

Chapter 2A: South Florida Hydrology and Water Management

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Highlights

Water Year 2023 (WY2023; May 1, 2021–April 30, 2022) had a total of 55.33 inches of rainfall, 2.11 inches above the historical average of 53.22. The wet season (June–September) received above average rainfall and the dry season (November–April) received about average rainfall in WY2023. During the WY2023 wet season (June–September), 35.27 inches of rain fell over all South Florida Water Management District (SFWMD) rainfall areas combined, which is 113% of the historical average. During the WY2023 dry season (November–April), 13.66 inches of rain fell over all SFWMD rainfall areas combined, which is 101% of the historical average. By region rainfall deviation from the historical average was as follows:

- Broward County: +17.02 inches
- Miami-Dade: +6.78 inches
- Water Conservation Areas 1 and 2: +6.56 inches
- Southwest Coast: +5.06 inches
- East Caloosahatchee: +3.85 inches
- Water Conservation Area 3: +3.63 inches
- West Everglades Agricultural Area (EAA): +3.42 inches
- East EAA: +2.60 inches
- Upper Kissimmee: +1.38 inches
- Big Cypress Preserve: +1.06 inches
- Lake Okeechobee: +0.49 inches
- Lower Kissimmee: -1.84 inches
- Martin/St. Lucie: -2.86 inches
- Palm Beach: -2.91 inches
- ENP: -11.00

Figure 2A-1 presents the major surface flow directions in the regional system for WY2023. **Table 2A-1** compares the WY2023 surface flows to WY2022 and historical average flows.

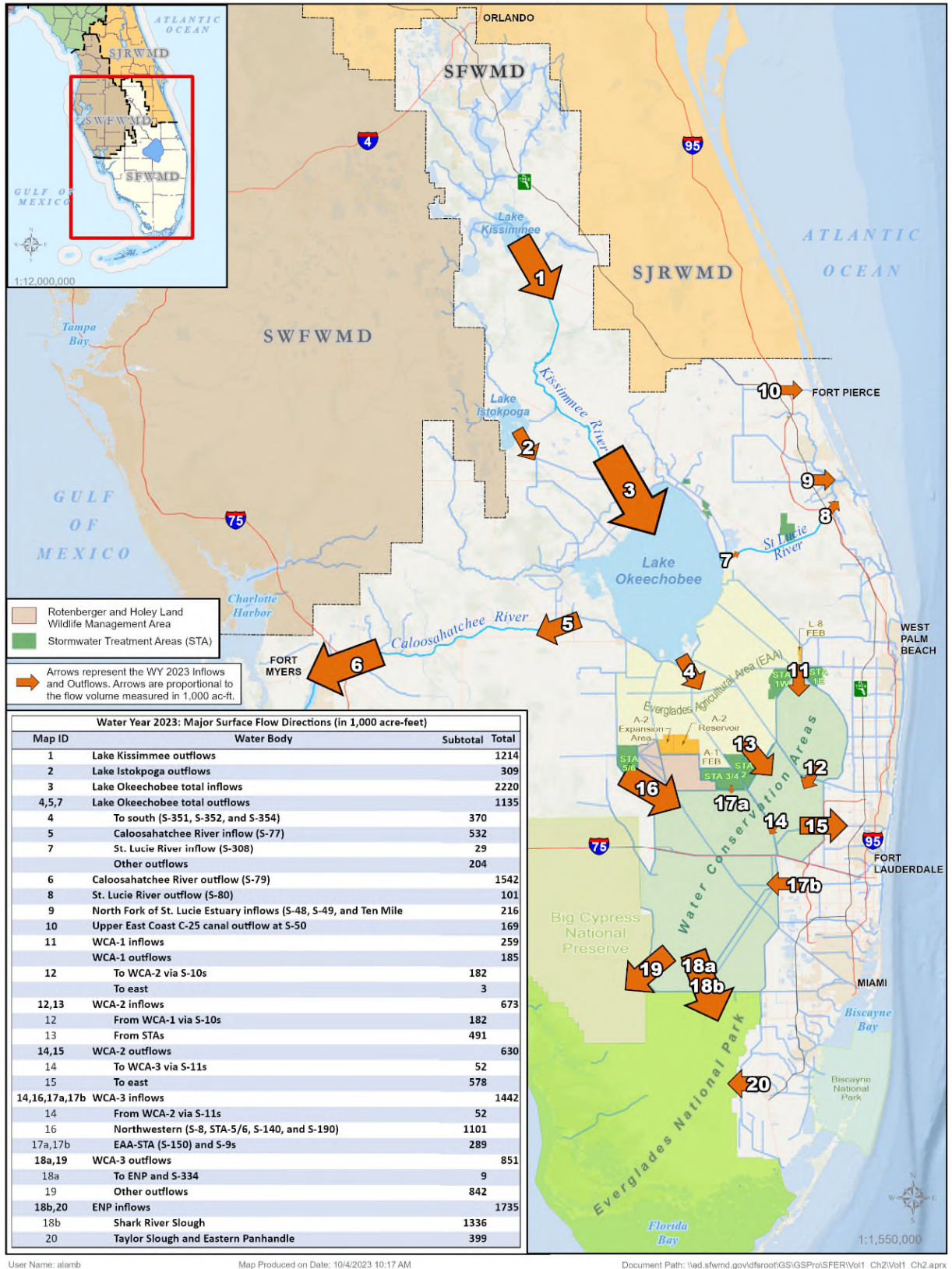


Figure 2A-1. WY2023 major surface flow directions.
 (Notes: ac-ft – acre-feet and STAs – Stormwater Treatment Area.)

Table 2A-1. Summary of surface flows in thousand acre-feet (10³ acre-feet) for WY2023 and WY2022, and historical flow statistics for major water bodies.

| Map ID | Water Body | WY2023 | | Historical ^{a,b} | | | WY2022 |
|-----------------------|---|--------------|-------------------------|---------------------------|--------------|------------|--------------|
| | | Flow | % of Historical Average | Annual Flow Statistics | | | Flow |
| | | | | Maximum | Average | Minimum | |
| 1 | Lake Kissimmee outflows | 1,214 | 164% | 2,175 | 740 | 16 | 690 |
| 2 | Lake Istokpoga outflows | 309 | 123% | 638 | 252 | 27 | 320 |
| 3 | Lake Okeechobee total inflows | 2,220 | 106% | 4,906 | 2,102 | 378 | 1,611 |
| | From north ^c | 2,096 | | | | | 1280 |
| | Other inflows | 124 | | | | | 331 |
| 4,5,7 | Lake Okeechobee total outflows | 1,135 | 75% | 3,979 | 1,505 | 177 | 1,394 |
| 4 | To south (S-351, S-352, and S-354) | d 370 | | | | | 524 |
| 5 | Caloosahatchee River inflow (S-77) | d 532 | 92% | 2,176 | 575 | 42 | 681 |
| 7 | St. Lucie River inflow (S-308) | d 29 | 10% | 1,018 | 278 | 4 | 115 |
| | Other outflows | e 204 | | | | | 74 |
| 6 | Caloosahatchee River outflow (S-79) | 1,542 | 119% | 3,616 | 1,298 | 87 | 899 |
| | Lake Okeechobee releases to Caloosahatchee Estuary | e 532 | | | | | 899 |
| | Caloosahatchee River Basin runoff into Caloosahatchee Estuary | e 1,010 | | | | | 0 |
| 8 | St. Lucie River outflow (S-80) | 101 | 32% | 1,193 | 319 | 0 | 315 |
| | Lake Okeechobee releases to St. Lucie Estuary | e 131 | | | | | 305 |
| | St. Lucie River Basin runoff into St. Lucie Estuary | e -30 | | | | | 10 |
| 9 | North Fork of St. Lucie Estuary inflows | 216 | 86% | 754 | 252 | 15 | 255 |
| | C-23 canal outflow at S-48 | 71 | | | | | 85 |
| | C-24 canal outflow at S-49 | 103 | | | | | 92 |
| | Ten Mile Creek at Gordy Road | 42 | | | | | 78 |
| 10 | Upper East Coast C-25 canal outflow at S-50 | 169 | 117% | 256 | 144 | 21 | 230 |
| 11 | WCA-1 inflows | 259 | 58% | 1,308 | 444 | 153 | 196 |
| 12 | WCA-1 outflows | 185 | 44% | 1,433 | 421 | 15 | 49 |
| 12 | To WCA-2 via S-10s | 182 | | | | | 46 |
| | To east | d 3 | | | | | 3 |
| 12,13 | WCA-2 inflows | 673 | 100% | 1,755 | 673 | 113 | 473 |
| 12 | From WCA-1 via S-10s | 182 | | | | | 46 |
| 13 | From STAs | 491 | | | | | 427 |
| 14,15 | WCA-2 outflows | 630 | 94% | 1,729 | 672 | 94 | 516 |
| 14 | To WCA-3 via S-11s | 52 | | | | | 411 |
| 15 | To east | d 578 | | | | | 105 |
| 14,16, 17a,17b | WCA-3 inflows | 1,442 | 118% | 2,269 | 1,222 | 393 | 1,343 |
| 14 | From WCA-2 via S-11s | 52 | | | | | 411 |
| 16 | Northwestern (S-8, STA-5/6, S-140, and S-190) | 1,101 | | | | | 792 |
| 17a,17b | EAA-STA (S-150) and S-9s | 289 | | | | | 140 |
| 18a,19 | WCA-3 outflows | 851 | 81% | 2,581 | 1,047 | 246 | 984 |
| 18a | To ENP and S-334 | d 9 | | | | | 1036 |
| 19 | Other outflows | 842 | | | | | -52 |
| 18b,20 | ENP inflows | 1,735 | 162% | 2,838 | 1,068 | 165 | 1,065 |
| 18b | Shark River Slough | 1,336 | | | | | 827 |
| 20 | Taylor Slough and Eastern Panhandle | e 399 | | | | | 238 |

a. Historical periods are 1972–2019 for all flows, except 1996–2019 for C-23 Canal and 2000–2019 for Ten Mile Creek.

b. Historical flow statistics list only total flows and major outflows from Lake Okeechobee. More information can be found in Appendix 2-4.

c. See Table 2 in Appendix 2-4 for included structures.

d. Includes water supply deliveries.

e. Derived from other flows.

INTRODUCTION

This chapter presents a large-scale overview of South Florida hydrology and water management system operations for Water Year 2023 (WY2023; May 1, 2022–April 30, 2023). It provides (1) a brief introduction of the regional water management system, (2) highlights of extreme hydrologic events, (3) summaries of rainfall, evapotranspiration, and groundwater levels by area, (4) a summary of wildfires, (5) overall water management operations, and (6) stage variations of major water bodies and surface flow across the region within the South Florida Water Management District (SFWMD) boundaries. Appendices 2-1 through 2-5 of this volume provide supplementary information for this chapter (**Table 2A-2**). Other Volume I chapters provide more details of hydrology at the basin level and discuss the incorporation of science into the water management decision-making process. Similar information from previous water years is available in chapters and appendices of past South Florida Environmental Reports (SFERs) – Volume I at www.sfwmd.gov/sfer.

Table 2A-2. List of appendices.

| Appendix | Title |
|----------|---|
| 2A-1 | Area Maps and Major Hydrologic Components |
| 2A-2 | Monthly Totals for Water Year 2023 Rainfall and Potential Evapotranspiration, and Historical Average Rainfall |
| 2A-3 | Monthly Flows for Water Year 2023, Water Year 2022, and Historical Averages |
| 2A-4 | Daily and Monthly Average Stages for Water Year 2023, Water Year 2022, and Historical Periods |
| 2A-5 | Water Year 2023 Groundwater Levels |

BACKGROUND

SOUTH FLORIDA’S WATER MANAGEMENT SYSTEM: A REGIONAL OVERVIEW

Located at the southern peninsula of Florida, the South Florida region features a humid semi-tropical climate and flat, low topography making the region vulnerable to flooding especially due to tropical storms and hurricanes with sustained high intensity rainfall. Highly variable hydrologic conditions can change quickly from extreme drought to flood. Annual rainfall amounts and seasonal rainfall patterns vary across the region because rainfall is highly influenced by the oceans surrounding the Florida peninsula and the large lakes within it (e.g., Lake Okeechobee). The intense sunlight Florida receives year-round heats the land surface, forming convective storms over cities and natural areas when sea breezes from both coasts move inland. Each year, tropical storms and hurricanes bring heavy rainfall to the region. South Florida’s climate is divided into three distinct seasons, based on the amount of rainfall received throughout the year (**Table 2A-3**). Long-term averages indicate South Florida has an annual rainfall of about 53 inches, and three-quarters of it occurs during the wet season and transitional months (Ali and Abteu 1999).

Table 2A-3. Seasonal rainfall averages in South Florida (Ali and Abteu 1999).

| Season | Months | Average Rainfall |
|--------------|-----------------|------------------|
| Dry | November–April | ~2 inches/month |
| Transitional | May and October | ~4 inches/month |
| Wet | June–September | ~7 inches/month |

The Central and Southern Florida Flood Control Project (C&SF Project), the highly engineered water management system within South Florida, is one of the world's largest including about 2,175 miles of canals, 2,130 miles of levee/berms, 915 water control structures, 620 culverts, 85 pump stations, and 3,537 hydrological monitoring stations at more than 687 flow sites, including 201 rain gauges and 22 weather stations. SFWMD and the United States Army Corps of Engineers (USACE) manage the region's water resources to meet and balance multiple objectives, including flood protection, water supply, navigation, recreation, and natural systems' needs. Working together, the two agencies operate water control structures according to regulation schedules and operational rules (USACE 1994, 1995, 1996, 2008, 2012).

The regional hydrology is driven by rainfall, rainfall-generated surface runoff, groundwater recharge and discharge, and evapotranspiration. Surface runoff recharges groundwater increases lake and impoundment water levels and replenishes wetlands. Several groundwater aquifers are part of South Florida's water resources, and their water levels respond quickly to changes in rainfall and surface water conditions including water in canals and lakes. Most municipal water supply sources utilize groundwater.

South Florida has a general north-to-south hydraulic gradient. The northernmost point of the South Florida hydrologic system is the Kissimmee Chain of Lakes (KCOL), which is a principal inflow source to Lake Okeechobee, the largest lake in the southeastern United States. Lake Okeechobee is the center of the South Florida hydrologic system and plays critical roles in flood control during the wet season and water supply during the dry season. The lake outflows to the St. Lucie River and Estuary, Caloosahatchee River and Estuary, Lake Worth Lagoon, Everglades Agricultural Area (EAA), and Everglades Stormwater Treatment Areas (STAs). The STAs are large, constructed wetlands that treat water (Chimney 2017) before it flows into the Everglades Protection Area (EPA), which includes Water Conservation Area (WCA) 1 (also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge), WCA-2, WCA-3, and Everglades National Park (ENP). Flow equalization basins (FEBs), relatively new additions to the water management system, help attenuate flows into the STAs. Appendix 2-1 provides area maps and background information about major hydraulic components in the regional water management system.

RAINFALL AREAS

The total rainfall area within South Florida, including ENP (about 1.4 million acres), covers about 18,000 square miles. SFWMD computes and reports rainfall estimates over about 16,000 square miles (10.3 million acres), which does not include ENP. The ENP rainfall is presented separately from the SFWMD average rainfall due to differing methods used for historic and current tracking. Major hydrologic regions are the Upper Kissimmee Basin (including the KCOL), Lower Kissimmee Basin (including Lake Istokpoga), Lake Okeechobee, EAA, Caloosahatchee River and St. Lucie River basins, Upper East Coast (UEC; including Martin and St. Lucie counties, as well as the northeastern portion of Okeechobee County), Lower East Coast (LEC; including Palm Beach, Broward, and Miami-Dade counties and parts of Monroe, Collier, and Hendry counties), WCAs, and Lower West Coast (LWC; including Lee County and portions of Charlotte, Collier, Glades, Hendry, and Monroe counties). More detailed maps are provided in Appendix 2-1.

In support of operations and data analyses, SFWMD has divided the region into 14 rainfall areas plus ENP (**Figure 2A-2** and **Table 2A-4**). Rainfall data from multiple and overlapping gauges are used to compute average rainfall over each area. Real-time rainfall observations aid in making water management decisions timely and effective.

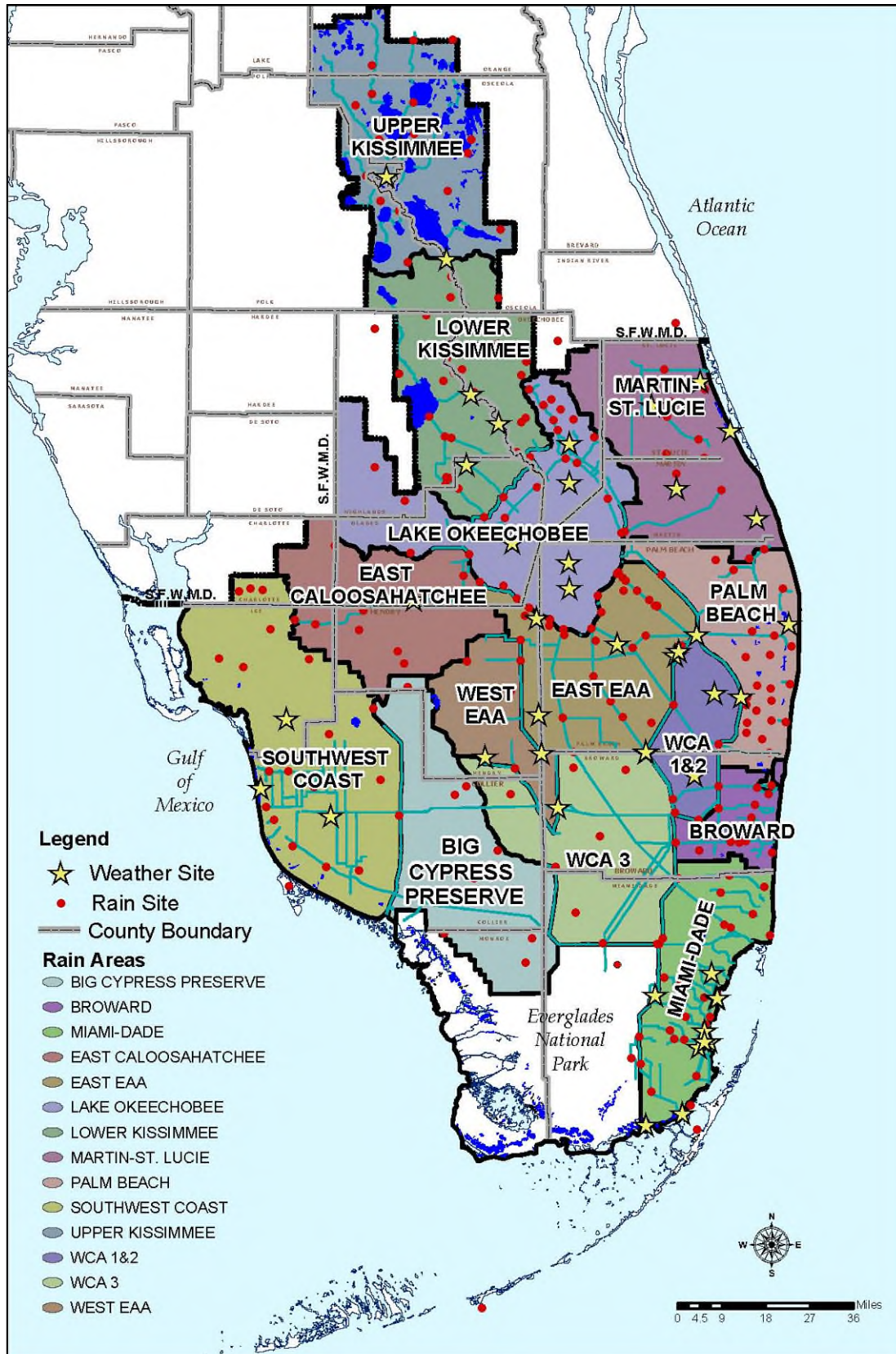


Figure 2A-2. SFWMD rainfall areas.

Table 2A-4. Surface areas of SFWMD’s rainfall areas along with their size and beginning of rainfall records.

| Rainfall Area | Area (1,000 acres) | Beginning of the Rainfall Record |
|----------------------------------|-----------------------|-------------------------------------|
| Upper Kissimmee | 1,020 | 1901 |
| Lower Kissimmee | 1,079 | 1965 |
| Lake Okeechobee | 981 | 1929 |
| East EAA | 660 | 1925 |
| West EAA | 309 | 1957 |
| WCA-1 & WCA-2 | 281 | 1957 |
| WCA-3 | 721 | 1957 |
| Martin/St Lucie | 786 | 1901 |
| Palm Beach | 519 | 1900 |
| Broward | 220 | 1943 |
| Miami-Dade | 567 | 1902 |
| East Caloosahatchee | 627 | 1919 |
| Big Cypress Preserve | 799 | 1914 |
| Southwest Coast | 1,764 | 1914 |
| Total SFWMD Rainfall Area | 10,334 | |
| ENP | 1,408 | |

STORAGE IN LAKES AND IMPOUNDMENTS

Flexibility in the regional water management system provides for storage for both flood control and water supply. While the available storage volume varies significantly from year to year due to highly variable rainfall and runoff, managing stage and storage alleviates the impact of rapid changes in rainfall amount and timing. Regulation schedules guide the management of water levels and storage in lakes and impoundments. The *Water Management in Water Year 2023* section later in this chapter provides details on the regulation schedule for each water body and temporary modifications from normal regulation schedules for WY2023. Regulation schedule deviations consider environmental needs, such as the Everglade snail kite (*Rostrhamus sociabilis plumbeus*), and construction and maintenance activities.

Stage-storage relationships for lakes and impoundments are critical information required for managing water levels and storage and computing average hydraulic residence time. For example, during wet conditions and high flow periods, storage between the actual stage and maximum regulatory stage is limited, and water must be released. Appendix 2A-4 in the 2007 SFER – Volume I (Abteu et al. 2007) compiles stage-storage charts for major lakes and impoundments and stage-area relationships where data are available.

PUMPING FACILITATES MOVING WATER

Moving water requires pumping in parts of the system due to the low gradient south of Lake Okeechobee. While elevations drop rapidly from Lake Kissimmee, which is at 50 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29), to Lake Okeechobee (about 15 ft NGVD29) over a distance of about 60 miles, elevations decrease gradually from the WCAs (15 ft NGVD29) to ENP (about 9 ft NGVD29) in about 70 miles. The water management system employs over 85 pump stations and installs temporary pumps as needed to move water. The average annual pumping volume for WY1996 through WY2023 was 3.6 million acre-feet (ac-ft) (Table 2A-5). The total pumped volume for WY2023 was 4.2 million ac-ft.

Table 2A-5. Total volume of water pumped by SFWMD for WY1996–WY2023.

| Water year | Volume of Water Pumped (million ac-ft) |
|-------------------|---|
| 1996 | 2.9 |
| 1997 | 1.8 |
| 1998 | 2.3 |
| 1999 | 1.7 |
| 2000 | 2.9 |
| 2001 | 1.6 |
| 2002 | 2.8 |
| 2003 | 3.4 |
| 2004 | 2.9 |
| 2005 | 3.5 |
| 2006 | 4.2 |
| 2007 | 2.4 |
| 2008 | 2.2 |
| 2009 | 3.7 |
| 2010 | 4.3 |
| 2011 | 2.4 |
| 2012 | 2.5 |
| 2013 | 4.1 |
| 2014 | 4.4 |
| 2015 | 4.1 |
| 2016 | 4.7 |
| 2017 | 4.3 |
| 2018 | 6.9 |
| 2019 | 5.1 |
| 2020 | 3.7 |
| 2021 | 6.7 |
| 2022 | 4.0 |
| 2023 | 4.2 |
| Average | 3.6 |

WATER YEAR 2023 HYDROLOGY

RAINFALL AND EVAPOTRANSPIRATION

South Florida is generally wet with an average annual rainfall of about 53 inches (1991–2020), and about 64% of it falls in the wet season from June to September (Ali and Abteew 1999). **Table 2A-6** shows the monthly and annual 30-year (1991–2020) historical average rainfall for each of the SFWMD’s rainfall areas and the overall SFWMD.

In previous chapter reporting years, historical average rainfall was calculated based on the data available from the beginning of the period of record through 1995 within each of SFWMD’s rainfall areas. Beginning with the 2022 reporting year chapter, the historical average rainfall presented is based on rainfall data from the last 30 years and represents the current climate of South Florida. The update is a more accurate basis for comparing monthly, seasonal, and annual climate conditions observed each water year to what is normal for SFWMD’s regional climate today. This update also aligns with regular operational reporting by the SFWMD.

Daily rainfall data for each of the SFWMD rainfall areas are available online at https://my.sfwmd.gov/sfwmd/common/images/weather/site_frm.html. The ENP rainfall data is produced from Raindar estimates and the average of the 25 rain gauges for which data is available in the SFWMD’s corporate environmental database, DBHYDRO (www.sfwmd.gov/dbhydro). **Table 2A-7** provides monthly rainfall for each of the SFWMD’s rainfall areas and ENP in WY2023. **Table 2A-8** presents the percent of monthly rainfall for each of the SFWMD’s rainfall areas and ENP in WY2023 relative to the 30-year historical average. **Table 2A-9** presents dry and wet return periods in terms of monthly rain in each rainfall area during WY2023.

During WY2023, rainfall within SFWMD boundaries was 55.33 inches, 2.11 inches above the historical average of 53.22. The wet season (June–September) received above average rainfall and the dry season (November–April) received about average rainfall in WY2023. During the WY2023 wet season, 35.27 inches of rain fell over all SFWMD rainfall areas combined, which is 113% of the historical average. During the WY2023 dry season, 13.66 inches of rain fell over all SFWMD rainfall areas combined, which is 101% of the historical average.

WY2023 began during the transitional month into the wet season with average rainfall in May 2022 (4.33 inches, 99%), and ended during the last month of the dry season with above average rainfall in April 2023 (6.11 inches, 225%). The region received below average rainfall in July 2022 (5.75 inches, 80%) and December 2022 (1.54 inches, 79%).

The wettest months of WY2023 were April 2022 (6.11 inches, 225%), June 2022 (10.32 inches, 119%), September 2022 (13.52 inches, 185%), and November 2022 (3.69 inches, 169%). During April 2023, Broward County received record breaking rainfall (16.60 inches, 496%), making April 2023 the wettest April in SFWMD record over the past 32 years.

Table 2A-6. SFWMD 30-year (1991–2020) historical average rainfall in inches.
 Source: [SFWMD 30-Year Historical Average Rainfall \(1991–2020, inches\) | South Florida Water Management District](#).

| Month | Upper Kissimmee | Lower Kissimmee | Lake Okeechobee | East EAA | West EAA | WCA-1 & WCA-2 | WCA-3 | Martin/St Lucie | Palm Beach | Broward | Miami-Dade | East Caloosahatchee | Big Cypress Preserve | Southwest Coast | SFWMD Average |
|---------------------------------------|-----------------|-----------------|-----------------|--------------|--------------|---------------|--------------|-----------------|--------------|--------------|--------------|---------------------|----------------------|-----------------|---------------|
| May | 3.88 | 3.91 | 3.70 | 3.70 | 4.83 | 5.05 | 4.94 | 4.34 | 5.07 | 5.47 | 5.42 | 4.27 | 4.61 | 3.92 | 4.37 |
| June | 8.46 | 7.92 | 7.40 | 7.40 | 8.51 | 8.07 | 8.93 | 7.46 | 8.39 | 8.60 | 8.98 | 9.50 | 10.10 | 10.12 | 8.65 |
| July | 6.98 | 6.95 | 5.82 | 6.68 | 8.18 | 6.75 | 7.13 | 6.47 | 6.18 | 6.73 | 7.14 | 7.99 | 8.07 | 8.97 | 7.20 |
| August | 7.77 | 7.59 | 6.88 | 7.34 | 8.15 | 7.58 | 7.47 | 8.13 | 8.40 | 7.89 | 8.17 | 8.78 | 8.44 | 9.43 | 8.03 |
| September | 6.31 | 6.13 | 5.89 | 6.58 | 7.16 | 7.03 | 7.04 | 7.20 | 8.24 | 8.37 | 8.82 | 7.55 | 8.10 | 8.94 | 7.31 |
| October | 3.13 | 3.27 | 3.18 | 3.79 | 4.02 | 4.96 | 4.58 | 5.18 | 5.82 | 6.48 | 6.55 | 3.27 | 4.06 | 3.74 | 4.15 |
| November | 1.90 | 1.67 | 1.64 | 1.98 | 1.84 | 2.53 | 2.39 | 2.99 | 3.30 | 3.64 | 3.10 | 1.78 | 1.91 | 1.83 | 2.18 |
| December | 2.40 | 1.83 | 1.60 | 1.62 | 1.66 | 2.10 | 1.64 | 2.38 | 2.76 | 2.38 | 2.29 | 1.72 | 1.57 | 1.77 | 1.94 |
| January | 2.43 | 1.97 | 1.95 | 2.13 | 2.20 | 2.25 | 2.01 | 2.47 | 3.22 | 2.51 | 1.97 | 2.11 | 2.13 | 2.39 | 2.24 |
| February | 2.09 | 2.00 | 1.78 | 1.88 | 1.83 | 2.20 | 1.92 | 2.31 | 2.72 | 2.28 | 2.04 | 1.84 | 1.88 | 1.89 | 2.01 |
| March | 2.83 | 2.53 | 2.41 | 2.35 | 2.28 | 2.56 | 1.97 | 3.08 | 3.11 | 2.60 | 2.22 | 2.26 | 1.99 | 2.15 | 2.43 |
| April | 2.72 | 2.48 | 2.31 | 2.50 | 2.66 | 2.85 | 2.98 | 2.99 | 3.24 | 3.35 | 3.03 | 2.65 | 2.73 | 2.43 | 2.71 |
| Total | 50.90 | 48.25 | 44.56 | 49.15 | 53.32 | 53.93 | 53.00 | 55.00 | 60.45 | 60.30 | 59.73 | 53.72 | 55.59 | 57.58 | 53.22 |
| Wet season (June–September) | 29.52 | 28.59 | 25.99 | 28.00 | 32.00 | 29.43 | 30.57 | 29.26 | 31.21 | 31.59 | 33.11 | 33.82 | 34.71 | 37.46 | 31.19 |
| Dry Season (November–April) | 14.37 | 12.48 | 11.69 | 12.46 | 12.47 | 14.49 | 12.91 | 16.22 | 18.35 | 16.76 | 14.65 | 12.36 | 12.21 | 12.46 | 13.51 |

Table 2A-7. WY2023 monthly, seasonal, and total annual rainfall in inches for each rainfall area and ENP. (Note: Data for each rainfall area is from the SFWMD’s 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 EST. ENP rainfall is the average of 25 rainfall gauge stations.)

| Month | Upper Kissimmee | Lower Kissimmee | Lake Okeechobee | East EAA | West EAA | WCA-1 & WCA-2 | WCA-3 | Martin/St Lucie | Palm Beach | Broward | Miami-Dade | East Caloosahatchee | Big Cypress Preserve | Southwest Coast | SFWMD Average | ENP |
|---------------------------------------|-----------------|-----------------|-----------------|--------------|--------------|---------------|--------------|-----------------|--------------|--------------|--------------|---------------------|----------------------|-----------------|---------------|--------------|
| May 2022 | 2.98 | 2.49 | 3.55 | 5.20 | 5.43 | 7.19 | 5.41 | 2.41 | 4.12 | 5.64 | 5.12 | 4.56 | 4.71 | 5.65 | 4.33 | 5.78 |
| June 2022 | 5.48 | 8.08 | 7.49 | 9.43 | 9.16 | 10.57 | 12.17 | 9.16 | 10.70 | 14.40 | 15.13 | 11.14 | 12.36 | 13.62 | 10.32 | 12.72 |
| July 2022 | 5.35 | 5.17 | 4.93 | 5.66 | 6.67 | 6.34 | 5.79 | 4.86 | 4.40 | 4.80 | 4.36 | 5.71 | 6.88 | 8.11 | 5.75 | 5.54 |
| August 2022 | 7.64 | 5.46 | 4.91 | 3.66 | 7.25 | 3.17 | 4.00 | 3.67 | 3.72 | 4.02 | 4.09 | 8.72 | 7.21 | 8.16 | 5.68 | 4.60 |
| September 2022 | 17.70 | 12.09 | 10.35 | 12.94 | 13.46 | 12.77 | 13.69 | 13.22 | 13.21 | 13.56 | 11.74 | 13.74 | 12.77 | 16.07 | 13.52 | 11.50 |
| October 2022 | 0.82 | 1.56 | 1.56 | 2.52 | 3.21 | 2.45 | 1.60 | 2.28 | 2.23 | 3.60 | 3.20 | 2.09 | 2.51 | 2.24 | 2.07 | 2.94 |
| November 2022 | 3.93 | 4.18 | 3.74 | 2.93 | 2.26 | 4.46 | 2.25 | 5.78 | 5.71 | 7.20 | 6.27 | 3.36 | 1.65 | 2.04 | 3.69 | 2.09 |
| December 2022 | 1.27 | 1.31 | 1.07 | 0.90 | 0.82 | 1.19 | 1.36 | 1.84 | 3.06 | 1.74 | 1.55 | 1.68 | 2.26 | 1.58 | 1.54 | 1.38 |
| January 2023 | 0.86 | 0.69 | 0.62 | 0.26 | 0.26 | 0.29 | 0.25 | 0.44 | 0.24 | 0.14 | 0.06 | 0.78 | 0.26 | 0.57 | 0.46 | 0.11 |
| February 2023 | 0.68 | 0.48 | 0.54 | 0.74 | 0.35 | 2.15 | 0.99 | 1.03 | 1.33 | 3.44 | 4.08 | 0.20 | 0.23 | 0.09 | 0.89 | 1.64 |
| March 2023 | 1.06 | 0.51 | 0.81 | 0.76 | 1.69 | 1.17 | 1.58 | 0.54 | 0.80 | 2.18 | 1.88 | 0.99 | 0.91 | 0.45 | 0.97 | 0.95 |
| April 2023 | 4.51 | 4.39 | 5.48 | 6.75 | 6.18 | 8.74 | 7.54 | 6.91 | 8.02 | 16.60 | 9.03 | 4.60 | 4.90 | 4.06 | 6.11 | 4.93 |
| Total | 52.28 | 46.41 | 45.05 | 51.75 | 56.74 | 60.49 | 56.63 | 52.14 | 57.54 | 77.32 | 66.51 | 57.57 | 56.65 | 62.64 | 55.33 | 54.65 |
| Wet season (June–September) | 36.17 | 30.80 | 27.68 | 31.69 | 36.54 | 32.85 | 35.65 | 30.91 | 32.03 | 36.78 | 35.32 | 39.31 | 39.22 | 45.96 | 35.27 | 34.37 |
| Dry Season (November–April) | 12.31 | 11.56 | 12.26 | 12.34 | 11.56 | 18.00 | 13.97 | 16.54 | 19.16 | 31.30 | 22.87 | 11.61 | 10.21 | 8.79 | 13.66 | 11.56 |

Table 2A-8. WY2023 monthly, seasonal, and total annual percentage of historical average.

| Month | Upper Kissimmee | Lower Kissimmee | Lake Okeechobee | East EAA | West EAA | WCA-1 & WCA-2 | WCA-3 | Martin/St Lucie | Palm Beach | Broward | Miami-Dade | East Caloosahatchee | Big Cypress Preserve | Southwest Coast | SFWMD Average |
|--------------------------------|-----------------|-----------------|-----------------|----------|----------|---------------|-------|-----------------|------------|---------|------------|---------------------|----------------------|-----------------|---------------|
| May 2022 | 77% | 64% | 96% | 141% | 112% | 142% | 110% | 56% | 81% | 103% | 94% | 107% | 102% | 144% | 99% |
| June 2022 | 65% | 102% | 101% | 127% | 108% | 131% | 136% | 123% | 128% | 167% | 168% | 117% | 122% | 135% | 119% |
| July 2022 | 77% | 74% | 85% | 85% | 82% | 94% | 81% | 75% | 71% | 71% | 61% | 71% | 85% | 90% | 80% |
| August 2022 | 98% | 72% | 71% | 50% | 89% | 42% | 54% | 45% | 44% | 51% | 50% | 99% | 85% | 87% | 71% |
| September 2022 | 281% | 197% | 176% | 197% | 188% | 182% | 194% | 184% | 160% | 162% | 133% | 182% | 158% | 180% | 185% |
| October 2022 | 26% | 48% | 49% | 66% | 80% | 49% | 35% | 44% | 38% | 56% | 49% | 64% | 62% | 60% | 50% |
| November 2022 | 207% | 250% | 228% | 148% | 123% | 176% | 94% | 193% | 173% | 198% | 202% | 189% | 86% | 111% | 169% |
| December 2022 | 53% | 72% | 67% | 56% | 49% | 57% | 83% | 77% | 111% | 73% | 68% | 98% | 144% | 89% | 79% |
| January 2023 | 35% | 35% | 32% | 12% | 12% | 13% | 12% | 18% | 7% | 6% | 3% | 37% | 12% | 24% | 21% |
| February 2023 | 33% | 24% | 30% | 39% | 19% | 98% | 52% | 45% | 49% | 151% | 200% | 11% | 12% | 5% | 44% |
| March 2023 | 37% | 20% | 34% | 32% | 74% | 46% | 80% | 18% | 26% | 84% | 85% | 44% | 46% | 21% | 40% |
| April 2023 | 166% | 177% | 237% | 270% | 232% | 307% | 253% | 231% | 248% | 496% | 298% | 174% | 179% | 167% | 225% |
| Total | 103% | 96% | 101% | 105% | 106% | 112% | 107% | 95% | 95% | 128% | 111% | 107% | 102% | 109% | 104% |
| Wet Season (June–September) | 123% | 108% | 107% | 113% | 114% | 112% | 117% | 106% | 103% | 116% | 107% | 116% | 113% | 123% | 113% |
| Dry Season (November–April) | 86% | 93% | 105% | 99% | 93% | 124% | 108% | 102% | 104% | 187% | 156% | 94% | 84% | 71% | 101% |

Table 2A-9. WY2023 monthly rainfall return periods for each area. Derived from Ali and Abtew (1999).
(Note: yr – year and avg – average.)

| Month | Upper Kissimmee | Lower Kissimmee | Lake Okeechobee | East EAA | West EAA | WCA-1 & WCA-2 | WCA-3 | Martin/St. Lucie | Palm Beach | Broward | Miami-Dade | East Caloosahatchee | Big Cypress Preserve | Southwest Coast |
|----------------|-----------------|-----------------|-----------------|-------------|-------------|---------------|------------|------------------|-------------|-------------|-------------|---------------------|----------------------|-----------------|
| May 2022 | <avg | >5-yr dry | <avg | >avg | <5-yr wet | 5-yr wet | avg | >5-yr dry | <avg | avg | <avg | >avg | >avg | <5-yr wet |
| June 2022 | >5-yr dry | >avg | >avg | >avg | avg | <5-yr wet | >5-yr wet | 5-yr wet | <5-yr wet | 10-yr wet | 10-yr wet | 5-yr wet | 5-yr wet | 10-yr wet |
| July 2022 | 5-yr dry | >5-yr dry | >5-yr dry | 5-yr dry | >5-yr dry | avg | <avg | >5-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | <avg |
| August 2022 | >avg | <avg | >5-yr dry | 50-yr dry | avg | 10-yr dry | 5-yr dry | 5-yr dry | > 5-yr dry | > 5-yr dry | > 5-yr dry | <5-yr wet | <avg | avg |
| September 2022 | 0 | 0 | 10-yr wet | <20-yr wet | 20-yr wet | 20-yr wet | >20-yr wet | 10-yr wet | 10-yr wet | >10-yr wet | >5-yr wet | 20-yr wet | 10-yr wet | 50-yr wet |
| October 2022 | <10-yr dry | >5-yr dry | 5-yr dry | >5-yr dry | <avg | >5-yr dry | <10-yr dry | 10-yr dry | 20-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | >5-yr dry |
| November 2022 | >5-yr wet | >10-yr wet | >10-yr wet | <5-yr wet | >avg | 5-yr wet | <avg | 10-yr wet | 5-yr wet | >10-yr wet | >10-yr wet | 10-yr wet | >avg | <5-yr wet |
| December 2022 | >5-yr dry | <avg | <avg | >5-yr dry | >5-yr dry | >5-yr dry | <avg | <avg | >avg | <avg | <avg | >avg | 5-yr wet | >avg |
| January 2023 | >5-yr dry | >5-yr dry | >5-yr dry | > 10-yr dry | > 10-yr dry | > 10-yr dry | <20-yr dry | > 10-yr dry | > 20-yr dry | <50-yr dry | > 50-yr dry | >5-yr dry | <10-yr dry | >5-yr dry |
| February 2023 | <10-yr dry | > 20-yr dry | 5-yr dry | 5-yr dry | > 10-yr dry | <avg | >5-yr dry | >5-yr dry | >5-yr dry | 5-yr wet | 10-yr wet | > 20-yr dry | <20-yr dry | <50-yr dry |
| March 2023 | > 5-yr dry | > 10-yr dry | <10-yr dry | <10-yr dry | >5-yr dry | >5-yr dry | >5-yr dry | <20-yr dry | <10-yr dry | <avg | <avg | >5-yr dry | >5-yr dry | > 5-yr dry |
| April 2023 | >5-yr wet | 10-yr wet | >10-yr wet | <20-yr wet | 20-yr wet | 50-yr wet | 20-yr wet | >10-yr wet | <20-yr wet | 1000-yr wet | <50-yr wet | >5-yr wet | 10-yr wet | >5-yr wet |

| | | | | | | | | | | | | |
|-------------------|------------|-----------|-----------|-----------|----------|---------|----------|-----------|-----------|-----------|------------|-------------|
| Color Code Legend | 100-yr dry | 50-yr dry | 20-yr dry | 10-yr dry | 5-yr dry | average | 5-yr wet | 10-yr wet | 20-yr wet | 50-yr wet | 100-yr wet | 1000-yr wet |
|-------------------|------------|-----------|-----------|-----------|----------|---------|----------|-----------|-----------|-----------|------------|-------------|

The driest months of WY2023 were August 2022 (5.68 inches, 71%), October 2022 (2.07 inches, 50%), January 2023 (0.46 inches, 21%), February 2023 (0.89 inches, 44%), and March 2023 (0.97 inches, 40%).

Annual rainfall totals in the Upper Kissimmee, Lower Kissimmee, Lake Okeechobee, East EAA, WCA-3, Martin/St. Lucie, Palm Beach, East Caloosahatchee, Big Cypress Preserve, and the Southwest Coast rainfall areas experienced average rainfall relative to the historical average, receiving between 95 and 109% of the average. Annual rainfall totals in the WCA-1 & WCA-2, Broward, and Miami-Dade rainfall areas exhibited rainfall surpluses relative to the historical average, receiving between 111 and 128% of the average.

The annual rainfall deviations from historical averages in each area are ranked in order from surplus to deficit: Broward (17.02 inches), Miami-Dade (6.78 inches), WCA-1 & WCA-2 (6.56 inches), Southwest Coast 5.06 inches), East Caloosahatchee (3.85 inches), WCA-3 (3.63 inches), West EAA (3.42 inches), East EAA (2.60 inches), Upper Kissimmee (1.38 inches), Big Cypress Preserve (1.06 inches), Lake Okeechobee (0.49 inches), Lower Kissimmee (-1.84 inches), Martin/St. Lucie (-2.86 inches), and Palm Beach (-2.91), and ENP (-11.00 inches).

Regionally, the balance between rainfall and evapotranspiration maintains the hydrologic system in either a wet or dry condition. Potential evapotranspiration (ETp) is the actual evaporation for lakes, wetlands, and any feature that is assumed to be wet year-round. In South Florida, solar radiation explains most of the variation in evapotranspiration (Abtew 1996). Available ETp data from the closest site to a rainfall region was used to estimate ETp for that area. **Table 2A-10** shows monthly ETp for SFWMD rainfall areas and ENP along with the SFWMD average, and **Table 2A-11** summarizes annual rainfalls, WY2023 ETp, and WY2023 rainfall anomalies.

Table 2A-10. WY2023 monthly ETp in inches for each rainfall area.

| Month | Upper Kissimmee | Lower Kissimmee | Lake Okeechobee | East EAA | West EAA | WCA-1 & WCA-2 | WCA-3 | Martin/St Lucie | Palm Beach | Broward | Miami-Dade | East Caloosahatchee | Big Cypress Preserve | Southwest Coast | SFWMD Average | ENP |
|----------------|-----------------|-----------------|-----------------|--------------|--------------|---------------|--------------|-----------------|--------------|--------------|--------------|---------------------|----------------------|-----------------|---------------|--------------|
| May 2022 | 5.71 | 5.91 | 5.99 | 5.76 | 5.85 | 5.77 | 6.11 | 5.76 | 6.11 | 6.11 | 5.42 | 5.54 | 6.11 | 6.09 | 5.87 | 5.42 |
| June 2022 | 4.94 | 5.29 | 5.47 | 5.53 | 4.68 | 5.50 | 5.31 | 5.53 | 5.65 | 5.65 | 4.72 | 4.91 | 5.65 | 4.92 | 5.27 | 4.72 |
| July 2022 | 5.38 | 5.65 | 5.70 | 5.75 | 5.09 | 5.97 | 5.87 | 5.75 | 5.62 | 5.62 | 5.67 | 5.17 | 5.62 | 4.82 | 5.55 | 5.67 |
| Augusts 2022 | 4.95 | 5.21 | 5.79 | 5.80 | 4.95 | 5.64 | 5.68 | 5.80 | 5.23 | 5.23 | 5.11 | 5.01 | 5.23 | 4.48 | 5.29 | 5.11 |
| September 2022 | 4.06 | 4.30 | 4.63 | 4.32 | 4.33 | 4.34 | 4.23 | 4.32 | 4.34 | 4.34 | 4.07 | 4.15 | 4.34 | 4.03 | 4.27 | 4.07 |
| October 2022 | 3.98 | 4.07 | 4.54 | 3.78 | 4.12 | 4.17 | 3.95 | 3.78 | 4.38 | 4.38 | 4.14 | 4.21 | 4.38 | 4.16 | 4.14 | 4.14 |
| November 2022 | 2.57 | 2.99 | 3.61 | 3.00 | 3.11 | 3.35 | 3.24 | 3.00 | 3.28 | 3.28 | 3.33 | 3.09 | 3.28 | 3.25 | 3.17 | 3.33 |
| December 2022 | 2.67 | 2.89 | 3.20 | 2.77 | 2.96 | 3.07 | 2.62 | 2.77 | 2.96 | 2.96 | 3.15 | 2.98 | 2.96 | 3.07 | 2.93 | 3.15 |
| January 2023 | 3.31 | 3.27 | 3.60 | 3.16 | 3.48 | 3.68 | 3.32 | 3.16 | 3.50 | 3.50 | 3.77 | 3.45 | 3.50 | 3.80 | 3.46 | 3.77 |
| February 2023 | 3.64 | 3.69 | 4.16 | 3.96 | 3.84 | 4.11 | 4.03 | 3.96 | 3.82 | 3.82 | 3.86 | 3.81 | 3.82 | 4.25 | 3.91 | 3.86 |
| March 2023 | 4.75 | 5.10 | 5.16 | 5.21 | 4.97 | 5.33 | 5.29 | 5.21 | 5.11 | 5.11 | 5.21 | 5.11 | 5.11 | 5.48 | 5.15 | 5.21 |
| April 2023 | 4.74 | 4.86 | 5.52 | 4.84 | 5.03 | 5.29 | 4.92 | 4.84 | 5.04 | 5.04 | 4.90 | 4.73 | 5.04 | 5.33 | 5.01 | 4.90 |
| Total | 50.70 | 53.23 | 57.37 | 53.86 | 52.41 | 56.25 | 54.56 | 53.86 | 55.03 | 55.03 | 53.35 | 52.17 | 55.03 | 53.67 | 54.04 | 53.35 |

Table 2A-11. WY2023 total and historical annual average rainfall, WY2023 rainfall deviation from historical annual average, and WY2023 ETp for each rainfall area. All values are in inches.

| Rainfall Area | WY2023 Rainfall | Historical Average Rainfall | Historical Period | WY2023 Rainfall Deviation | WY2023 ETp |
|--------------------------------|-----------------|-----------------------------|-------------------|---------------------------|--------------|
| Upper Kissimmee | 52.28 | 50.90 | 1991–2020 | 1.38 | 50.70 |
| Lower Kissimmee | 46.41 | 48.25 | 1991–2020 | -1.84 | 53.23 |
| Lake Okeechobee | 45.05 | 44.56 | 1991–2020 | 0.49 | 57.37 |
| East EAA | 51.75 | 49.15 | 1991–2020 | 2.60 | 53.86 |
| West EAA | 56.74 | 53.32 | 1991–2020 | 3.42 | 52.41 |
| WCA-1 & WCA-2 | 60.49 | 53.93 | 1991–2020 | 6.56 | 56.25 |
| WCA-3 | 56.63 | 53.00 | 1991–2020 | 3.63 | 54.56 |
| Martin/St. Lucie | 52.14 | 55.00 | 1991–2020 | -2.86 | 53.86 |
| Palm Beach | 57.54 | 60.45 | 1991–2020 | -2.91 | 55.03 |
| Broward | 77.32 | 60.30 | 1991–2020 | 17.02 | 55.03 |
| Miami-Dade | 66.51 | 59.73 | 1991–2020 | 6.78 | 53.35 |
| East Caloosahatchee | 57.57 | 53.72 | 1991–2020 | 3.85 | 52.17 |
| Big Cypress Preserve | 56.65 | 55.59 | 1991–2020 | 1.06 | 55.03 |
| Southwest Coast | 62.64 | 57.58 | 1991–2020 | 5.06 | 53.67 |
| SFWMD Average | 55.33 | 53.22 | 1991–2020 | 2.11 | 54.04 |
| Wet Season (June–September) | 35.27 | 31.19 | 1991–2020 | 4.08 | 305.68 |
| Dry Season (November–April) | 13.66 | 13.51 | 1991–2020 | 0.15 | 354.59 |
| ENP | 43.90 | 55.00 | 1942–2022 | -0.35 | 53.35 |

WILDFIRES

In WY2023, a total of 0 acres of land burned within SFWMD boundaries. The annual total is well below the historical average of 98,228 acres per year. **Figure 2A-3** depicts the number of acres burned per water year based on wildfires that were 10 acres or larger within the SFWMD boundaries from WY1982 to WY2023 and the historical average based on the period of record. In South Florida, the number and size of wildfires are generally correlated to dry conditions. Drought years have typically above average burned acres and massive fires with more acres burned per fire (i.e., WY1989, WY1990, WY1999, WY2001, and WY2007).

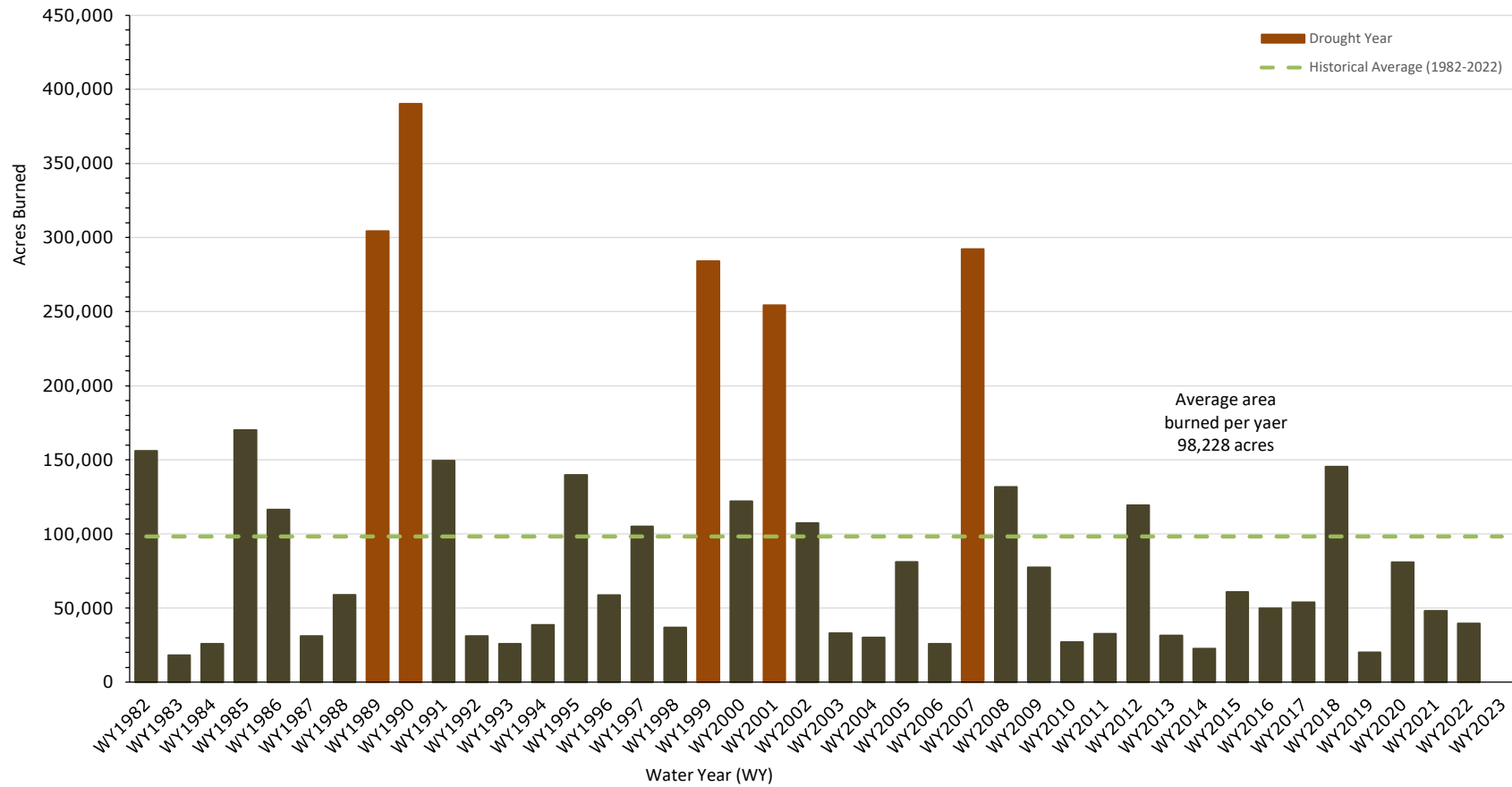


Figure 2A-3. Acres burned within SFWMD boundaries by wildfires 10 acres or larger per water year for WY1982–WY2023.

GROUNDWATER

The SFWMD is divided into four major water supply planning areas: Kissimmee, Upper East Coast (UEC), Lower East Coast (LEC), and Lower West Coast (LWC); see Figure 1 in Appendix 2A-5 for the locations of the planning areas. Aquifers in each area provide water for agricultural, commercial, industrial, and domestic uses. The Kissimmee Basin is served by both a surficial aquifer and a deep aquifer, the Floridan aquifer system. The UEC's principal source of groundwater is the surficial aquifer system, and the LEC's primary groundwater source is the surficial Biscayne aquifer. The LWC relies on three aquifer systems for water supply: surficial aquifer system, intermediate aquifer system, and 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).

In general, WY2023 groundwater levels reflect regional rainfall conditions, increasing during the wet season and declining during the dry season. Observations representing groundwater level fluctuation monitored by USGS are shown in Appendix 2A-2 for the stations shown in Figure 1 of the same appendix. For additional information on aquifers and water supply go to <https://www.sfwmd.gov/our-work/water-supply>.

WATER MANAGEMENT IN WATER YEAR 2023

OVERVIEW

Within the SFWMD region, water management depends on antecedent conditions as well as spatial and temporal distributions of rainfall across Central and South Florida. Operations include both flood control and water supply modes based on weather and wet/dry conditions. Typically, flood control mode is conducted during the wet season or high rainfall events, while water supply mode is performed in the dry season or during dry conditions. Weather extremes add many challenges to water management operations.

SFWMD and USACE water managers use established water control plans, which include regulation schedules and rules, as guidance to adjust inflows and outflows. Regulation schedules are water elevation lines designed to serve multiple purposes including flood control and water supply needs on a long-term basis. For each water body, a regulation schedule was developed by USACE and SFWMD in cooperation with other agencies and stakeholders. While regular operations often follow prescribed plans, shorter-term strategies also consider various constraints. Under certain environmental- or weather-related conditions, operations may deviate from regulation schedules for a specific area.

Water managers, scientists, and engineers from SFWMD, USACE, and other state agencies meet weekly to discuss the regional system status and possible operational scenarios. The meeting starts with the previous week's weather report and the coming week's rainfall forecast. USACE and SFWMD water managers summarize the last week's system-wide water management operations. A presentation on risk indicators related to water supply and Lake Okeechobee Regulation Schedule 2008 (LORS2008) operational guidance for the current week follows. The latter part of the meeting reports hydrological and ecological conditions for various areas—Kissimmee Basin, Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, Everglades STAs, and the Everglades—along with operational recommendations. Once a month, seasonal climate outlooks and groundwater conditions are also provided. SFWMD submits to USACE a weekly Operational Position Statement memorandum with recommendations on Lake Okeechobee operations. USACE's leadership and SFWMD's executive management approve operational changes.

The daily average stage in major water bodies for WY2023 along with their respective regulation schedules (lines) are provided later in this section. Usually, stages are controlled to follow the regulation lines, which are high in the fall and winter to save water for the dry season and reach the lowest point on

June 1 to prepare the storage capacity for the wet season. **Table 2A-12** provides the average stages for WY2023, and comparisons to WY2022 and historical stages. Appendix 2A-4 includes graphs for daily and monthly average stages in WY2023, WY2022, and historical periods for major lakes, impoundments, and ENP. All water levels are in ft NGVD29 in this chapter.

Table 2A-12. WY2023, WY2022, and historical stage statistics for major lakes and impoundments. (Note: Stages are in ft NGVD29.)

| Lake or Impoundment | WY2023 Average | Stage in Periods of Records | | | Historic Period | WY2022 |
|------------------------|-------------------|-----------------------------|---------|---------|--------------------|--------|
| | | Average | Minimum | Maximum | | |
| Alligator Lake | 63.18 | 62.75 | 58.13 | 64.52 | 1993–2022 | 63.29 |
| Lake Myrtle | 61.21 | 60.92 | 58.45 | 65.67 | 1993–2022 | 61.07 |
| Lake Mary Jane | 60.43 | 60.25 | 57.34 | 63.86 | 1993–2022 | 60.31 |
| Lake Gentry | 60.83 | 60.76 | 58.31 | 61.97 | 1993–2022 | 60.98 |
| East Lake Tohopekaliga | 56.63 | 56.58 | 52.24 | 60.57 | 1993–2022 | 56.61 |
| Lake Tohopekaliga | 53.79 | 53.63 | 48.28 | 56.82 | 1993–2022 | 53.65 |
| Lake Kissimmee | 50.83 | 50.41 | 42.87 | 56.64 | 1929–2022 | 50.38 |
| Lake Istokpoga | 38.79 | 38.80 | 35.84 | 39.78 | 1993–2022 | 38.86 |
| Lake Okeechobee | 14.42 | 14.01 | 8.82 | 18.77 | 1931–2022 | 14.48 |
| WCA-1 | 16.67 | 15.80 | 10.00 | 18.16 | 1953–2022 | 16.69 |
| WCA-2A | 12.49 | 12.51 | 9.33 | 15.64 | 1961–2022 | 12.50 |
| WCA-3A | 9.73 | 9.64 | 0.00 | 12.80 | 1962–2022 | 9.54 |
| ENP, Slough | 6.95 | 6.08 | 2.01 | 8.08 | 1952–2022 | 6.65 |
| ENP, Wet Prairie | 3.14 | 2.26 | -2.69 | 7.10 | 1953–2022 | 2.44 |

Table 2A-1, in the *Highlights* section, provides the WY2023 total flow for major water bodies and comparisons to the WY2022 and historical data. Appendix 2A-4 includes tables and graphs for monthly flows at each flow monitoring site and comparisons to WY2022 flows and historical averages. The historical period used for flow statistics is 1972–2022, except for the C-23 Canal at S-48 (1996–2022) and Ten Mile Creek at Gordy Road (2000–2022). Maps showing water control structures, canals, and major water bodies are available in previous SFRs. All flow volumes are in 1,000 acre-ft (kac-ft) in this chapter.

UPPER KISSIMMEE

The KCOL, located within the Upper Kissimmee Basin, includes seven lake groups containing more than two dozen lakes. A series of control structures (**Table 2A-13**; see Figure 1 in Appendix 2A-5) regulate lake levels and adjust outflows on seasonally varying schedules to balance flood control and water supply. Those structures are operated according to their respective regulation schedules to meet seasonal lake recession or ascension objectives (see Chapter 9 of this volume for more information). The *Master Water Control Manual for Kissimmee River – Lake Istokpoga* (USACE 1994) contains details on water control operations for the Kissimmee River.

Table 2A-13. Lake groups and control structures in the Upper and Lower Kissimmee basins.

| Kissimmee Basin | Control Structure | Regulated Stage Range (ft NGVD29) |
|---|------------------------------|--------------------------------------|
| Upper Kissimmee: Lake Group | | |
| Brick, Alligator, Lizzie, Trout, Coon, Center, etc. | S-58 and S-60 | 62.0–64.0 |
| Gentry, etc. | S-63 | 59.5–61.5 |
| Myrtle, Preston, Joel, etc. | S-57 | 60.0–62.0 |
| Hart, Mary Jane, etc. | S-62 | 59.5–61.0 |
| East Tohopekaliga, Fells Cove, etc. | S-59 | 55.0–58.0 |
| Tohopekaliga, etc. | S-61 | 52.0–55.0 |
| Kissimmee, Hatchineha, and Cypress | S-65 | 49.0–52.5 |
| Lower Kissimmee System | | |
| Pool A | S-65A | 46.3 |
| Pool D | S-65D and S-65DX1 | 26.8 |
| Pool E | S-65E | 21.0 |
| Lake Istokpoga | S-68, S-68X, S-67, and S-67X | 37.5–39.5 |

The Upper Kissimmee Basin received near average rainfall (52.38 inches; 103% of average) in WY2023. Large rainfall deficits occurred in June 2022 (monthly total of 5.48 inches; 65% of average), October 2022 (monthly total of 0.82 inches; 26% of average), December 2022 (monthly total of 1.27 inches; 53% of average), January 2023 (monthly total of 0.86 inches; 35% of average), February 2023 (monthly total of 0.68 inches; 33% of average), and March 2023 (monthly total of 1.06 inches; 37% of average). Large rainfall surpluses occurred in September 2022 (monthly total of 17.0 inches; 281% of average) and November 2022 (monthly total of 3.93 inches; 207% of average) due to Hurricanes Ian and Nicole respectively. Stages were generally around historical averages except for Lake Kissimmee which exhibited below average stages in June, July, and August 2022 and above average stages from September 2022 to February 2023 (Figure 7b in Appendix 2A-4; see Chapter 9 of this volume for more details), Lake Gentry, which had below average stages in June and July 2022 (Figure 4a in Appendix 2A-4), and Lake Myrtle, Lake Mary Jane, East Lake Tohopekaliga, and Lake Tohopekaliga during October 2022 following Hurricane Ian (Figures 2b, 4b, 5b, and 6b in Appendix 2A-4). Discharge from Lake Kissimmee flowed continuously into the Kissimmee River through the year. The total flow into the Kissimmee River for WY2023 was 1,214 kac-ft, 164% of the historical average. **Figures 2A-4** and **2A-5** show the WY2023 daily average stages, daily rainfall, and flood regulation schedules for lake groups within the KCOL. **Table 2A-12** above presents stage statistics, and Appendix 2A-3 shows more graphs for daily and monthly average stages.

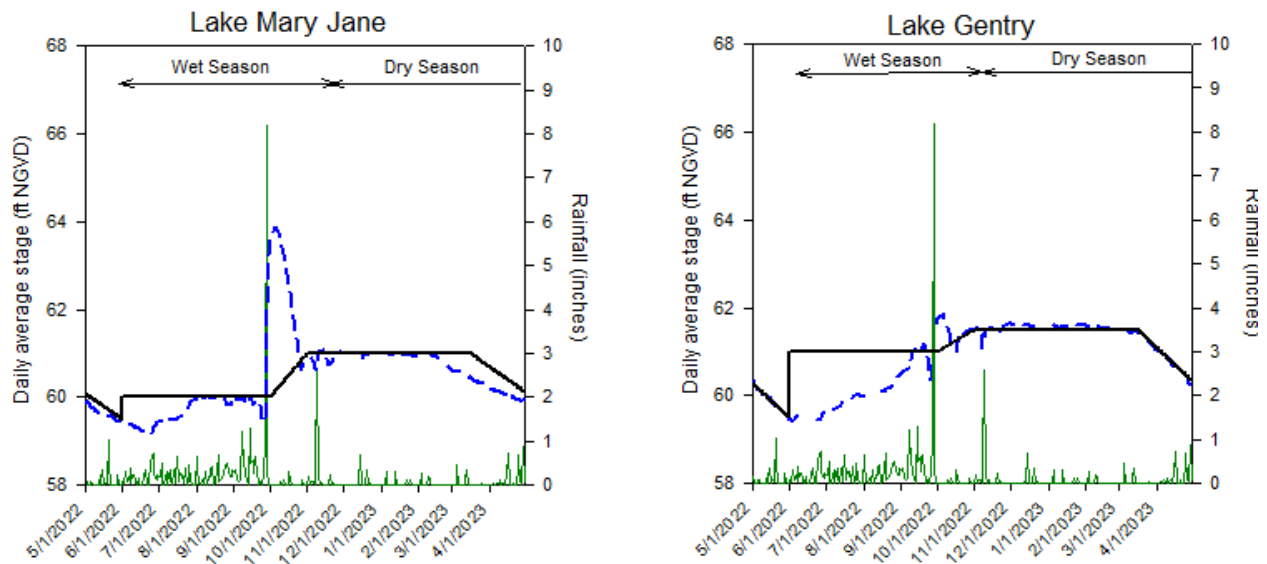
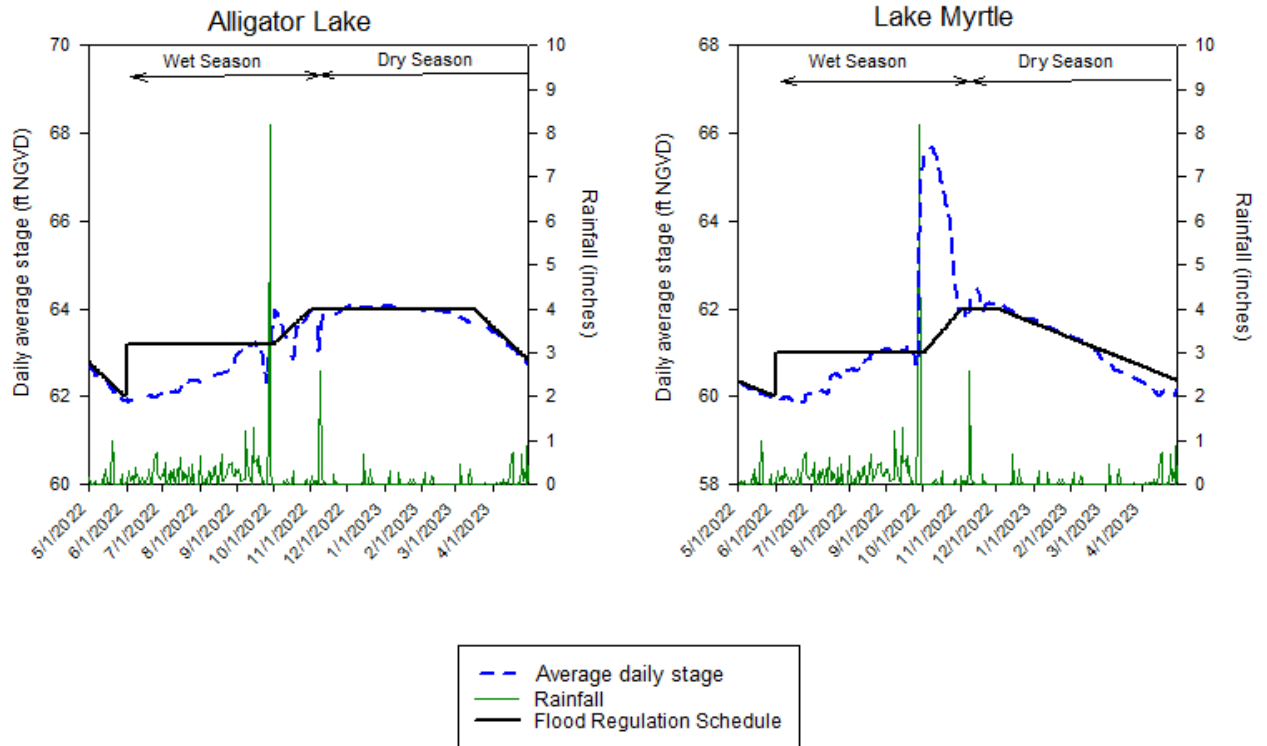


Figure 2A-4. Average daily water levels (stage), regulation schedule, and rainfall for (a) Alligator Lake, and (b) Lakes Myrtle, (c) Mary Jane, and (d) Gentry.

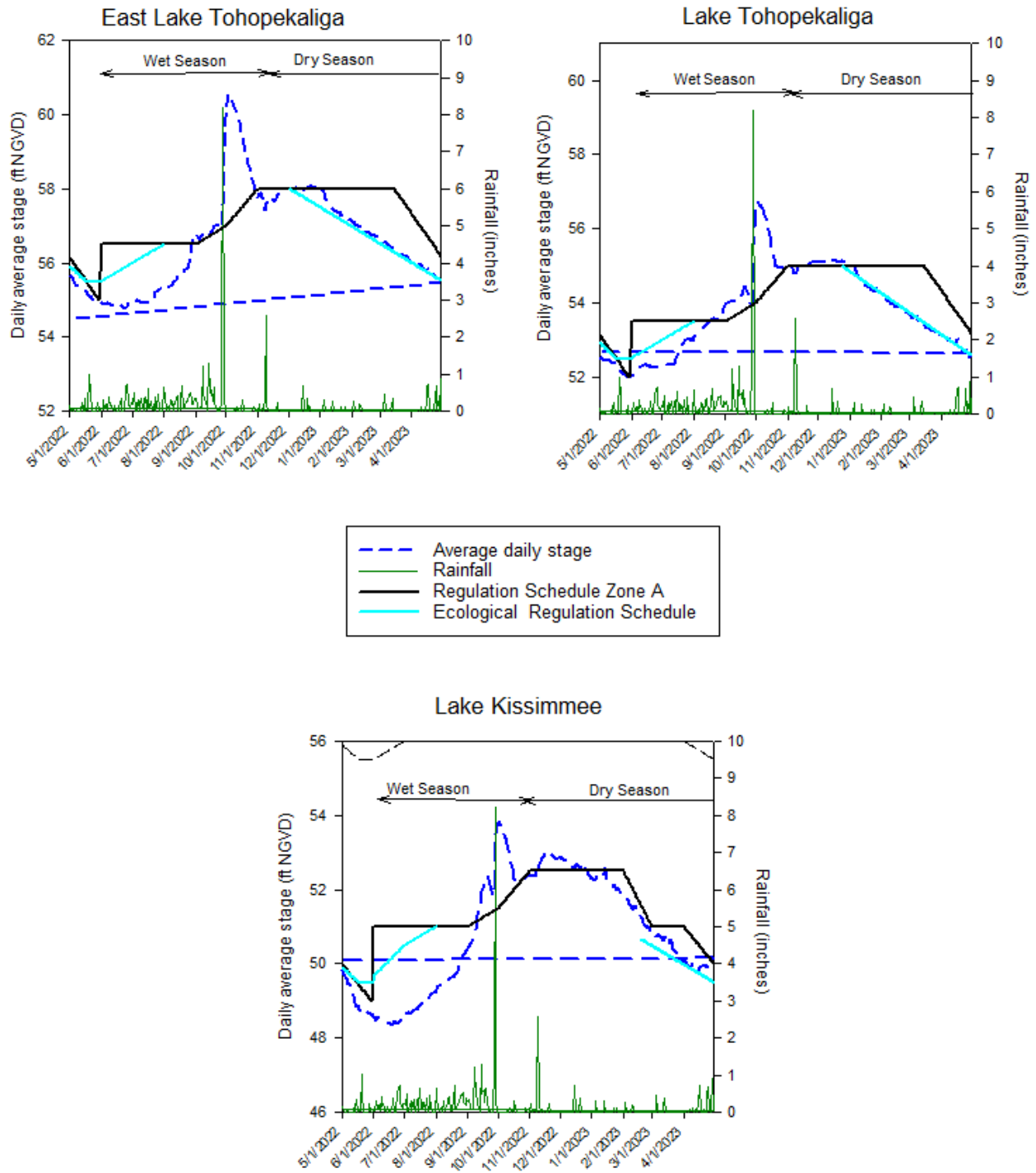


Figure 2A-5. Average daily water levels (stage), regular regulation schedule, and rainfall for (a) East Lake Tohopekaliga, (b) Lake Tohopekaliga, and (c) Lake Kissimmee.

LOWER KISSIMMEE

The Lower Kissimmee System included three structures along the C-38 Canal (also known as the Kissimmee River): S-65A, S-65D, and S-65E (**Table 2A-13**; Figure 1 in Appendix 2A-1). These structures are operated for maintaining optimum stages that benefit the environment. **Figure 2A-6** shows the daily average stage, daily rainfall, and regulation schedules for Lake Istokpoga during WY2023. The Lower Kissimmee Basin received near average rainfall (46.41 inches; 96% of average). Large rainfall deficits occurred in May 2022 (monthly total of 2.49 inches; 64% of average), October 2022 (monthly total of 1.56 inches; 48% of average), January 2023 (monthly total of 0.69 inches; 35% of average), February 2023 (monthly total of 0.48 inches; 24% of average), and March 2023 (monthly total of 0.51 inches; 20% of average). Large rainfall surpluses occurred following Hurricanes Ian and Nicole in September 2022 (monthly total of 12.09 inches; 197% of average) and November 2022 (monthly total of 4.18 inches; 250% of average) respectively, and in April 2023 (monthly total of 4.39 inches; 177% of average). Lake Istokpoga stage was slightly below the regulation schedule throughout most of the year except in late September 2022 through mid-October 2022 due to rainfall from Hurricane Ian. The total outflow for WY2023 (309 kac-ft) was above the historical average (**Table 2A-1** in the *Highlights* section). **Table 2A-12** above presents stage statistics and Appendix 2A-4 shows more graphs for daily and monthly average stages.

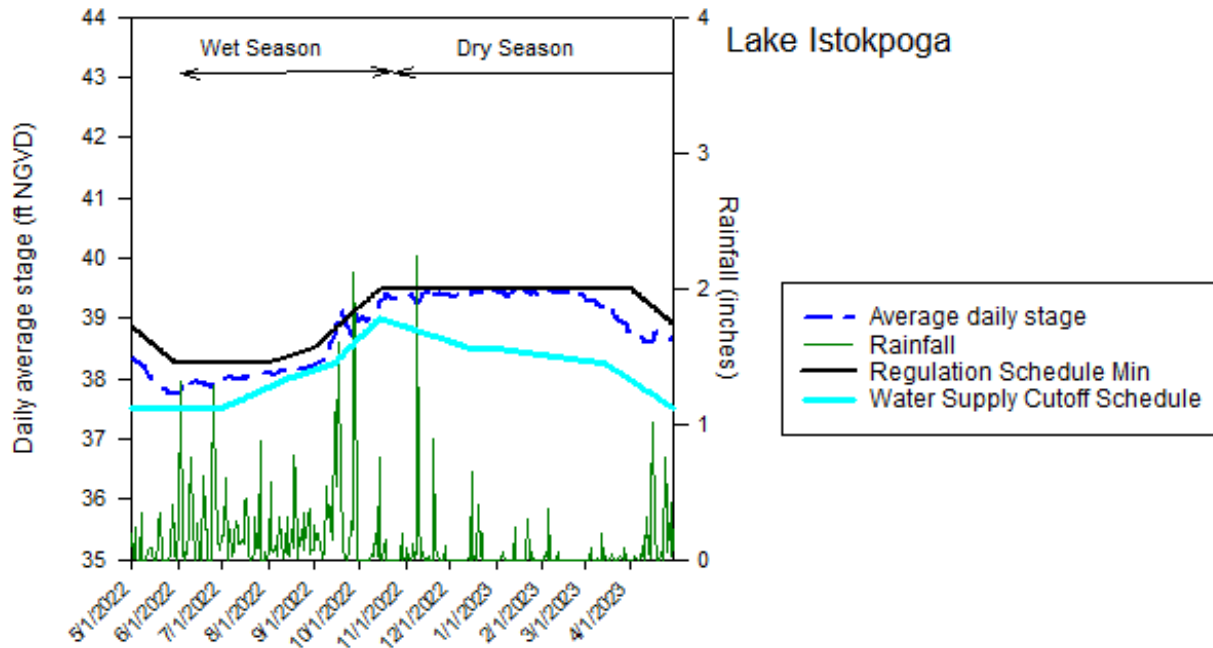


Figure 2A-6. Average daily water levels (stage), regulation schedule, and rainfall for Lake Istokpoga.

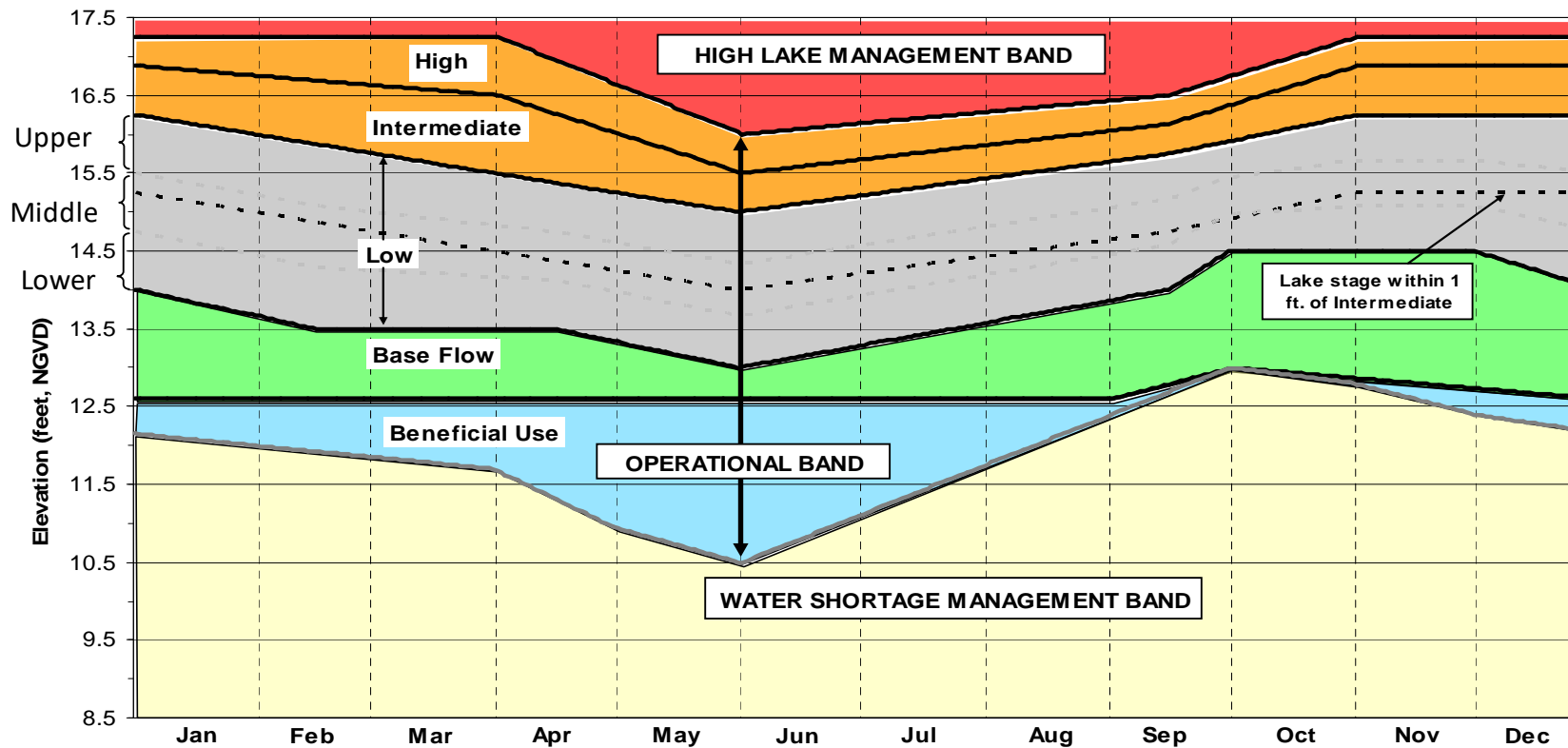
LAKE OKEECHOBEE

USACE manages Lake Okeechobee water levels to balance flood control, public safety, navigation, water supply, and ecological health. The current regulation schedule for Lake Okeechobee, known as LORS2008, which was initiated in May 2008 (USACE 2008), incorporates current and future (outlook) climatic information in the decision-making process. The regulation schedule (**Figure 2A-14**) has three main bands: High Lake Management Band (top), Operational Band (middle), and Water Shortage Management Band (bottom). The Operational Band is further divided into High, Intermediate, Low, Base Flow, and Beneficial Use sub-bands or use categories. In the High Lake Management Band, large flood control releases are required, and outlet canals may be maintained above their optimum water management elevations. In the Operational Band, substantial flood control or water supply releases may be implemented, and 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. The lake regulation schedule is implemented through two release guidance flowcharts (decision trees, USACE 2008). The Part C flowchart guides the determination of discharges to the WCAs, while the Part D flowchart helps to determine discharges to the estuaries and to tide. The operational flexibility of the LORS2008 schedule allows adjustments to the timing and magnitude of Lake Okeechobee discharges based on the lake and WCA water levels, tributary hydrologic conditions, multi-season climatic and hydrologic outlook, as well as downstream estuary conditions.

Figure 2A-15 depicts Lake Okeechobee's daily water level, regulation schedule, and water management decisions for WY2023. Various water management decisions, based on the lake water level and other relevant factors, are marked in the figure: releases from the lake via the S-308 structure into the St. Lucie River, which may pass to the St. Lucie Estuary via the S-80 structure; releases from the lake via the S-77 structure into the Caloosahatchee River, which may pass to the Caloosahatchee Estuary via the S-79 structure; and regulatory releases to the WCAs via the Everglades STAs.

In WY2023, the lake stage remained within the Base Flow Sub-band of LORS2008 from May 2022 through late August 2022 when it dipped down into the Beneficial Use Sub-band and Water Shortage Management Sub-band through mid-September 2022. By the end of October 2022, the lake stage climbed back up into the Beneficial Use Sub-band, Base Flow Sub-band, and Low Sub-band and eventually entered the Intermediate Sub-band in early December 2022 where it remained through late-January 2023, it then dropped back into the Low Sub-band for the remainder of the water year. The average stage for WY2023 was 14.42 ft NGVD29, 0.41 ft higher than the historical average (**Table 2A-12**). **Table 2A-12** above presents additional information about stage statistics. Figure 9 in Appendix 2A-4 shows more graphs for daily and monthly average stages.

The total inflow into Lake Okeechobee for WY2023 was 2,220 kac-ft, 106% of the historical average (2.1 million ac-ft; see **Table 2A-1** in the *Highlights* section). The majority of the inflow came from the border north of the S-308 and S-77 structures (Table 2 of Appendix 2A-1 list structures included in the north group). The outflow for WY2023 was 1,135 kac-ft, 75% of the historical average (1.5 million ac-ft). Southward outflow, via S-351, S-352, and S-354, totaled 370 kac-ft; 33% of the total outflow during WY2023. The rest of the outflow was to the Caloosahatchee River (532 kac-ft; 47% of the total outflow) and St. Lucie River (29 kac-ft; 21% of the total outflow). Appendix 2A-3 provides monthly inflows and outflows at each flow monitoring site, as well as comparisons to historical averages. **Table 2A-1** in the *Highlights* section includes flow statistics and comparisons.



NOTES:

High Lake Management Band: Outlet canals may be maintained above their optimum water management elevations.

Operational Band: Outlet canals should be maintained within their optimum water management elevations.

Water Shortage Management Band: Outlet canals may be maintained below optimum water management elevations.

CENTRAL AND SOUTHERN FLORIDA PROJECT

2008 LAKE OKEECHOBEE

INTERIM REGULATION SCHEDULE

PART B

DATED: March 2008

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT

CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

Figure 2A-7. Operational sub-bands in Lake Okeechobee’s current regulation schedule (LORS2008).

WY2023 Lake Okeechobee Water Level and Releases

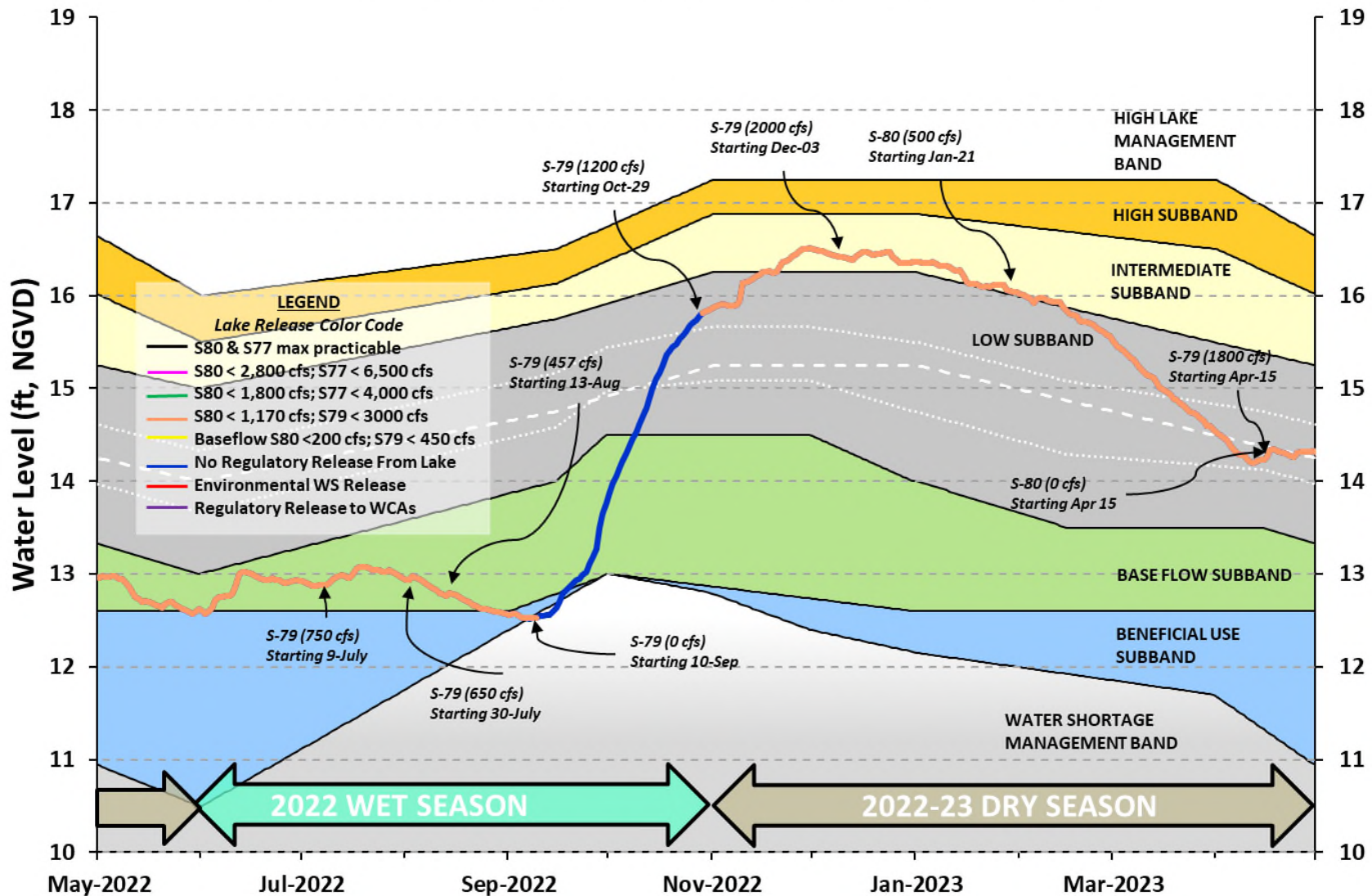


Figure 2A-8. Daily Lake Okeechobee water levels, regulation schedule, and release recommendations from LORS2008 weekly implementations in WY2023. (Notes: cfs – cubic feet per second and WS – Water Supply.)

UPPER EAST COAST AND ST. LUCIE RIVER

The St. Lucie River (C-44 Canal) receives runoff from its watershed (C-44 Basin) and Lake Okeechobee releases via the S-308 spillway and the Port Mayaca Lock (USACE 2008; Figure 3 in Appendix 2A-3). S-308 can reverse runoff from the St. Lucie River Watershed back to the lake when the lake stage is below 14.5 ft NGVD29; the optimum elevation for the St. Lucie River is between 14.0 and 14.5 ft NGVD29. Discharges are made through S-308 for water supply or maintaining the river stage, and excessive water passes to the St. Lucie Estuary via the S-80 structure. S-80 discharge to the estuary contains a mixture of Lake Okeechobee releases and runoff from the St. Lucie River Watershed.

For WY2023, Lake Okeechobee released 29 kac-ft via S-308 into the St. Lucie River (C-44/St. Lucie Canal) for water supply or other losses, and 101 kac-ft were released to the St. Lucie Estuary via S-80 (**Table 2A-1** in the *Highlights* section). The runoff from the St. Lucie River Watershed discharged to the estuary was estimated at 30 kac-ft (**Table 2A-1**).

In WY2023, the Martin/St. Lucie Basin had below average rainfall (52.14 inches; 95% of historical average). Inflows into both the South Fork (via S-80) and North Fork (via S-48, S-49, and Ten Mile Creek at the Gordy Road structure) of the St. Lucie Estuary were 32 and 86% of historical averages, respectively. Appendix 2A-3 provides monthly inflows (Table 4) and outflows (Figure 4) at each flow monitoring site, as well as comparisons to historical averages.

LOWER WEST COAST AND CALOOSAHATCHEE RIVER

The Caloosahatchee River receives flow from both its watershed runoff and Lake Okeechobee releases via S-77, a gated spillway and lock structure (USACE 2008). Adaptive Protocols for Lake Okeechobee Operations, adopted on September 16, 2010, provide a framework for environmental water supply releases to the Caloosahatchee Estuary in the Lake Okeechobee Low Sub-band at the beginning of the dry season (SFWMD 2010). A decision tree guides recommendations for the dry season lake releases to the estuary based on the estuary salinity level and other constraints.

S-78, the second gated spillway along the Caloosahatchee River downstream of the S-77 structure, passes Lake Okeechobee releases and runoff from the East Caloosahatchee Watershed. Downstream of S-78 is the S-79 structure, the third gated spillway and lock (Figure 4 in Appendix 2A-1). The optimum water control elevation in the Caloosahatchee River is 10.6 to 11.5 ft NGVD29 for the segment between S-77 and S-78, and 2.8 to 3.2 ft NGVD29 for the segment upstream S-79. Lake Okeechobee releases into the Caloosahatchee River that are not used for water supply passed to the estuary via S-79. The S-79 discharge includes a mix of Lake Okeechobee releases and runoff from the East and West Caloosahatchee watersheds. Water management decisions regulating releases through S-79 into the estuary are shown in **Figure 2A-10** above.

For WY2023, Lake Okeechobee released 532 kac-ft (92% of the historical average) into the Caloosahatchee River via S-77, those lake releases passed to the estuary via S-79 (**Table 2A-1** in the *Highlights* section). S-79 discharged 1,542 kac-ft (119% of the historical average) into the estuary. Table 5 and Figure 5 in Appendix 2A-3 provide monthly inflows and outflows at S-77 and S-79, as well as comparisons to historical averages. **Table 2A-1** includes flow statistics and comparisons.

EVERGLADES AGRICULTURAL AREA

Four major canals pass through the EAA: West Palm Beach, Hillsboro, North New River, and Miami (Figure 5 in Appendix 2A-1). These canals carry runoff from the EAA to relieve local flooding and convey releases from Lake Okeechobee. Canal flows are pumped into the Everglades STAs by the S-5A, S-319, S-6, G-370, G-372, G-434, and G-435 pump stations for water quality improvement before moving into WCAs, wildlife management areas, and the Seminole Tribe of Florida's Big Cypress Reservation. Discharges to the east coast occur through the West Palm Beach Canal. Bypass flows (diversion) to the

WCAs may happen, though rarely do, when the STAs are unable to treat all runoff water. Under extreme flooding risks to the communities of South Bay, Belle Glade, and Clewiston, water may be pumped into the lake following strict permit requirements. Under dry conditions, these four primary canals provide water supply for agricultural irrigation through gravity release from Lake Okeechobee. 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 to their respective fields.

The inflow from Lake Okeechobee to EAA canals come from three gated spillways, S-351, S-352, and S-354. When EAA canals convey Lake Okeechobee releases, the maximum tailwater elevation below S-351, S-352, and S-354 should not exceed 12 ft NGVD29.

EVERGLADES PROTECTION AREA

The Everglades Protection Area consists of the WCAs and ENP. The current USACE water control plan governing operations of WCAs, ENP, and the South Dade Conveyance System is the Combined Operational Plan (COP) established on August 28, 2020 (USACE 2020). The 2020 COP modified the WCA-3A regulation schedule from the 2012 Everglades Restoration Transition Plan (ERTP; USACE 2012) and the 2002/2006 Interim Operational Plan for Protection of the Cape Sable Seaside Sparrow (CSSS; USACE 2006) before the ERTP. To protect CSSS critical habitats during the nesting season from October 1 to July 14, structures discharging west into the Big Cypress National Preserve are closed. Also, operations of S-12A, S-12B, S-3332B, S-332C, S-332D, S-199, and S-200 are subject to various limitations during the CSSS nesting season (USACE 2018).

Water Conservation Area 1

WCA-1 stage is regulated between 14.00 and 17.50 ft NGVD29 mainly by controlling outflow at structures S-10A, S-10C, S-10D, and S-39. The *Master Water Control Manual – Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System* (USACE 1996) contains the regulation schedule for WCA-1. It varies from high stages in the late fall and winter to low stages at the beginning of the wet season. The indicator stage for regulation changes in two periods are (1) gauge 1-8C in the eastern rim canal from January 1 to June 30, and (2) the average of three interior gauges, 1-7, 1-8T, and 1-9 (see Appendix 2A-1, Figure 5) from July 1 to December 31 but only during rising stages when canal stage exceeds the marsh average. This reporting uses the average of the three interior gauges, 1-7, 1-8T, and 1-9, to represent water levels in WCA-1 because it reflects marsh conditions.

During WY2023, water levels in WCA-1 varied from 15.40 to 16.72 ft NGVD29, remaining consistently slightly above the historical average each month. The water level started at 15.86 ft NGVD29 and ended the water year at 16.36 ft NGVD29. **Figure 2A-9a** depicts WY2023 daily average water level, daily rainfall, and regulation schedule for WCA-1. **Table 2A-12** above presents stage statistics, and Figure 10 in Appendix 2A-3 shows graphs for daily and monthly average stages.

The total inflow into WCA-1 for WY2023 was 259 kac-ft, 58% of the historical average (see **Table 2A-1** in the *Highlights* section). Of this inflow, 101 kac-ft was from STA-1 East (STA-1E) through pump station S-362 and 158 kac-ft was from STA-1 West (STA-1W) through pump stations G-251 and G-310 (see Appendix 2-4, Table 6). No flood diversion inflow came through G-300, G-301, or G-338. The total outflow from WCA-1 for WY2023 was 185 kac-ft, 44% of the historical average (**Table 2A-1**). The majority of outflow moved into WCA-2A through the S-10 structures (182 kac-ft), while the rest went to the Hillsboro Canal through S-39 (3 kac-ft), and no flows east through G-94A and G-94C (see Appendix 2A-4, Table 7). No backflow occurred through G-300 and G-301 into the L-8 or C-51 canals. Appendix 2A-4 provides monthly inflows and outflows at each monitoring site, as well as comparisons to historical averages. **Table 2A-1** includes flow statistics.

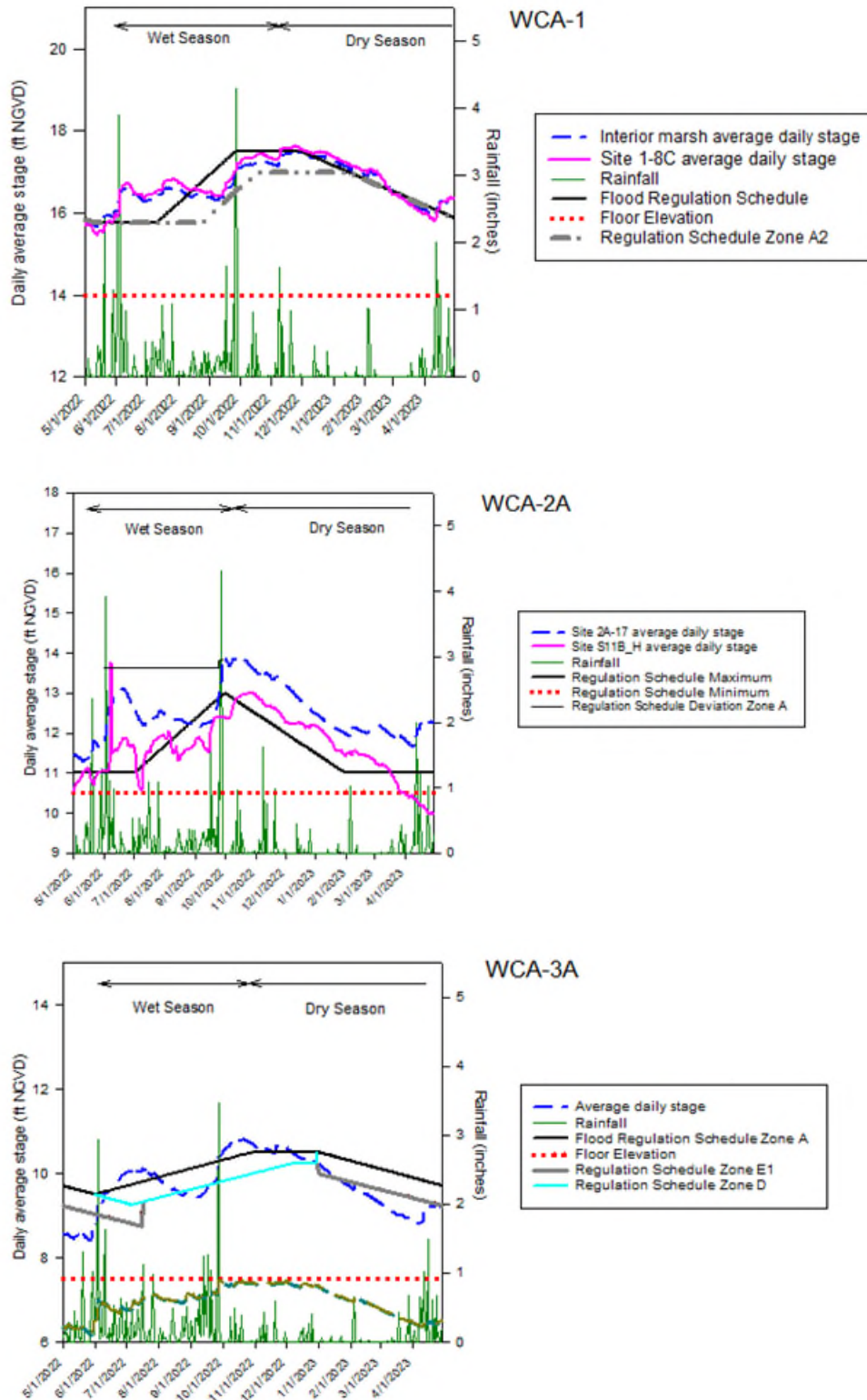


Figure 2A-9. Average daily water levels (stage), regulation schedule, and rainfall for (a) WCA-1, (b) WCA-2A, and (c) WCA-3A.

Water Conservation Area 2

The *Master Water Control Manual – Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System* (USACE 1996) also contains the regulation schedule for WCA-2A. The indicator stages for regulation changes occur in three periods: (1) interior gauge 2A-17 (Site 17; see Appendix 2A-5, Figure 5) from July 1 to December 31, (2) a transition in January to S-11B headwater if gauge 2A-17 recedes to 11.5 ft NGVD29, and (3) S-11B headwater from February 1 to June 30. This reporting uses the interior gauge 2A-17 to represent water levels in WCA-2A. WCA-2B does not have a regulation schedule because of high seepage rates. Releases to WCA-2B through S-144, S-145, and S-146 are terminated when stage at indicator gauge 2B-99 (Site 99; see Appendix 2-5, Figure 5) 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.

In WY2023, the WCA-2A water level started at 11.46 ft NGVD29, reached a maximum of 13.92 ft NGVD29 in February 2023, stayed above the regulation schedule most of the water year, and ended at 12.27 ft NGVD29 in April 2022. The WY2023 average stage was 12.49 ft NGVD29, around the historical average (**Table 2A-12** above). **Figure 2A-9b** depicts WY2023 daily average water level, daily rainfall, and the regulation schedule for WCA-2A. **Table 2A-12** presents stage statistics, and Figure 11 in Appendix 2A-3 shows graphs for daily and monthly average stages.

The total inflow into WCA-2 for WY2023 was 673 kac-ft, 100% of the historical average (**Table 2A-1** in the *Highlights* section). Inflow into WCA-2 came from STA-2 discharges pumped by G-335 and G-436 (348 kac-ft), STA-3/4 discharges pumped by S-7 (132 kac-ft), and outflow from WCA-1 through the S-10 structures (192 kac-ft) (see Appendix 2A-4, Table 8). The total outflow from WCA-2 for WY2023 was 630 kac-ft, 94% of the historical average (**Table 2A-1**). The majority of outflows moved into WCA-3A through structures S-11A, S-11B, and S-11C (533 kac-ft), while the rest went to canals 13 and 14 through structures S-38 (27 kac-ft) and S-34E (less than 1 kac-ft), and as backflow through S-7 (70 kac-ft) (Appendix 2A-4, Table 9). Appendix 2A-4 provides monthly inflows and outflows at each monitoring site, as well as comparisons to historical averages. **Table 2A-1** includes flow statistics.

Water Conservation Area 3

USACE developed the regulation schedule for WCA-3A as part of the 2012 ERTTP water control plan (USACE 2012). It prescribes and prohibits discharges through specified water control structures based on water levels and time of the year. The indicator stage for operation is the average of three marsh gauges: 3-63, 3-64, and 3-65 (see Appendix 2-1, Figure 5). WCA-3B does not have a regulation schedule due to high rates of seepage. Tables 10 and 11 in Appendix 2-3 are lists of inflow and outflow at WCA-3 water control structures, respectively. Water pumped by G-404 from the Miami Canal into the L-4 borrow canal either enters WCA-3A through an ungauged gap (elevation 3 ft NGVD29, an opening into the L-3 extension canal) or is pumped by G-409 to the west for water supply. The flow difference between G-409 and G-404 pumps is the inflow to WCA-3A through the gap. Also, the southern outflow from STA-5/6 moves into WCA-3A through the gap.

Figure 2A-9c depicts WY2023 daily average water level, daily rainfall, and the regulation schedule for WCA-3A. In WY2023, the WCA-3A stage began at 8.56 ft NGVD29, peaked at 10.82 ft NGVD29 in October 2022, remained near average the rest of the water year and ended at 9.21 ft NGVD29 in April 2023, an extremely low level, due to low rainfall. **Table 2A-9** above presents stage statistics, and Figure 12 in Appendix 2A-4 shows graphs for daily and monthly average stages.

Total inflow into WCA-3A for WY2023 was 1,442 ac-ft, 118% of the historical average (**Table 2A-1** in the *Highlights* section). Contributions to inflow are 52 kac-ft from WCA-2 via S-11A, S-11B, and S-11C; 272 kac-ft from S-9 and S-9A; 119 kac-ft from STA-5/6; 17 kac-ft from S-150; 253 kac-ft from S-8; 82 kac-ft from S-140; 69 kac-ft from S-190; and 60 kac-ft from the northwest gap (see Appendix 2A-3,

Table 10). The total outflow from WCA-3A for WY2023 was 851 kac-ft, 81% of the historical average. The outflow through each set of structures was 8,587 kac-ft through S-12A, S-12B, S-12C, and S-12D and 251 kac-ft through S-333 into ENP; now flows went west through S-343A, S-343B, and S-344 or through S-31 and S-337 (see Appendix 2A-3, Table 11). There was no backflow through S-8 and S-150 during the water year. Appendix 2A-3 provides monthly inflows and outflows at each monitoring site, as well as comparisons to historical averages. **Table 2A-1** includes flow statistics.

Everglades National Park

Sites P-33 (ground elevation 5.06 ft NGVD29) and P-34 (ground elevation 2.09 ft NGVD29) represent stages in Shark River Slough and wet prairie habitat, respectively (Sklar et al. 2003; see Appendix 2A-1, Figure 5). In WY2023, the average stages at P-33 and P-34 were 6.95 and 3.14 ft NGVD29, respectively (**Table 2A-12** above). **Figures 2A-10a** and **2A-10b** depict the daily average water level and rainfall at P-33 and P-34, respectively, for WY2023. **Table 2A-12** presents stage statistics, and Figures 13 and 14 in Appendix 2-4 shows graphs for daily and monthly average stages.

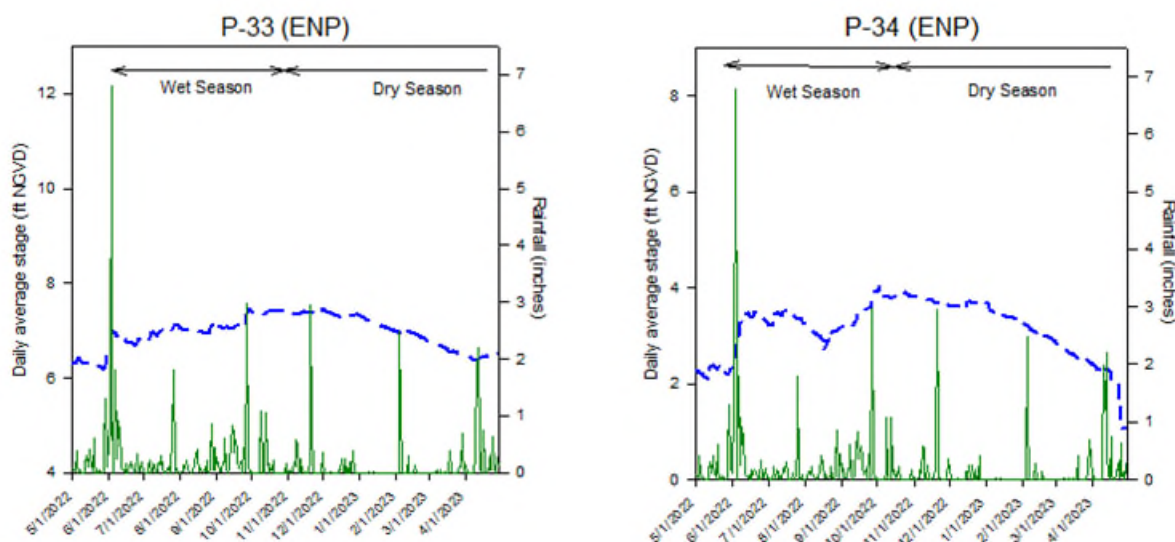


Figure 2A-10. Average daily water levels (stage), regulation schedule, and rainfall for ENP gauges (a) P-33 and (b) P-34.

Detailed descriptions of the current water delivery plan to ENP are contained in the *Environmental Assessment and Finding of No Significant Impact, 2018: L-29 Canal and G-3273 Constraint Relaxation Including the Northern Detention Area (Revised Operational Strategy Increment 2), Miami-Dade County, Florida* (USACE 2018). Surface water deliveries to Shark River Slough in ENP outflow from WCA-3 via S-12A, S-12B, S-12C, S-12D, S-333, S-355A, 355B, S-355 temporary pump, and the S-356 structures. Surface water enters Taylor Slough through S-328 or Berm B3 in the S-332D Detention Area, which is part of water pumped by S-332D, and through G-737 in the Frog Pond Detention Area for water pumped by S-200. Water pumped by S-332B and S-332C into the C-111 North and South detention areas as well as water pumped by S-199 into the Aerojet Canal does not have surface discharging points into ENP. Therefore, surface inflow to Taylor Slough includes S-332D and G-737 (partial S-199 flow) only, excluding S-332B, S-332C, and S-200 flows discharged into detention areas. The surface inflow to the Eastern Panhandle of ENP via the S-18C structure is the difference between S-18C and S-197.

The total inflow into ENP for WY2023 was 1,735 kac-ft, 162% of the historical average (**Table 2A-1** in the *Highlights* section). 1,336 kac-ft (34%) of the total ENP inflow moved into Shark River Slough and

the majority of Shark River Slough inflow came from the S-12A, S-12B, S12C, and S-12D structures. Of ENP inflow, 251 kac-ft entered through S333-334 (14%), 242 kac-ft through S-356 (14%), 245 kac-ft through S-332D (14%) and 10 kac-ft through G-737 (>1%) into Taylor Slough, and 82 kac-ft through S-18C (5%) into the Eastern Panhandle (Appendix 2A-3, Table 12). Appendix 2A-3 provides monthly inflows and outflows at each monitoring site, as well as comparisons to historical averages. **Table 2A-1** includes flow statistics.

WATER YEAR 2023 EXTREME HYDROLOGIC EVENTS

2022 HURRICANE SEASON

WY2023 (2022 Atlantic Basin Hurricane Season: June 1, 2022 to November 30, 2022) featured 14 named storms (**Figure 2A-11**). Three major storms, Tropical Storm Alex, Hurricane Ian, and Hurricane Nicole posed a risk to South Florida during the 2022 hurricane season. Storm event summaries for major storms and hurricanes are documented in the *Water Year 2023 Extreme Event Summaries* section of this chapter. The summaries detail the characteristics of storms and state of the water management system and the operations following each event.

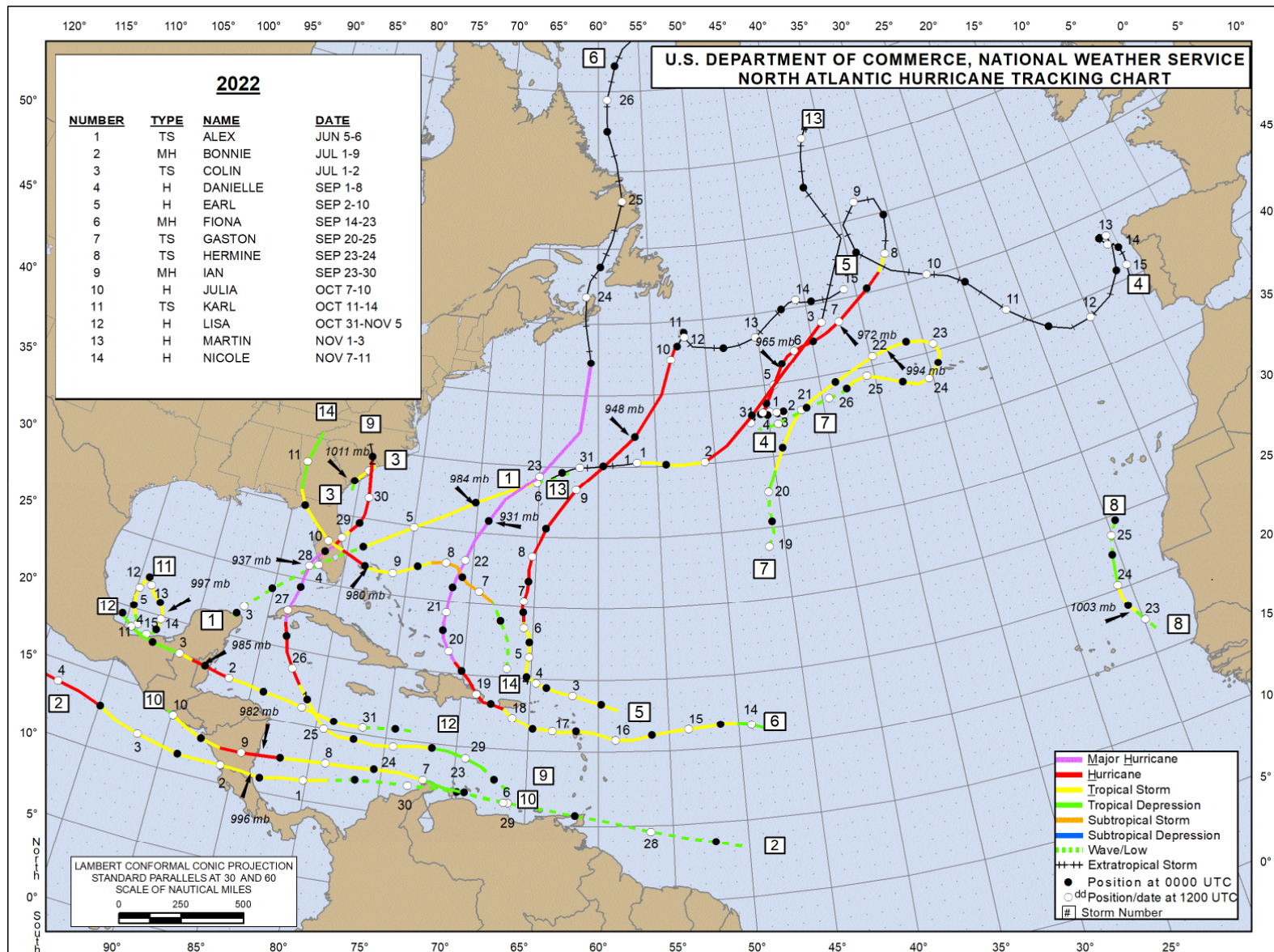


Figure 2A-11. Tropical systems tracks and durations during WY2023 (2022 hurricane season).
 Source: <https://www.nhc.noaa.gov/data/#tcr>. (Note: UTC – Coordinated Universal Time.)

2022/2023 EL NIÑO SOUTHERN OSCILLATION

El Niño Southern Oscillation (ENSO) is an ocean-atmosphere phenomenon that is reflected in the warming or cooling of the eastern Pacific Ocean. An El Niño/La Niña event occurs when the sea surface temperature (SST) increases/decreases (+0.5/-0.5) every 2 to 7 years and is accompanied by atmospheric changes. The increase in SST at the equatorial eastern Pacific Ocean is attributed to the weakening of the easterly trade winds that result in warm water from the western Pacific Ocean moving to the east. The decrease in SST at the equatorial eastern Pacific Ocean is attributed to the strong easterly trade winds bringing cooler water to the surface.

During El Niño years in South Florida, the dry season rainfall tends to increase, reaching ~140% of normal. Conversely, during La Niña years, the dry season rainfall decreases often dropping ~60 to 65% of normal, with the largest effects lasting from November to March. El Niño conditions create wind shear that weakens Atlantic tropical systems. La Niña conditions weaken trade winds over the Atlantic Ocean, which supports tropical cyclone development.

ENSO declarations from the National Oceanographic and Atmospheric Administration (NOAA) are delivered monthly or as needed and rely on observations of both SST and atmospheric conditions. The 2022/2023 Water Year started in a La Niña condition. Forecasts called for a potential third year La Niña. La Niña persisted through February 2023 with a switch to ENSO Neutral conditions in March 2023. El Niño conditions were predicted for the following months and the next water year.

Figure 2A-12 depicts the Multivariate ENSO Index Version 2, which is the empirical orthogonal function of five different variables—sea level pressure, SST, zonal and meridional components of the surface wind, and outgoing longwave radiation—over the tropical Pacific basin (30°S-30°N and 100°E-70°W) (NOAA 2023). The Multivariate ENSO Index Version 2 values depict the move from a La Niña (-0.5 or below) to an ENSO Neutral condition (greater than -0.5 and less than 0.5).

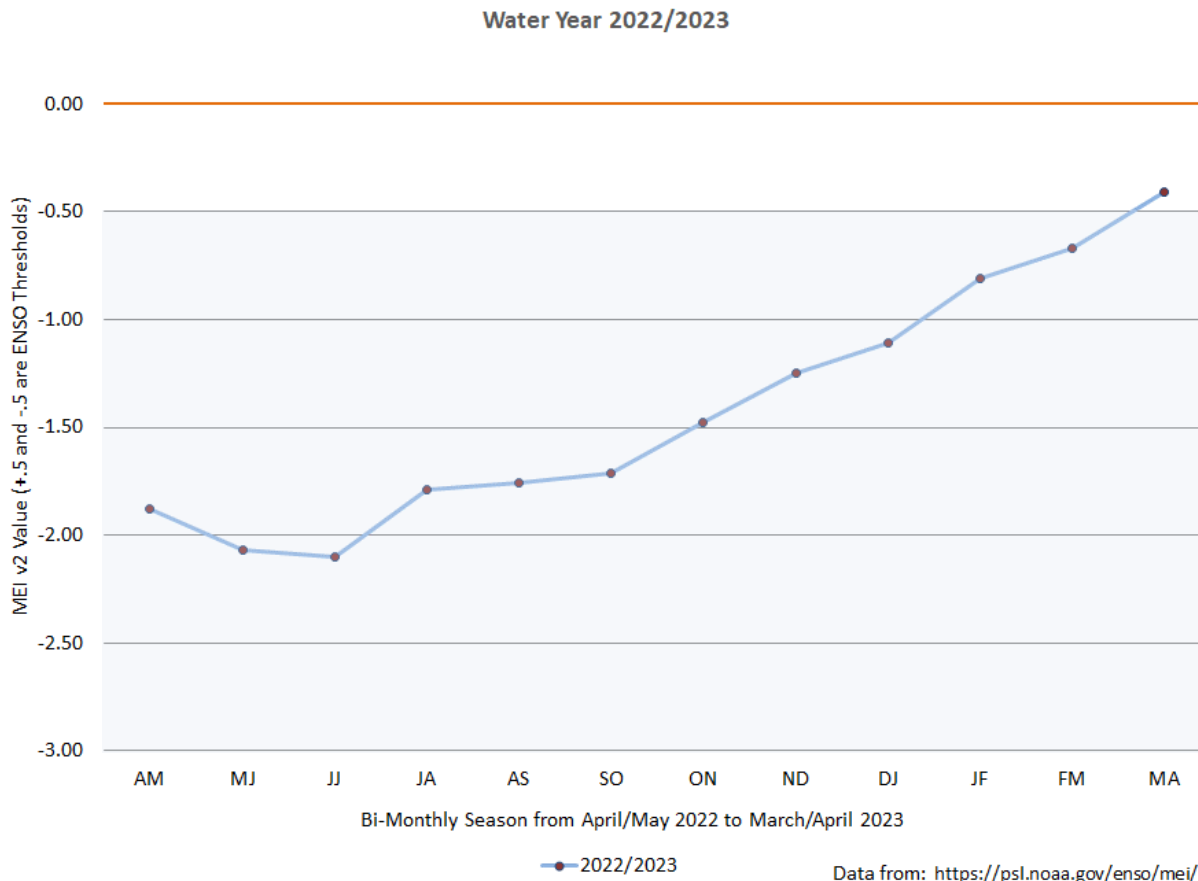


Figure 2A-12. 2022/2023 Multivariate ENSO Index v2 for April/May 2022 through March/April 2023. Data source: <https://psl.noaa.gov/enso/mei/>.

WATER YEAR 2023 EXTREME EVENT SUMMARIES

OVERVIEW

Flood protection in South Florida is a shared responsibility between local governments and SFWMD. SFWMD operates the primary canal system, which is designed to convey excess stormwater from the secondary and tertiary systems operated by local governments. SFWMD is responsible for maintaining appropriate canal levels to ensure they can continuously accept excess stormwater from local drainage systems. Local governments are responsible for delivering excess stormwater efficiently and effectively to SFWMD canals to prevent flooding in local communities. The difference between inland and tidal water levels at coastal structures determines the flood control discharge capacity.

SFWMD prepares storm event and action reports to document the characteristics and impacts of major weather events. The reports are unique to each event and not compiled for all events. The reports typically focus only on areas of impact and the data collected before, during, and after each event is not standardized. Some reports can be found in the SFWMD’s technical report archive, while other storm reporting and documentation are available across SFWMD business units. The events’ summary information presented below was extracted from briefs such as weekly environmental conditions and operations presentations and references of authoritative sources such as NOAA.

This section provides summaries of sustained extreme events and details the state of the water management system and the operations following the events. The summaries are based on the data reported

during operational meetings and data from authoritative data sources to memorialize key aspects of major and extreme events during WY2023 that influenced water management. The purpose of memorializing the information in this annual report on major tropical storms and hurricanes and extreme rainfall events in South Florida is twofold:

1. **Document Historical Data:** It serves as a record of the major and extreme events that have affected the region over the years. This data can be used for research, historical reference, and planning for the future. It also helps with model calibration and refinement in support of adaptation planning.
2. **Evaluate Water Management:** The annual report allows for an analysis of how the water management system responded to the storms and aids in identifying operational enhancements or infrastructure investments that are needed, as applicable.

Four major events impacted the region during the 2023 water year and are summarized in this year's chapter: (1) Tropical Storm (TS) Alex in June 2022, (2) Hurricane Ian in September 2022, (3) Hurricane Nicole, and (4) the extreme rainfall event that took place in eastern Broward County in April 2023.

POTENTIAL TROPICAL CYCLONE ONE: JUNE 4–5, 2022

- **Tropical Storm/Hurricane Category:** Potential Tropical Cyclone One (PTC1) was a precursor disturbance that formed over the southeastern Gulf of Mexico, east-southeast of South Florida, from remnants of an eastern Pacific basin hurricane system. It became a post-tropical cyclone, a former tropical storm that transitioned to a non-tropical storm, named once it passed to the east of Florida, as it entered the Atlantic Ocean and passed near Bermuda, becoming a short-lived tropical storm (TS), TS Alex (**Figure 2A-13**).
- **Path and Date of Landfall:** PTC1 developed near the Yucatan Peninsula, moved north-northeast across the eastern Gulf of Mexico, and made landfall near Naples on the west coast of South Florida on the morning of June 4 (**Figure 2A-13**).
- **Antecedent Conditions:** The week leading up to the arrival of PTC1 exhibited average to above average rainfall throughout the region (**Figures 2A-14** and **2A-15**).
- **Rainfall and Flooding:** PTC 1 produced heavy rainfall across South Florida beginning on June 3 and flooding was reported in portions South Florida, mainly in urban along coastal areas of Miami-Dade, Broward, and southeastern Palm Beach counties. Rainfall totals within various rainfall areas ranged between 1.70 and 6.71 inches (**Table 2A-14**) across the region, 282% of the normal rainfall based on historical record (**Figure 2A-16**) and ranked as a 15-year rainfall event.
- **Wind Speed and Damage:** PTC1 wind speeds remained at around 40 mile per hour (mph) on June 3 and 4, rising to 46 mph as it exited South Florida and entered the Atlantic Ocean.
- **Storm Surge:** PTC1 produced minimal storm surge across South Florida and the Florida Keys. Tide gauges along both the southwestern and southeastern coasts of Florida reported storm surge amounts of 1 to 1.5 ft, above normal tide levels with the highest value at Naples where 1.48 ft of storm surge was observed. Combined with the tide, this resulted in storm surge inundation of around 0.5 to 1 ft above normally dry ground.

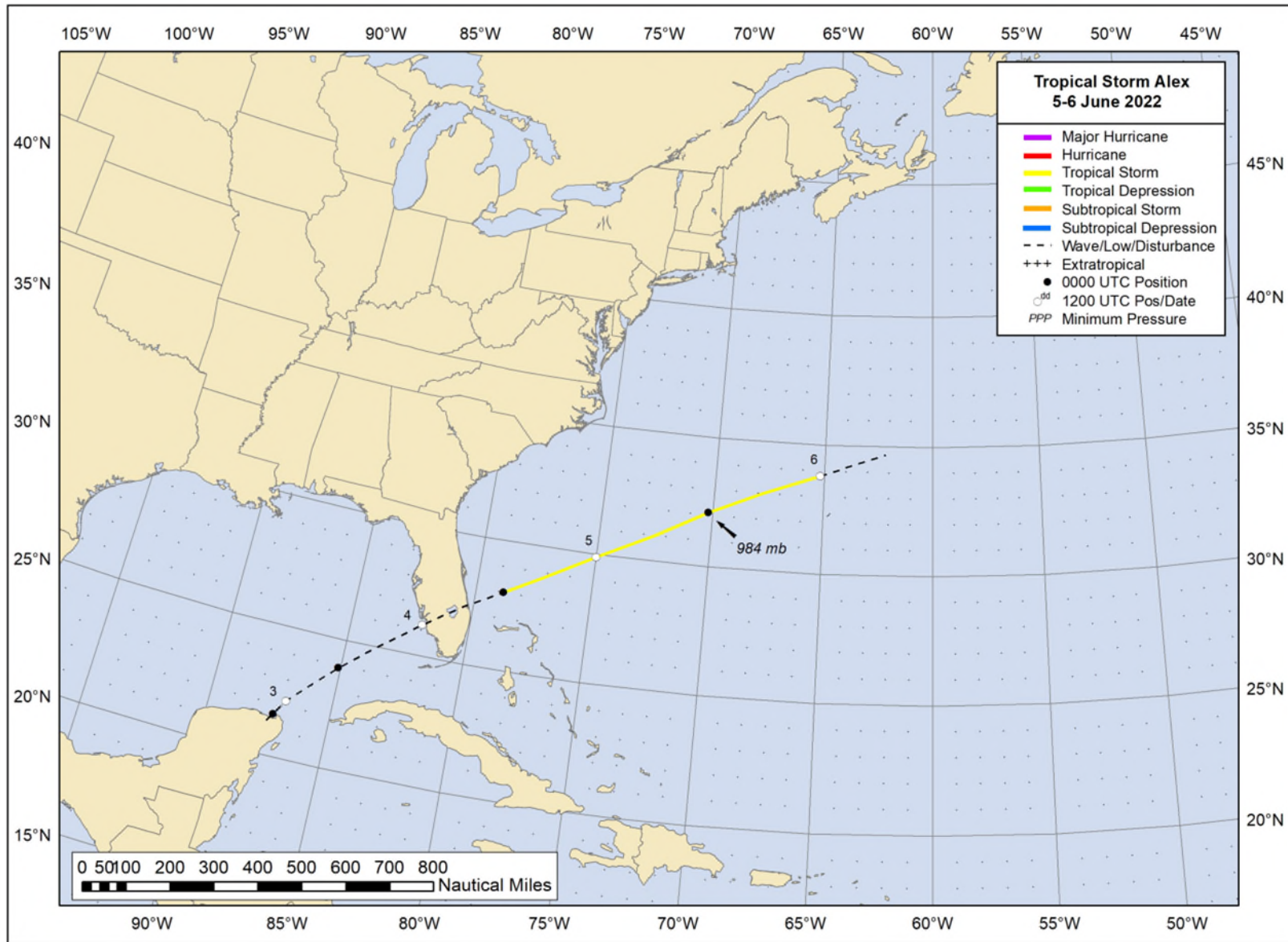


Figure 2A-13. Best track positions for TS Alex, June 5–6, 2022 (Brown and Delgado 2022).

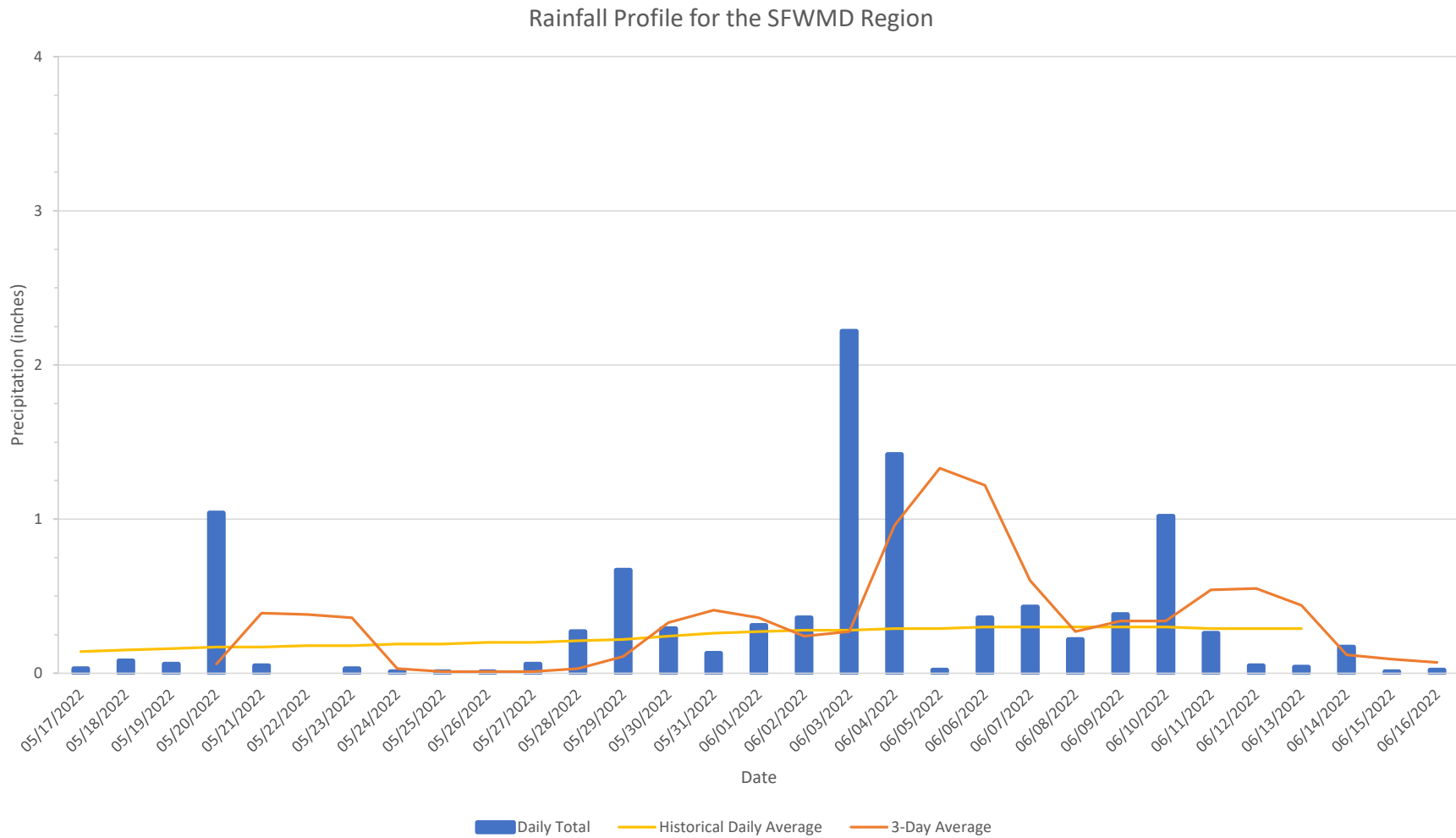


Figure 2A-14. Rainfall profile for the SFWMD region before, during, and after PTC1/TS Alex.

Data source: <https://apps.sfwmd.gov/nexrad2> and Weekly Environmental Conditions and Operations Meeting Presentation for June 14, 2022.

Table 2A-16. Total rainfall in each rainfall area.

Source: Weekly Environmental Conditions and Operations Meeting Presentation for June 7, 2022.

| Basin | Rainfall (inches) |
|----------------------|------------------------------|
| Big Cypress Preserve | 2.74 |
| Broward | 6.51 |
| Miami-Dade | 6.71 |
| EAA East | 1.87 |
| EAA West | 2.06 |
| East Caloosahatchee | 2.84 |
| Martin/St. Lucie | 1.60 |
| Palm Beach | 3.77 |
| Southwest Coast | 4.77 |
| WCA-3 | 2.94 |
| WCA-1 & WCA-2 | 3.91 |

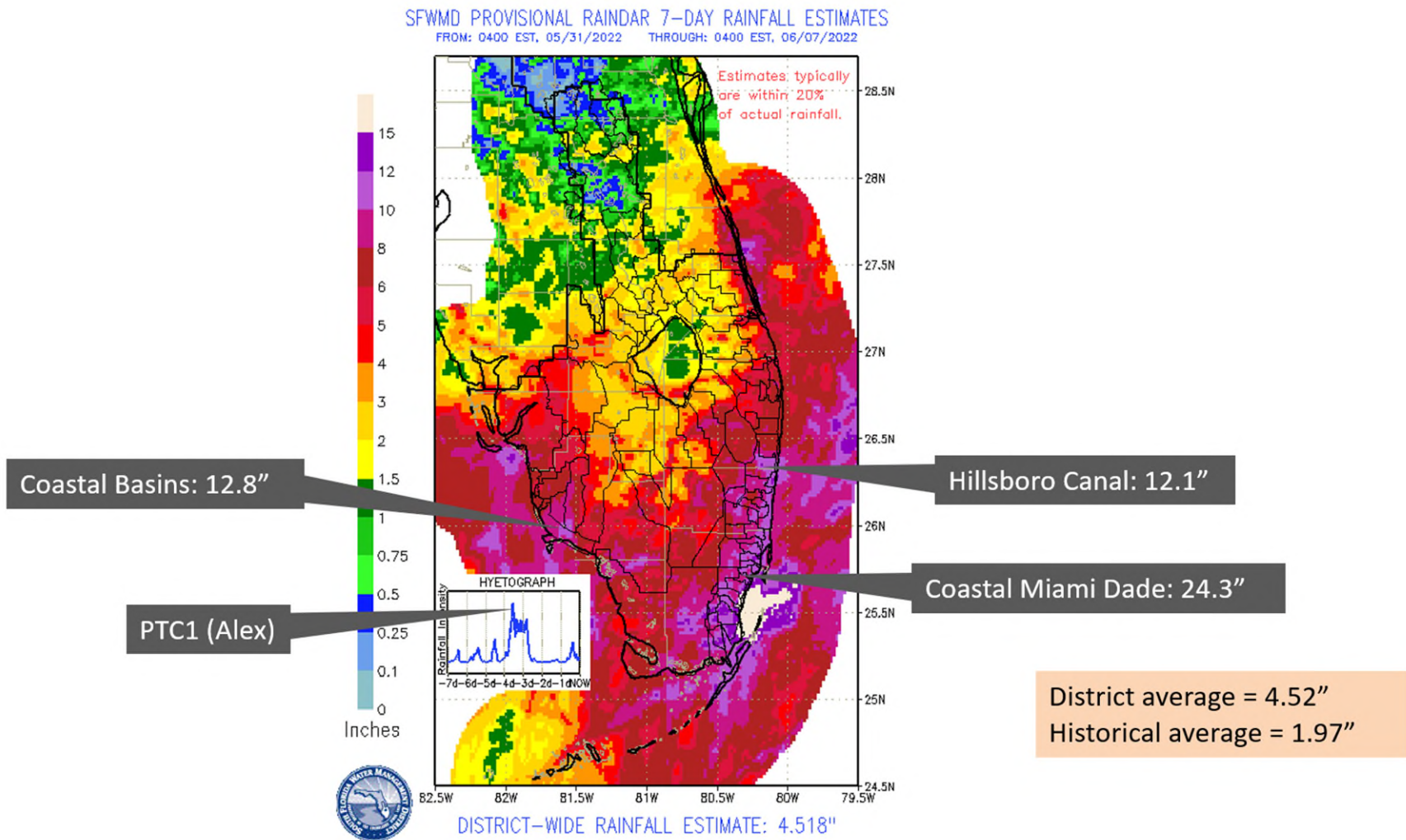


Figure 2A-15. 7-Day rainfall estimates from May 31, 2022, through June 7, 2022, over the entire SFWMD region.
 Source: Weekly Environmental Conditions and Operations Meeting Presentation for June 7, 2022.

District wide: 282% of normal

Every location above normal

>300% of normal along southern coasts

UK 48% of normal

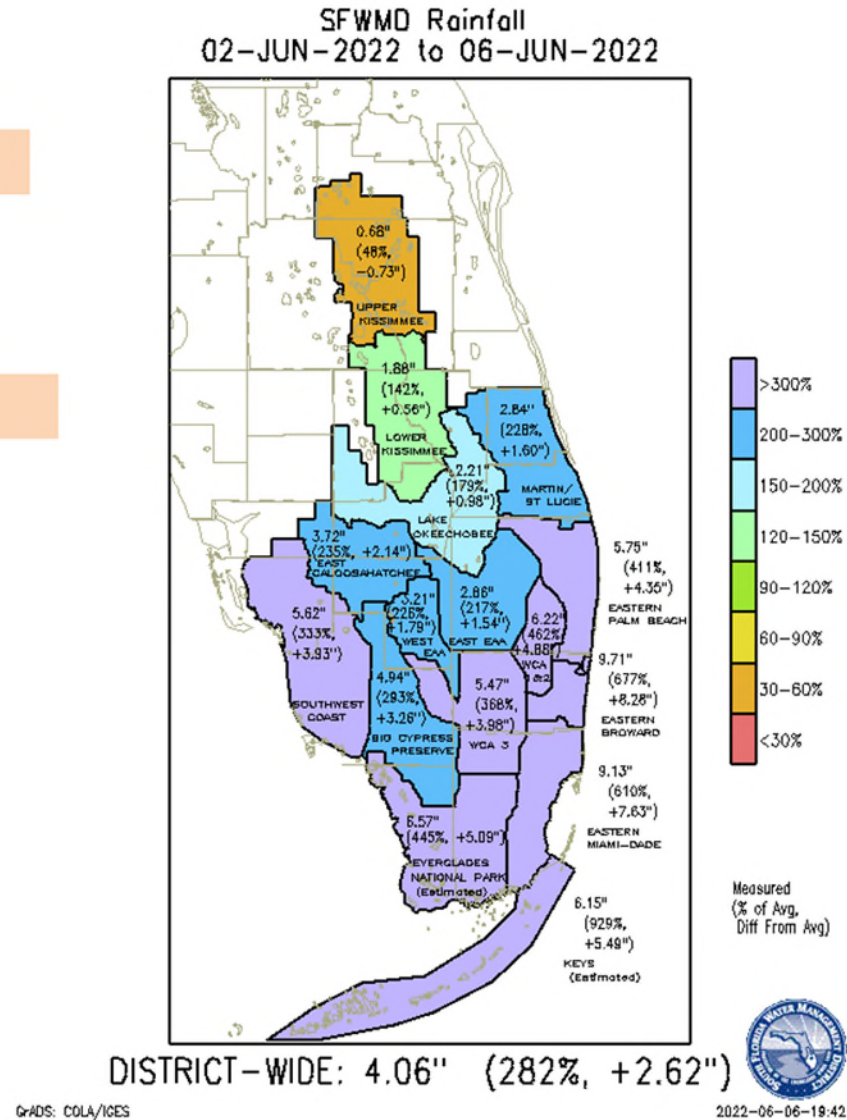


Figure 2A-16. Historical comparison of rainfall estimates from June 2, 2022, through June 6, 2022, over the entire SFWMD region. Source: Weekly Environmental Conditions and Operations Meeting Presentation for June 7, 2022.

HURRICANE IAN: SEPTEMBER 27–28, 2022

- **Storm/Hurricane Category:** Ian was a category 5 hurricane that impacted the west coast and central regions of Central and South Florida. Ian weakened to a tropical storm as it moved offshore into the Atlantic Ocean. Ian ranks as the third costliest hurricane to have made landfall in the continental United States impacting Florida, Georgia, and the Carolinas.
- **Path and Date of Landfall:** Hurricane Ian developed off the west coast of Africa, moved eastward across the Atlantic Ocean, and then head north when it entered the southeastern Caribbean, and made landfall at Cayo Costa on the southwest coast of South Florida on the morning of September 28 at category 4 intensity (**Figure 2A-17**).
- **Antecedent Conditions:** The weeks leading up to the arrival of Hurricane Ian exhibited above average rainfall across the region, and near average on the eight antecedent days (**Figure 2A-18**).
- **Rainfall and Flooding:** Ian produced heavy rainfall across central and southwestern Florida beginning on September 27 and flooding was reported across the area, along coastal and rural areas. Ian reached two rainfall peaks as it made its way across the state (**Figure 2A-19**). Within the SFWMD region, the Upper Kissimmee Basin received the most rainfall with over 15 inches of rainfall recorded and ranked above a 200-year event (**Figures 2A-19** and **2A-20**). Flooding from surge was reported along South Florida’s west coast and flooding from rainfall was reported in Charlotte, Collier, DeSoto, Hardee, Hillsborough, Lee, Manatee, Orange, Osceola, Pinellas, Polk, Sarasota, and Seminole counties.
- **Wind Speed and Damage:** The highest reported sustained wind observation near the landfall location was 108 mph on September 28 with a peak gust of 140 mph.
- **Storm Surge:** Ian produced catastrophic storm surge along the southwest coast of Florida, impacting the barrier islands near Fort Myers, as well as rivers and bays such as the Caloosahatchee River, Estero Bay, the Imperial River, and Naples Bay. Peak storm surge inundation levels of 10 to 15 ft above ground level (AGL) occurred in Fort Myers Beach (**Figure 2A-21**). The SFWMD gauge network recorded new record high peak stage at the COCO1 coastal structure in the Big Cypress Basin (BCB) on South Florida’s west coast (**Figure 2A-22**). The peak exceeded design water of structure. The surge caused ~400 cubic feet per second (cfs) of flow inland (negative flow). Recovery to normal levels took ~12 hours, occurring on September 29, 2022. The control structure was locked fully open from the time storm surge forecast was issued, with concerns of high potential for communication loss. Power was lost and generator return of normal structure control was not until October 3, 2022.

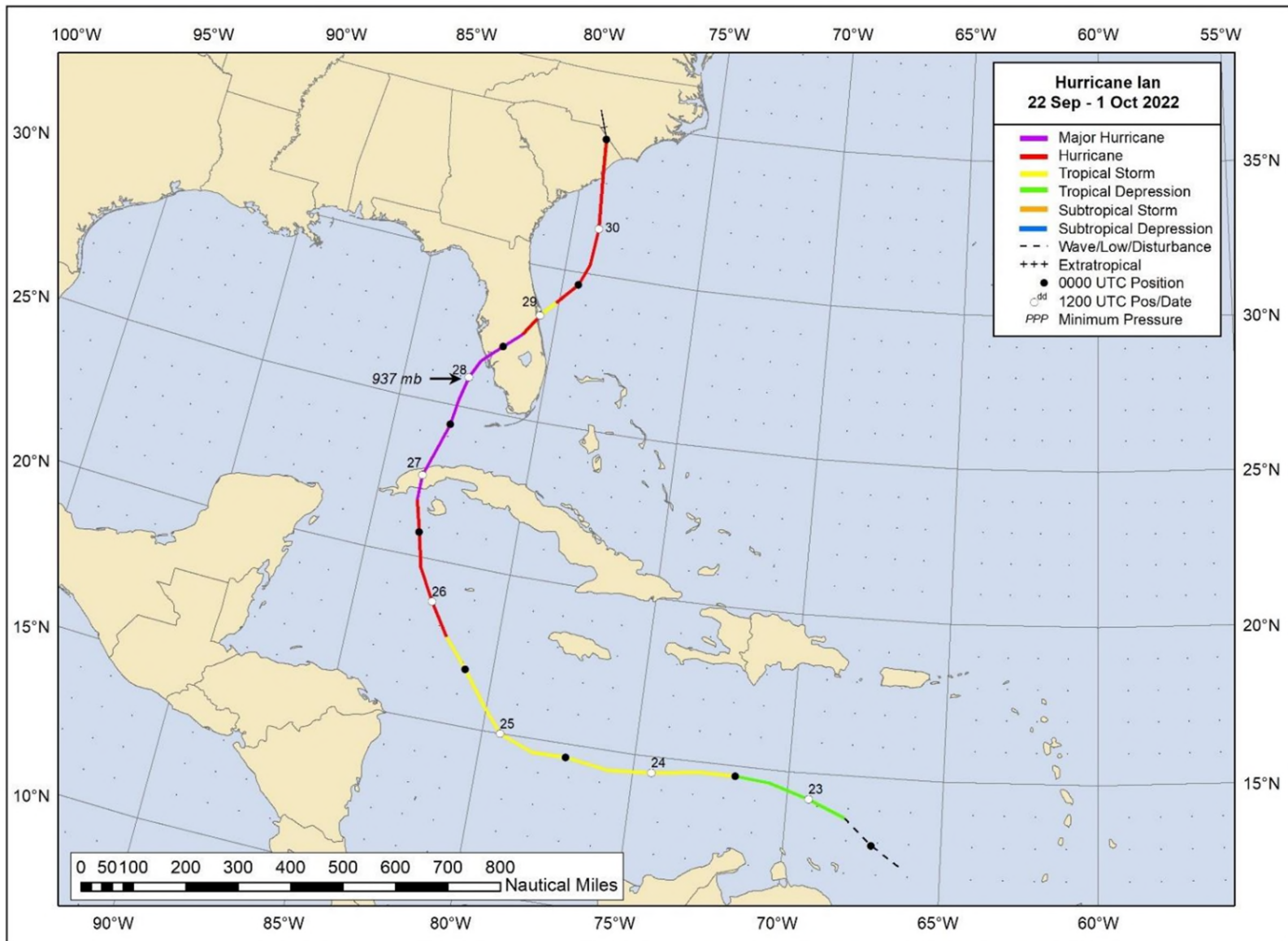


Figure 2A-17. Best track positions for Hurricane Ian, September 22 through October 1, 2022 (Bucci et al. 2023).

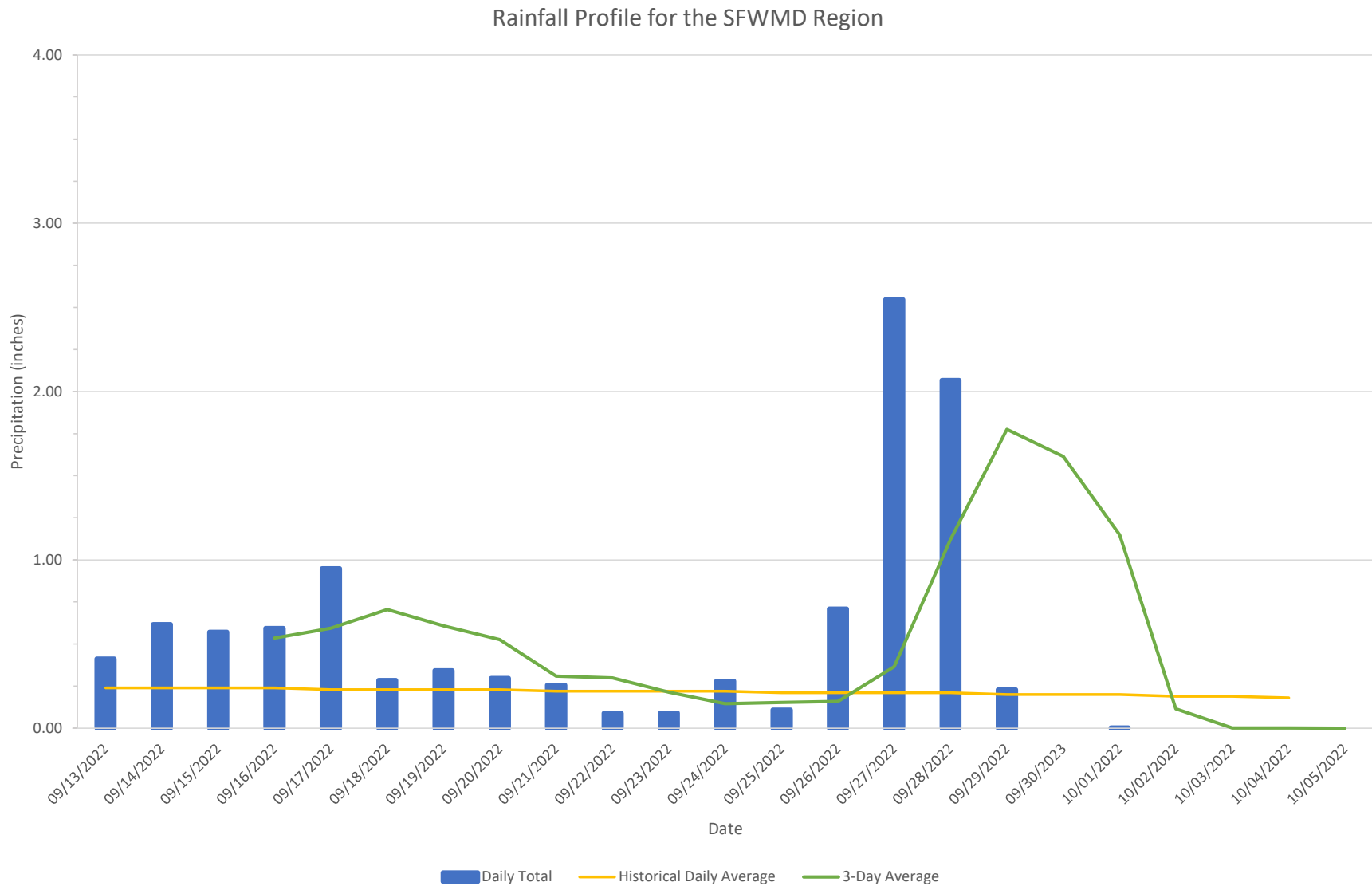


Figure 2A-18. Rainfall profile for the SFWMD region before, during, and after Hurricane Ian. Data source: <https://apps.sfwmd.gov/nexrad2> and Weekly Environmental Conditions and Operations Meeting Presentation for October 4, 2022.

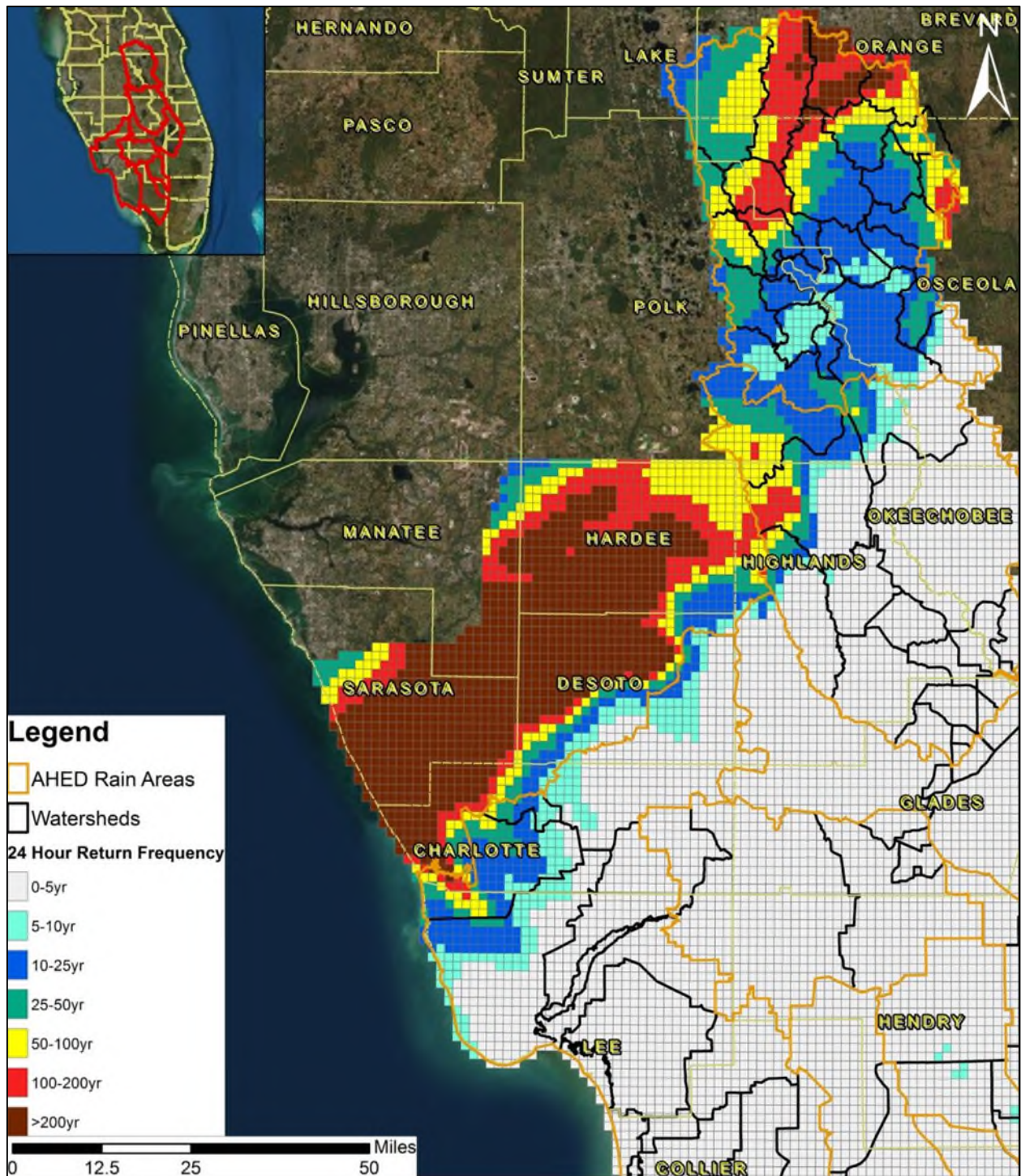


Figure 2A-19. Peak 24-hr NEXRAD rainfall data observed during Hurricane Ian, referenced to NOAA Atlas 14 precipitation frequency estimates . Data source: <https://apps.sfwm.d.gov/nexrad2/>.

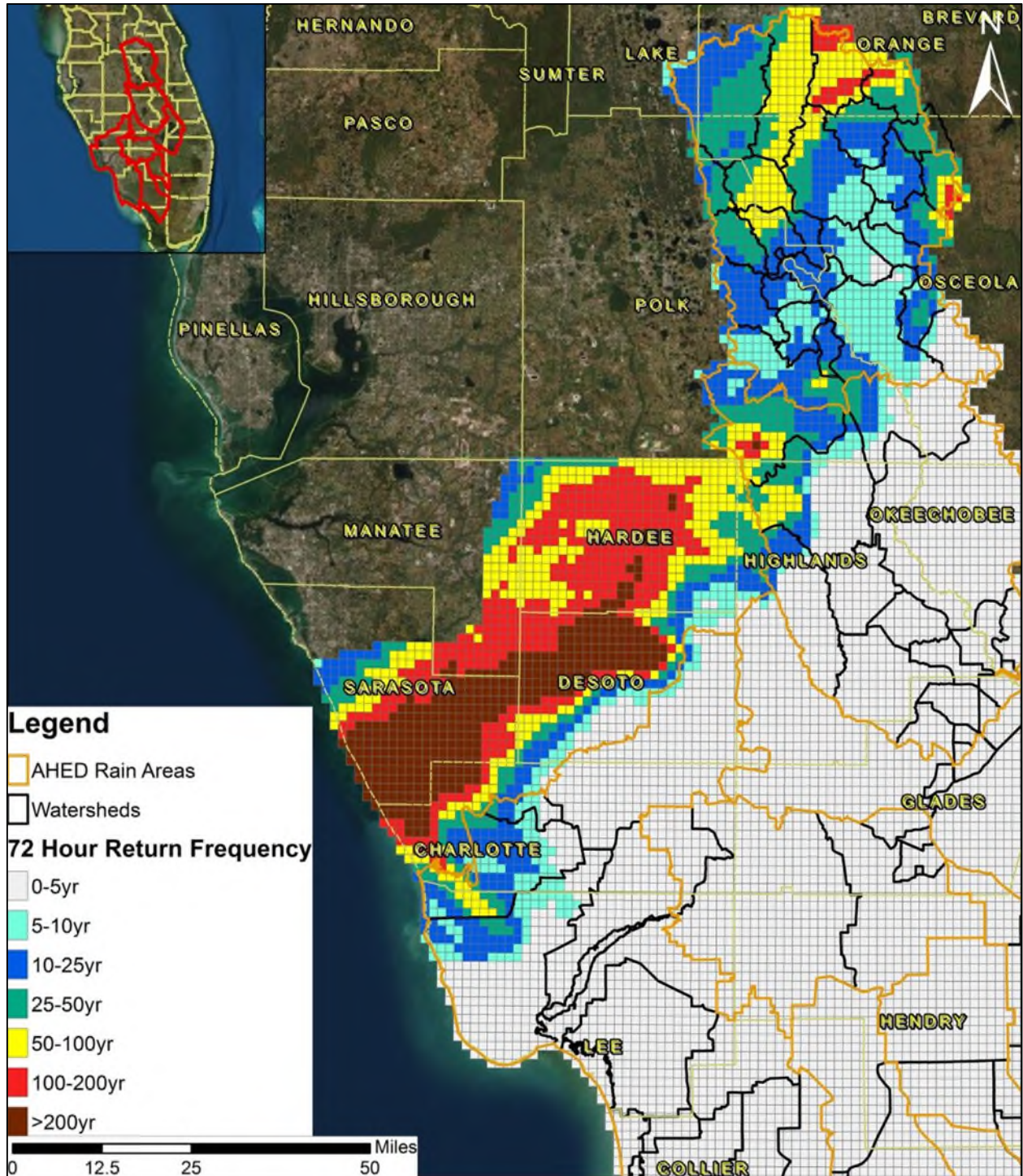


Figure 2A-20. Peak 72-hour NEXRAD rainfall data observed during Hurricane Ian, referenced to NOAA Atlas 14 precipitation frequency estimates . Data source: <https://apps.sfwmd.gov/nexrad2/>.



Figure 2A-21. Analyzed storm surge inundation (ft AGL) along the coasts of Florida, Georgia, South Carolina, and North Carolina from Hurricane Ian (Bucci et al. 2023).

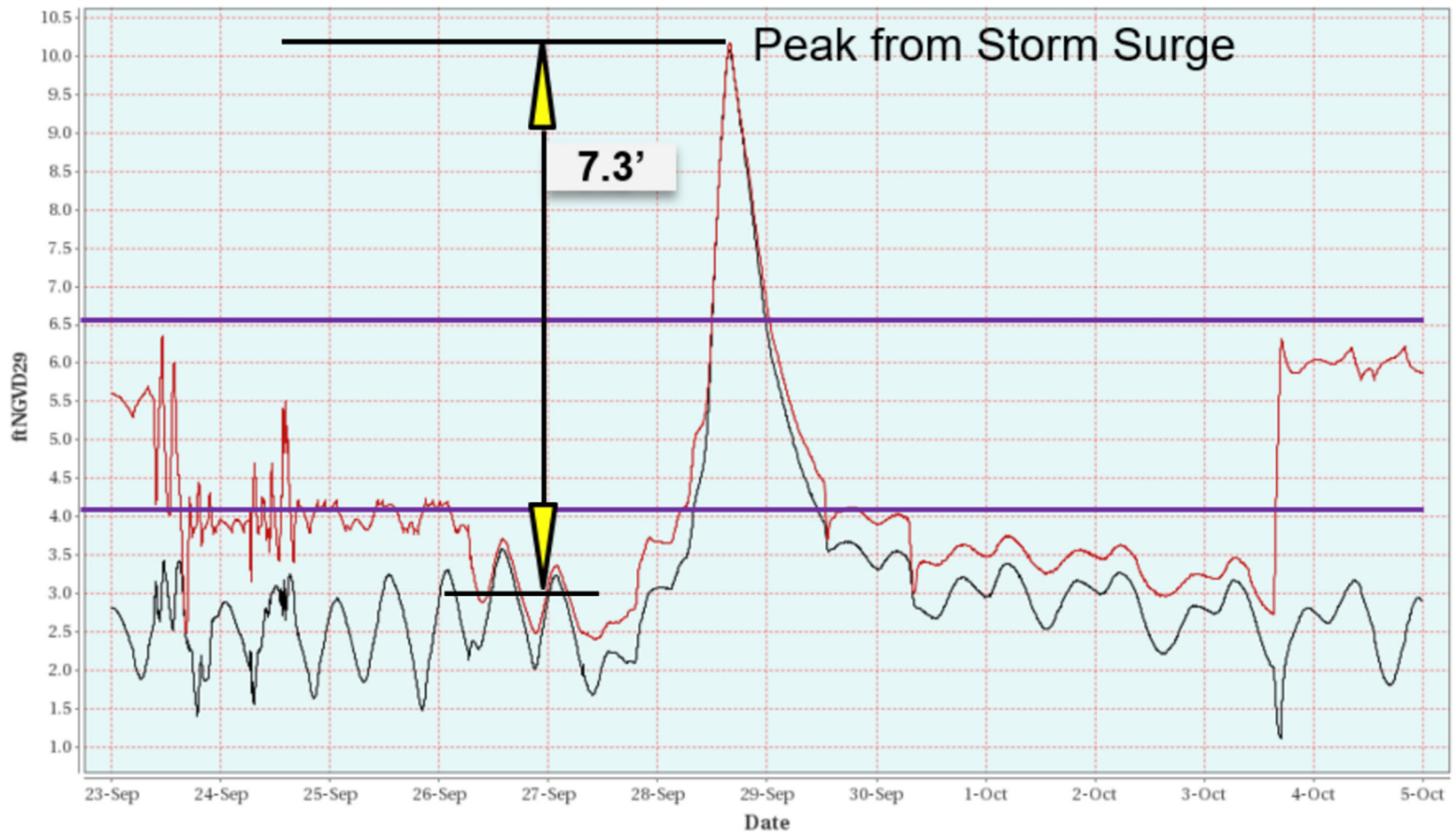


Figure 2A-22. Storm surge profile analysis at COCO1 Coastal Structure outfall. The two purple lines denote the low and high operating ranges of the structure and the red and black lines denote the headwater and tailwater, respectively. Normally, there is several feet difference between the headwater and tailwater. During the event, when the gates were locked open, the headwater and tailwater nearly matched.

HURRICANE NICOLE: NOVEMBER 9–10, 2022

- **Storm/Hurricane Category:** Nicole was a category 1 hurricane that impacted the UEC of the SFWMD region and central and northern areas of the state, just weeks after Hurricane Ian. Nicole weakened to a tropical storm upon making landfall. Due to its large size, Nicole's impacts extended from the Bahamas and Florida northward to South Carolina. Notably, Nicole was the sixteenth and final storm of the 2022 Hurricane Season. Becoming a hurricane late in the season, Nicole was only the third hurricane on record to make landfall in Florida during the month of November, with the last storm being Hurricane Kate in 1985.
- **Path and Date of Landfall:** Nicole made landfall on the east-central coast of Florida at midday on November 9, 2022. Nicole entered the Gulf of Mexico on November 10 but later made landfall as a tropical storm in the Florida Panhandle as it made its way northeast (**Figure 2A-23**).
- **Antecedent Conditions:** The week leading up to the arrival of Hurricane Nicole exhibited below average rainfall across most of the region. Nicole coincided with the King Tide season and the November 8, 2022, full moon (**Figure 2A-24**).
- **Rainfall and Flooding:** Nicole produced rainfall totals between 1 and 3 inches across most of the SFWMD region and 3 to 6 inches along the east coast and north of Lake Okeechobee (**Figure 2A-25**). The highest rainfall totals were observed in localized areas north of the SFWMD region. The maximum reported storm total is 7.11 inches near Orlando. No major flooding was reported in the SFWMD region.
- **Wind Speed and Damage:** In the landfall area along South Florida's UEC, the highest reported sustained wind was 62 mph in Martin County on the morning of November 10, and the highest reported gust was 75 mph in New Smyrna Beach, which is outside of the SFWMD operating region.
- **Storm Surge:** Nicole produced an impactful storm surge along a large portion of the east coast of Florida, battering beaches with elevated water levels and wave action. Sensors from various National Ocean Service tide gauges and United States Geological Survey (USGS) stream gauges along the United States east coast measured 3 to 4 ft of water above mean higher high water (MHHW) from Jupiter Inlet, Florida, northward to St. Simons Island, Georgia (**Figure 2A-26**).

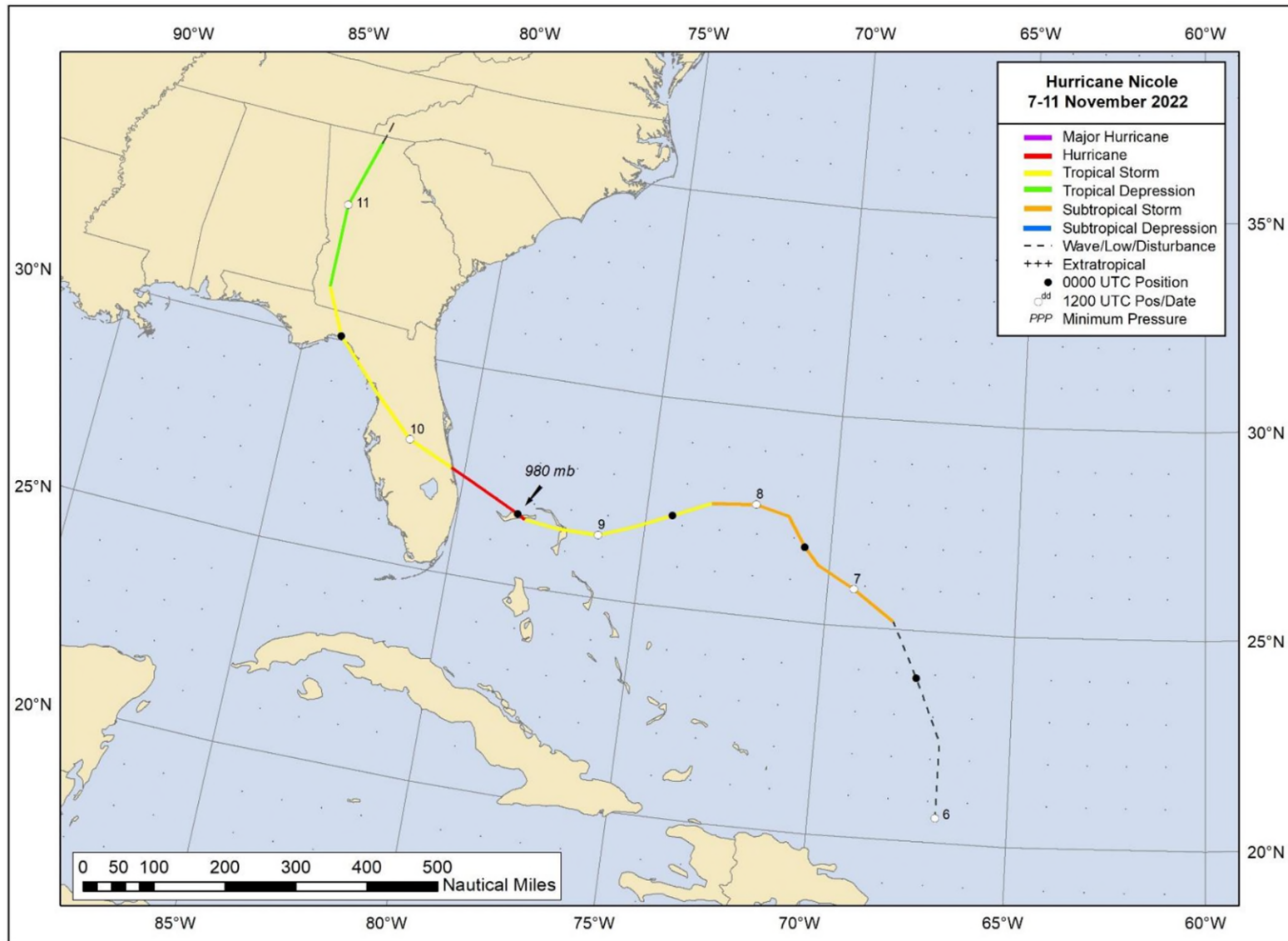


Figure 2A-23. Best track positions for Hurricane Nicole, 7–11 November 2022 (Beven and Alaka 2023).

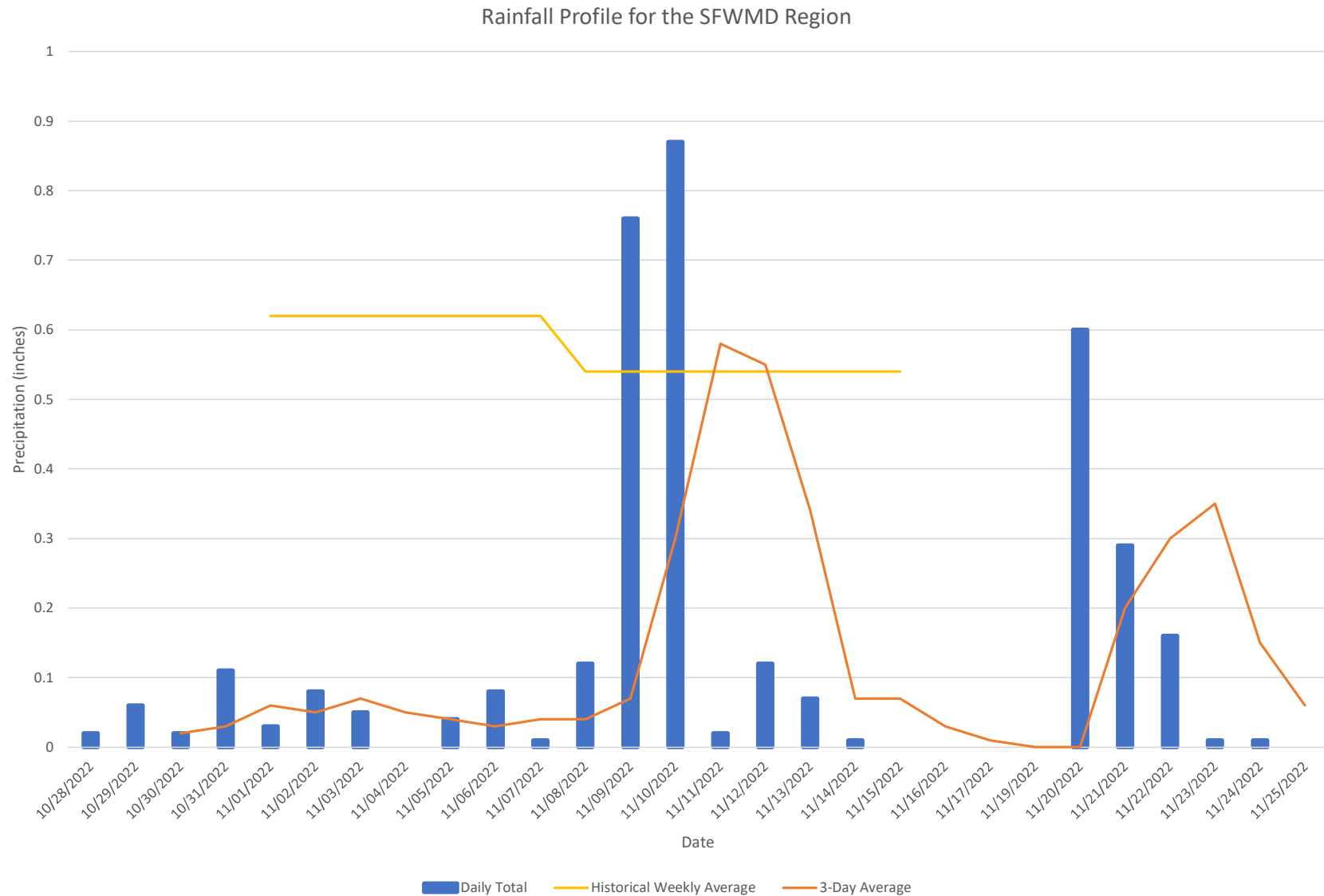


Figure 2A-24. Rainfall profile for the SFWMD region before, during, and after Hurricane Nicole. Data source: <https://apps.sfwmd.gov/nexrad2> and Weekly Environmental Conditions and Operations Meeting Presentations for November 8 and 15, 2022.

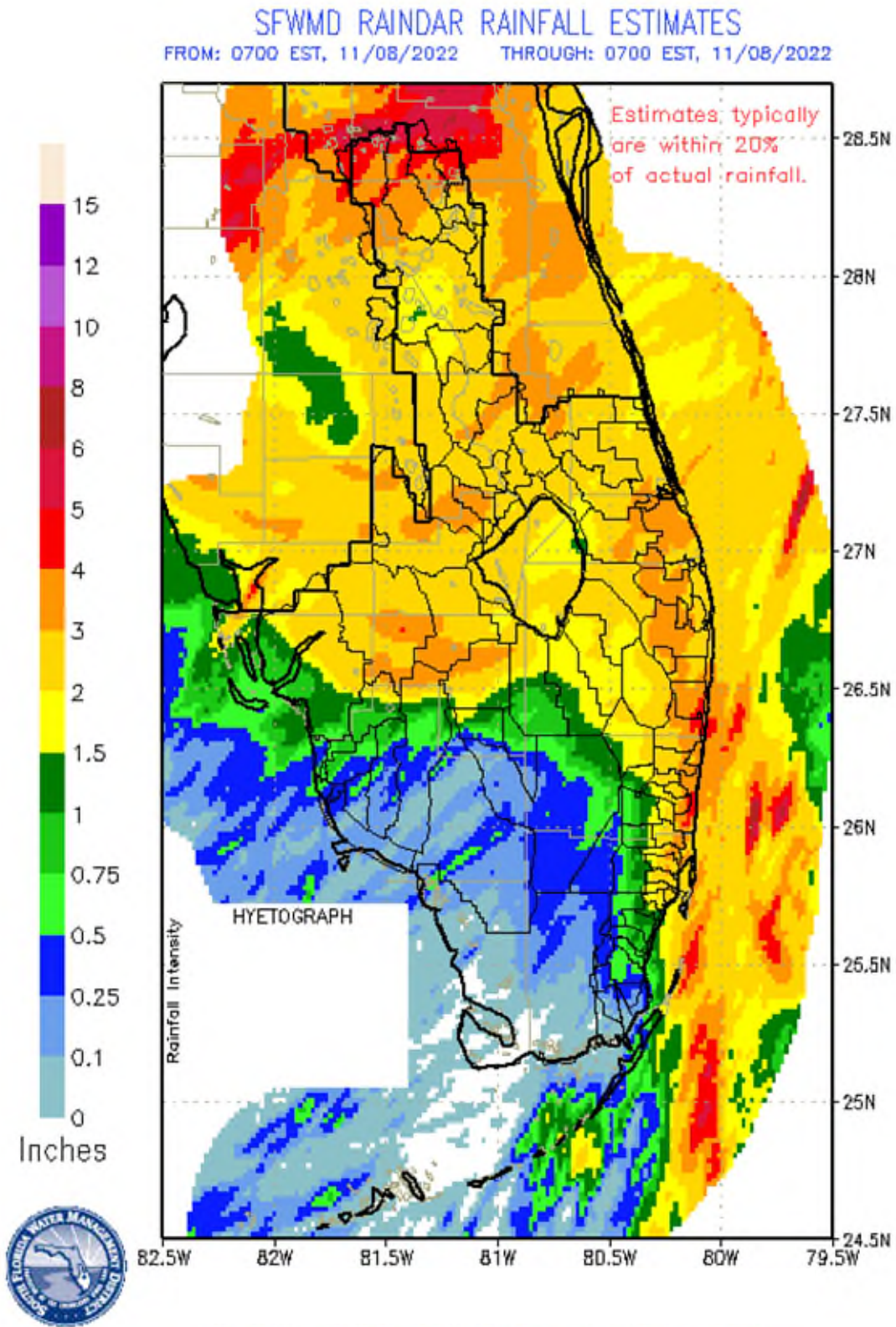


Figure 2A-25. Storm total rainfall associated with Hurricane Nicole, November 8-11, 2023.

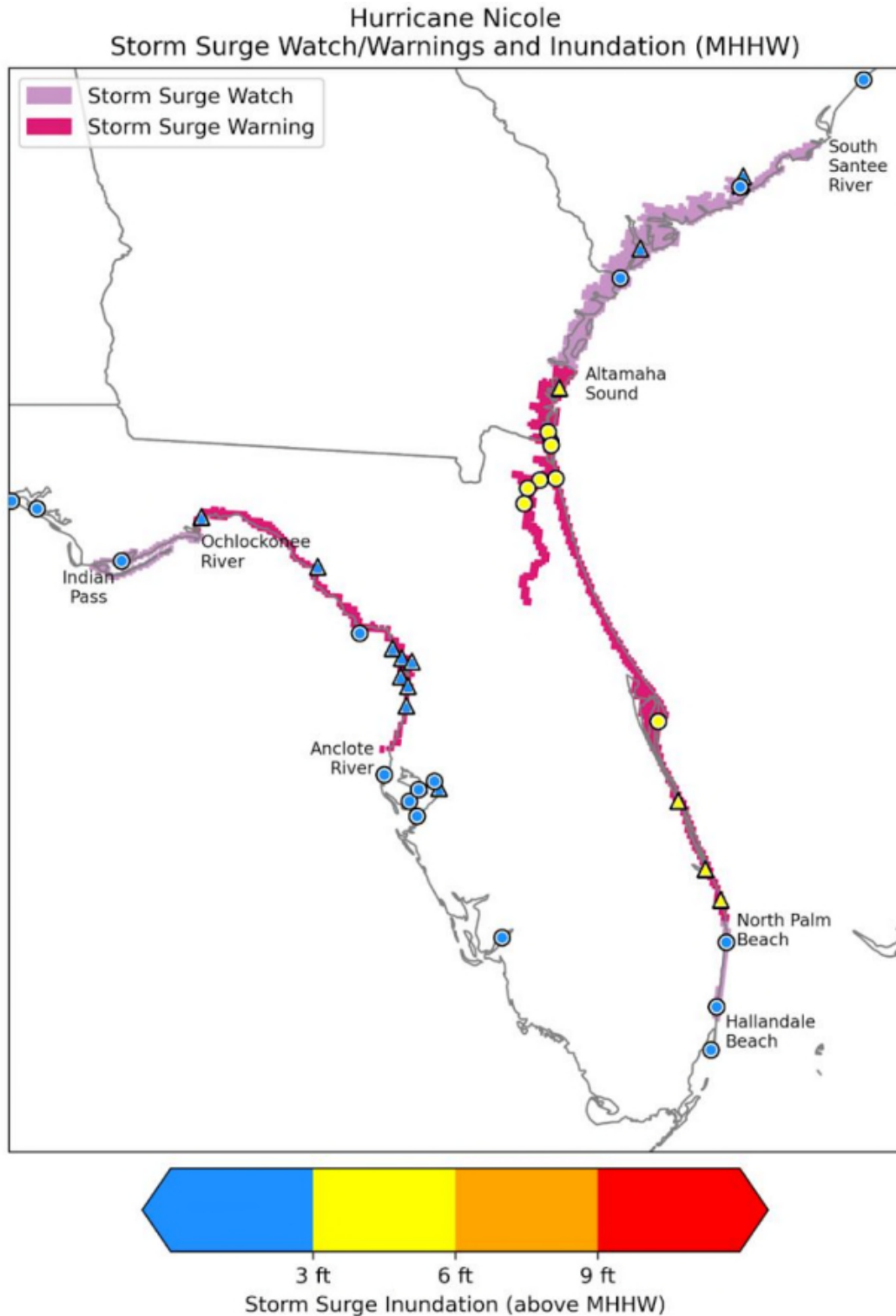


Figure 2A-26. Maximum water levels measured during Hurricane Nicole from National Ocean Service tide gauges (circles) and USGS stream gauges (triangles), as well as areas covered by storm surge watches (lavender) and warnings (magenta) issued at 1500 Coordinated Universal Time (UTC) on November 9, 2022. Water levels are referenced as feet above mean higher high water (MHHW), which is used as a proxy for inundation (above ground level or AGL) on normally dry ground along the immediate coastline (Beven and Alaka 2023).

FORT LAUDERDALE EXTREME RAINFALL EVENT: APRIL 12, 2023

- **Event Description:** The Fort Lauderdale extreme rainfall event on April 12, 2023, set the state’s wettest day on record registered at the Fort Lauderdale-Hollywood International Airport WeatherSTEM weather station. This single-day rainfall total was the wettest for the Broward County rainfall area in the last 32 years and was wetter than the wettest April over the same period. The extreme rainfall event was not associated with tropical activity or named tropical storm/hurricane system. Instead, it resulted from specific meteorological conditions, where a system of low pressure in the Gulf of Mexico was met with a warm front moving in through the southeast of the peninsula from the Atlantic Ocean in the early afternoon, leading to a stationary supercell thunderstorm, driven by convective processes where warm air rises and cold air sinks, creating instability in the atmosphere, over Fort Lauderdale/Hollywood International Airport in eastern Broward County in the late afternoon of April 12. Moisture levels overspreading the SFWMD region were as high as those observed on some of the wettest summer days. The extreme and localized event produced above average rainfall, lightning, thunder, strong winds, hail, and tornadoes.
- **Antecedent conditions:** The extreme and localized rainfall occurred during the final weeks of WY2023 toward the end of the 2021-2022 dry season, before the onset of the 2023 wet season in May 2023 (which is part of WY2024). The event was preceded by dry conditions during the first week of April and rain in the three days preceding it (**Figure 2A-27**).
- **Rainfall:** The extreme rainfall event produced between 15 and 26 inches of rainfall over a localized and densely populated urban area in eastern Broward County from around 5:00 p.m. to midnight Eastern Standard Time (EST) (**Figures 2A-28 and 2A-29**). Notably, the SFWMD’s strategically placed rain gauges recorded just over 8 inches of rainfall in eastern Broward, underscoring the localized nature of the event. **Figure 2A-30** depicts the 6-hour rainfall return period frequency analysis based on data from SFWMD’s Next Generation Radar (NEXRAD) database using NOAA Atlas 14 precipitation frequency estimates as reference.
- **Flooding:** On the afternoon of April 12 at 2:35 p.m. EST, the National Weather Service in Miami, Florida (NWS Miami 2023) issued the first ‘flash flood warning’ alert. At 7:58 p.m. EST, the service issued a rare ‘flash flood emergency’ alert for areas in and around the cities of Hollywood, Dania Beach, and Fort Lauderdale. Hollywood, Fort Lauderdale, Dania Beach, and Oakland Park reported significant flooding, prompting closure of schools and the shutdown of Fort Lauderdale-Hollywood International Airport the following day, Thursday, April 13. A ‘flash flood warning’ remained in effect for Fort Lauderdale, Pembroke Pines, and Hollywood through 9:30 pm EST on April 13 due to additional heavy rain in the days that followed. Property damage due to flooding was reported in areas across eastern Broward County.
- **Tornadoes:** Atmospheric conditions also resulted in the development of two Enhanced Fujita Scale (EF) 0 tornadoes that touched down in Dania Beach and Sheridan Beach.

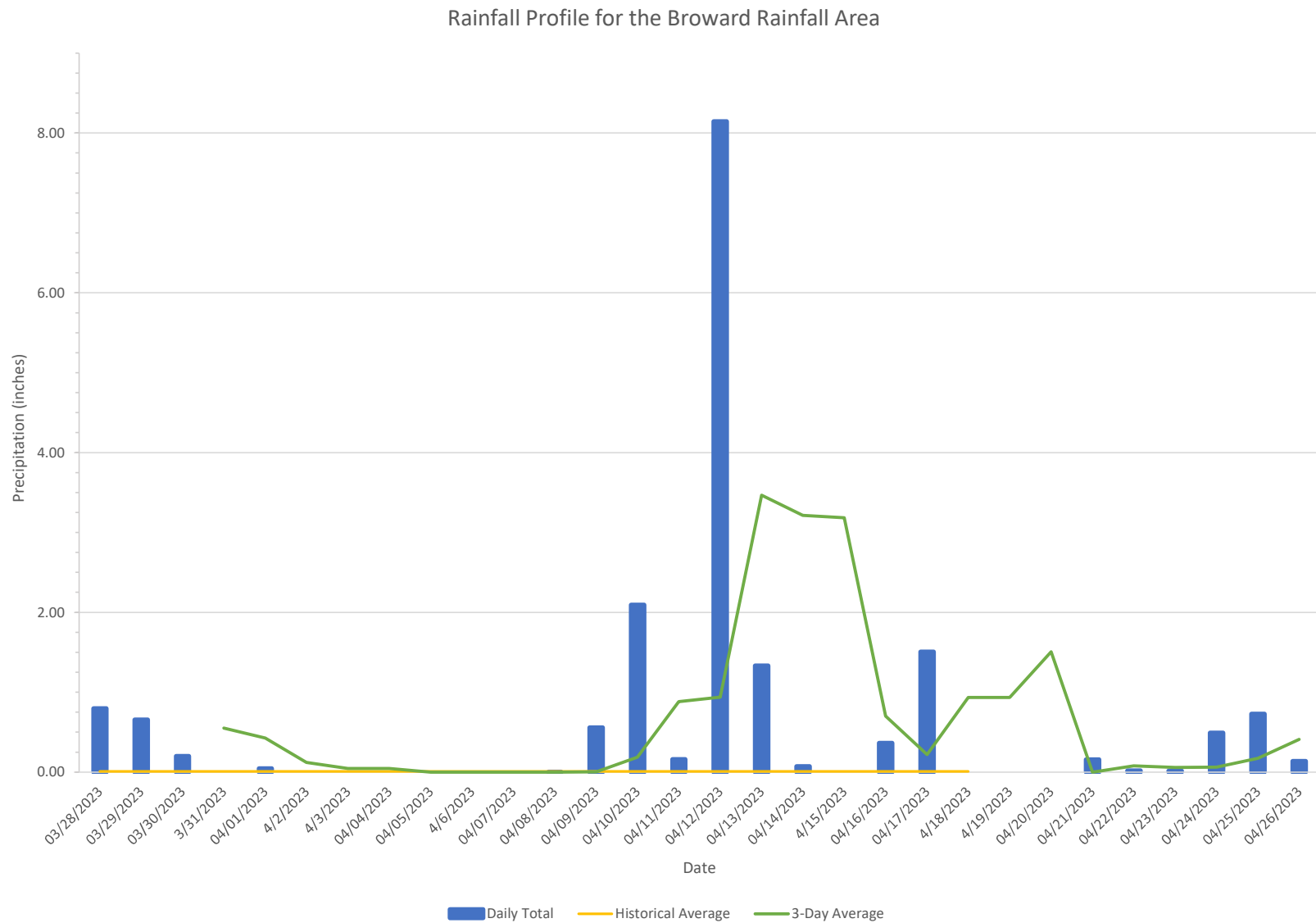


Figure 2A-27. Rainfall profile for the Broward rainfall area before, during, and after the Fort Lauderdale extreme rainfall event. Data source: <https://apps.sfwmd.gov/nexrad2> and Weekly Environmental Conditions and Operations Meeting Presentation for April 18, 2023.

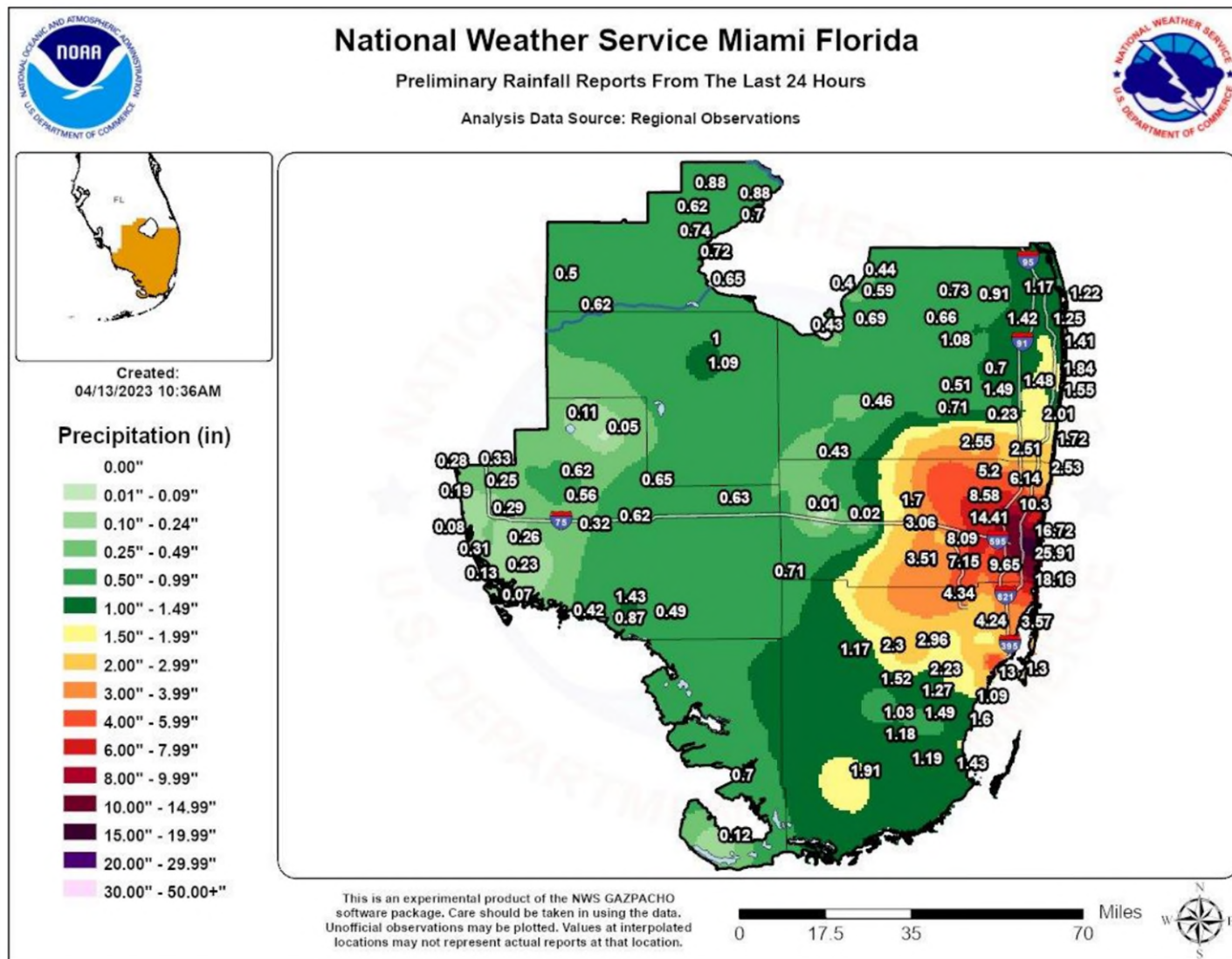


Figure 2A-28. Preliminary 24-hour reported rainfall totals from the National Weather Service in Miami, Florida showing 25.91 inches of rainfall. Source: <https://www.ncei.noaa.gov/access/monitoring/monthly-report/briefings/20230518.pdf>. The final climatological record for April 12 in Fort Lauderdale indicates 22.50 inches of rain, available at https://www.weathebradr.gov/media/mfl/climate/Daily_Records_Fort_Lauderdale.pdf.

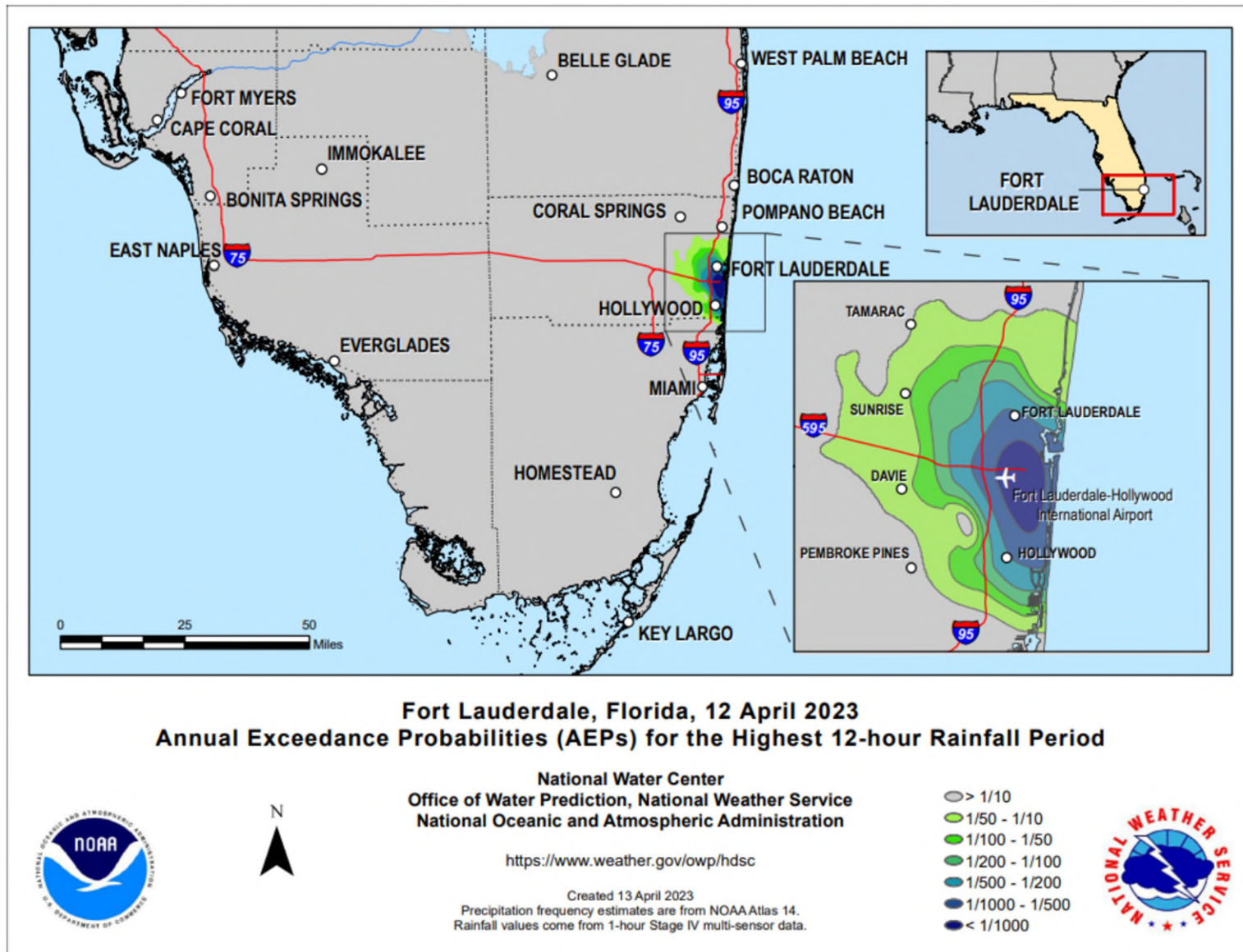


Figure 2A-29. Annual exceedance probabilities (also known as the chance of occurrence) for the 12-hour period with the highest rainfall totals on April 12, 2023. Source: <https://www.ncei.noaa.gov/access/monitoring/monthly-report/briefings/20230518.pdf>.

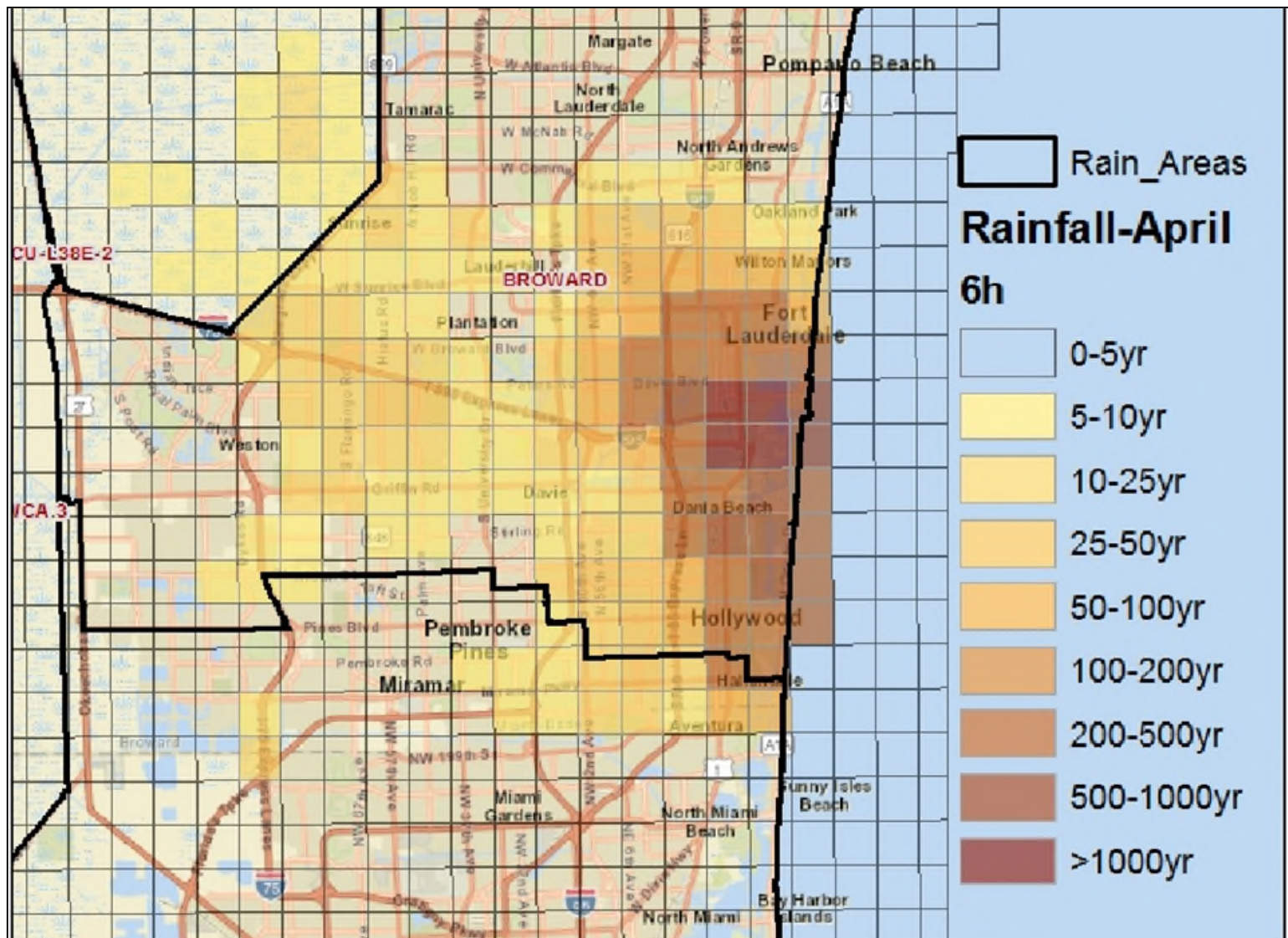


Figure 2A-30. Peak 6-hour rainfall return frequency analysis for the Fort Lauderdale extreme rainfall event on April 12, 2023 data observed during Hurricane Ian, referenced to NOAA Atlas 14 precipitation frequency estimates. Data Source: <https://apps.sfwmd.gov/nexrad2/>.

CLOSING REMARKS

The combination of antecedent wet conditions and consequent elevated groundwater levels with the occurrence of extreme rainfall events, elevated tides, and storm surge result in compound flooding risks, as observed with Hurricane Ian. Alternately, extreme rainfall events alone may lead to widespread or localized flood impacts, as observed with the Fort Lauderdale extreme rainfall event on April 12, 2023. Climate change impacts, including sea level rise and extreme rainfall, might contribute to more frequent flooding and compound flooding events, as observed in WY2023. Chapter 2B of this volume describes long-term trends of selected observed data to monitor how these or other extreme conditions are evolving in South Florida and how they might impact future conditions. These observed long-term trends compose the Water and Climate Resilience Metrics.

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