent). There was no flow through S-150 due to maintenance construction. Inflows through the northwest gap opening were estimated at 10 percent with STA-5/6 contributions through the gap estimated at 4 percent. L-4 borrow canal gap or opening into the L-3 extension canal that is currently not gauged has a bottom width of 150 ft at an elevation of 3 ft NGVD29 (SFWMD 2002). Water released from the Miami Canal through the G-404 pumps into the L-4 canal but not released to the west through G-409 is estimated as inflow to WCA-3A through the gap. Also, outflows from STA-5/6 are considered inflows into WCA-3A through the gap as reported in Chapter 3A. Inflows from the east through structures S-9 and S-9A accounted for 9 percent of the total inflow. The S-140 and S-190 structures to the northwest contributed 8 and 3 percent of the inflow to WCA-3A, respectively.

WY2015 outflows from WCA-3A (779,167 ac-ft) were 78 percent of the historical average. Outflows from WCA-3A into ENP were through structures S-12A, B, C, and D (48 percent); S--151 (14 percent); S-333 (20 percent) with potential flow to ENP to the south or flow east through S--334; S-344 and S-343 (9 percent); S-31 (1 percent); and S-337 (8 percent); and no flow through S-30. There was minor flow through S-142. There was no backflow through S-8 and S-150. WY2015 monthly inflows and outflows are shown in Appendix 2-5, Tables 10 and 11, respectively. Monthly historical average, WY2014, and WY2015 inflows and outflows are shown in Appendix 2-6, Figures 14 and 15, respectively. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments and canals.

Everglades National Park

ENP is located south of WCA-3A and WCA-3B. Criterion for water delivery into ENP was the new Everglades Restoration Transition Plan regulation schedule replacing the Interim Operational Plan as of October 19, 2012. Water level monitoring at sites P-33 and P-34 has been used in previous reports as representative of slough and wet prairie, respectively (Sklar et al. 2003). Station elevations for P-33 and P-34 are 5.06 and 2.09 ft NGVD29, respectively (Sklar et al. 2000). Historical water level data for sites P-33 (1952–2015) and P-34 (1953–2015) were obtained from the District's corporate environmental database, DBHYDRO. WY2015 water level at both sites was far lower than WY2014 for each month reflecting the drought condition in the park. WY2015 average water level at P-33 was 6.28 ft NGVD29 and at P-34 was 2.51 ft NGVD29. **Figure 2-15**, panels c and d, depict the daily average water level and rainfall at P-33 and P-34, respectively, for WY2015. WY2015 daily and historical average water levels for P-33 and P-34 are shown in Appendix 2-3, Figures 13 and 14, respectively. Monthly historical average, WY2014, and WY2015 water levels for P-33 and P-34 are shown in Appendix 2-4, Figures 13 and 14, respectively. **Table 2-7** depicts WY2015, WY2014, and historical mean, maximum, and minimum stages.

WY2015 inflow into the ENP (1,015,301-ft) was 103 percent of the historical average and 64 percent of WY2014 inflows. Inflow into the ENP is mainly through structures S-12A, B, C, and D; S-18C, S-332B, S-332C, S-332D, S-333, S-199, and S-200. The major inflow (37 percent) was through the S-12 structures. The S-332B structure contributed (11 percent); S-332C (10 percent); S-332D (10 percent); S-18C (8 percent); S-333 (14 percent); S-200 (4 percent); and S-199 (6 percent). S-175, S-355A, S-355B, and S-356 had no flows. WY2015 monthly inflows are shown in Appendix 2-5, Table 12. Monthly historical average, WY2014, and WY2015 inflows are shown in Appendix 2-6, Figure 16. **Table 2-8** depicts WY2015, WY2014, and historical flow statistics for major impoundments.

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