SOUTH FLORIDA WATER MANAGEMENT DISTRICT

THE 2000-2001 DROUGHT IN SOUTH FLORIDA

EXECUTIVE SUMMARY

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2000–2001 Drought Report: Executive Summary

INTRODUCTION

The 2000–2001 drought in Central and South Florida was a significant hydrologic and water management event. During this period, all water users experienced a critical water supply shortage. The continual monthly rainfall deficit compounded the decline in storage volume, forcing the South Florida Water Management District (District or SFWMD) to declare a drought emergency and implement water use restrictions. Daily, weekly, and monthly drought reports were generated to assist water management decision making and inform the public about the status of the system. The District took the lead in facilitating a multi-agency response to this event, coordinating a series of decisions and actions to protect the public interest.

Historical droughts and water shortages have been marked by (1) declines in lakes, reservoirs, and groundwater levels, (2) declines in rainfall and runoff, and (3) increases in the number and magnitude of wildfires. In Central and South Florida, severe droughts were reported in 1932, 1955–1957, 1961–1963, 1971–1972, 1973–1974, 1980–1982, 1985, 1988–1989, 1990, and 2000–2001. Drought impacts have been measured in loss of agricultural products, inadequate public water supply, loss of soil by wind erosion and subsidence, saltwater intrusion into freshwater aquifers, fires, other economic losses associated with water use, and ecological effects.

The District is divided into four planning areas within which water supply planning and other activities are focused: the Lower East Coast (LEC), Lower West Coast (LWC), Upper East Coast (UEC), and the Kissimmee Basin. This summary provides an overview on the effects of the 2000–2001 drought on water levels, flow, storage, groundwater levels, system operations, water demand and supply management, and environmental impacts for each of these regions. It also provides drought information for Lake Okeechobee, Lake Kissimmee, Lake Istokpoga and the Indian Prairie Basin, the Kissimmee River Basin, the Water Conservation Areas (WCAs) and the Stormwater Treatment Areas (STAs). The summary presents a chronology associated with water use restrictions and water demand management and describes the role emergency management and communications played in the District's response to drought. This information highlights the economic impacts of the drought and discusses the lessons learned and recommendations stemming from the District's experience with related issues. The Executive Summary and Parts I and II of the complete drought report are available on the District's website at http://www.sfwmd.gov/org/ema/reports/drought_report_2001/index.htm and are also available on CD-ROM upon request.

DROUGHT SEVERITY

The Palmer Drought Severity Index is used to monitor drought conditions occurring over several months. The index uses moisture conditions, precipitation, temperature, field capacity, and weather trends to compute an index value. Near normal conditions are represented by an index value between 0 ± 0.49; severe droughts have an index value of -3.0 or less. **Figure 1** shows the index values for the five climatic divisions covering the District at the onset of the most recent drought through September 2001.

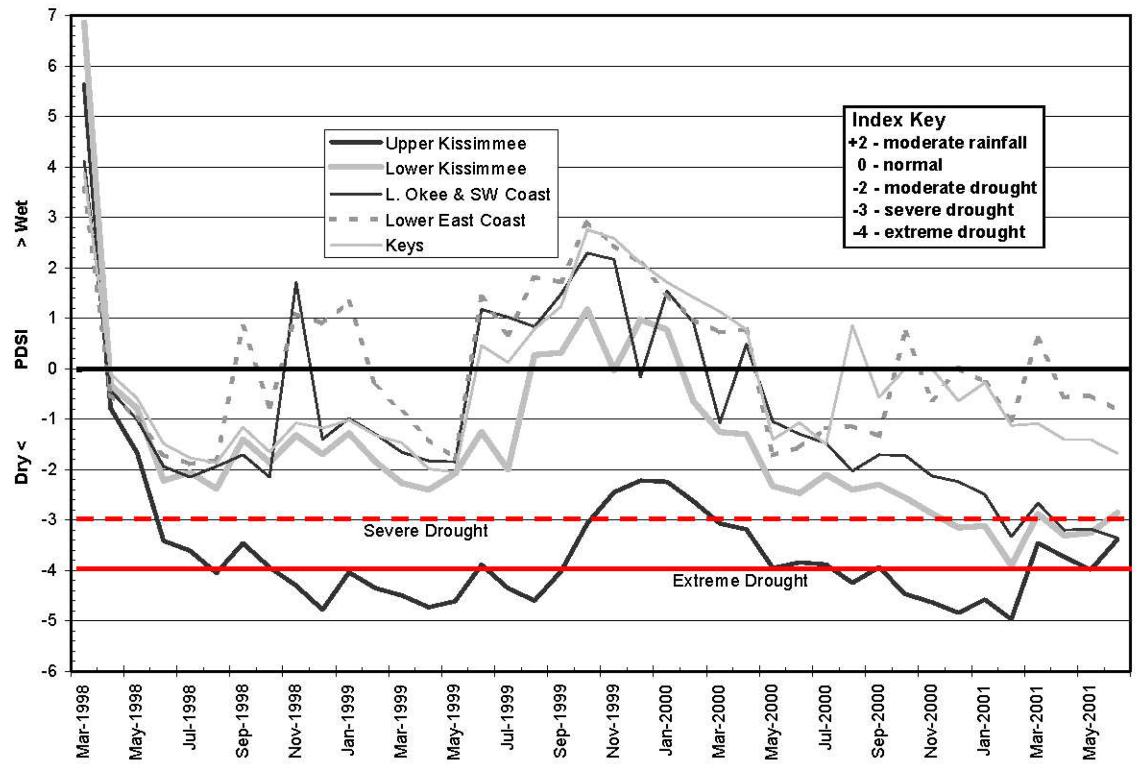

Figure 1. Palmer Drought Severity Index - Florida climatic divisions 3, 4, 5, 6, and 7 (March 1998–September 2001)

RAINFALL

The District receives a high amount of rainfall, caused by frontal, convective, and tropical weather systems. Typically, the wet season lasts from June through October and accounts for 66 percent of annual rainfall; the dry season lasts from November to May. Runoff from rainfall events is stored in ponds, lakes, impoundments, and aquifers and each reflects drought conditions. Excess water is discharged to the ocean to control flooding. Critical decision making is required to manage flooding or avoid potential water shortages. In this subtropical environment, both water shortage and flooding have the potential to occur in any month of the year.

Early indications of the drought can be traced back to November 1999, the beginning of the dry season. Rainfall during the dry season (November to May) was below expected values in 2000 and 2001 (**Figure 2**). During the 2000 wet season (June to October), rainfall was below expected amounts for all rainfall areas, except Miami-Dade (**Figure 3**). Most areas in the northern part of the District experienced monthly deficits throughout the period starting November 1999. The Broward, Miami-Dade, WCA-1, and WCA-2 rainfall areas were relatively less affected by the drought. The Upper Kissimmee, Lower Kissimmee, and Lake Okeechobee watersheds contribute most of the inflows to Lake Okeechobee. The 2000 annual rainfall for these three areas

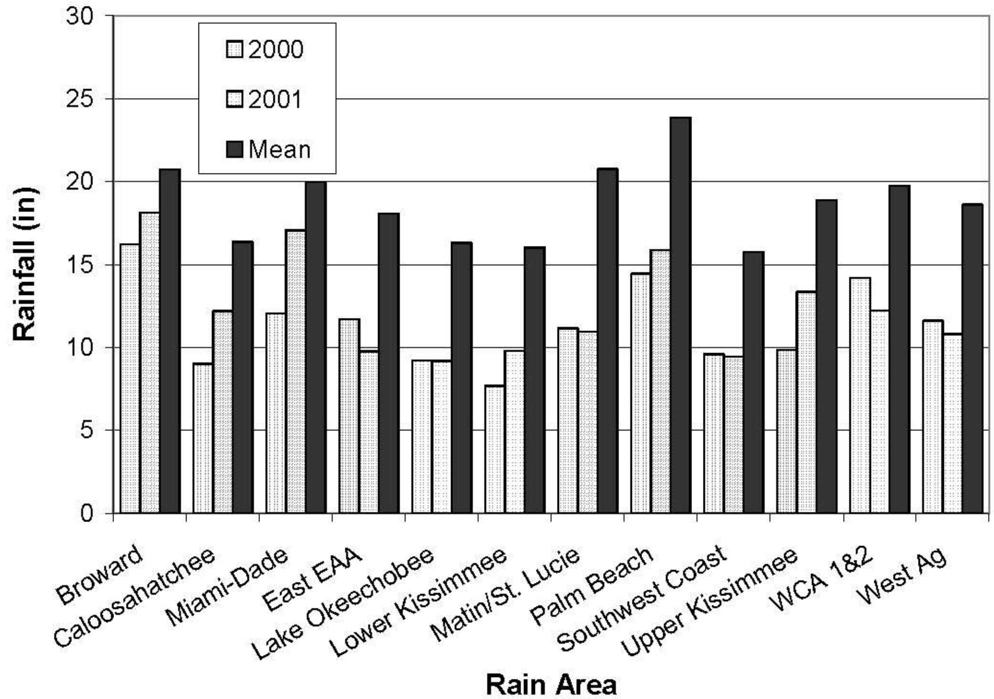

Figure 2. Dry season observed rainfall versus mean rainfall by rain area during 2000–2001

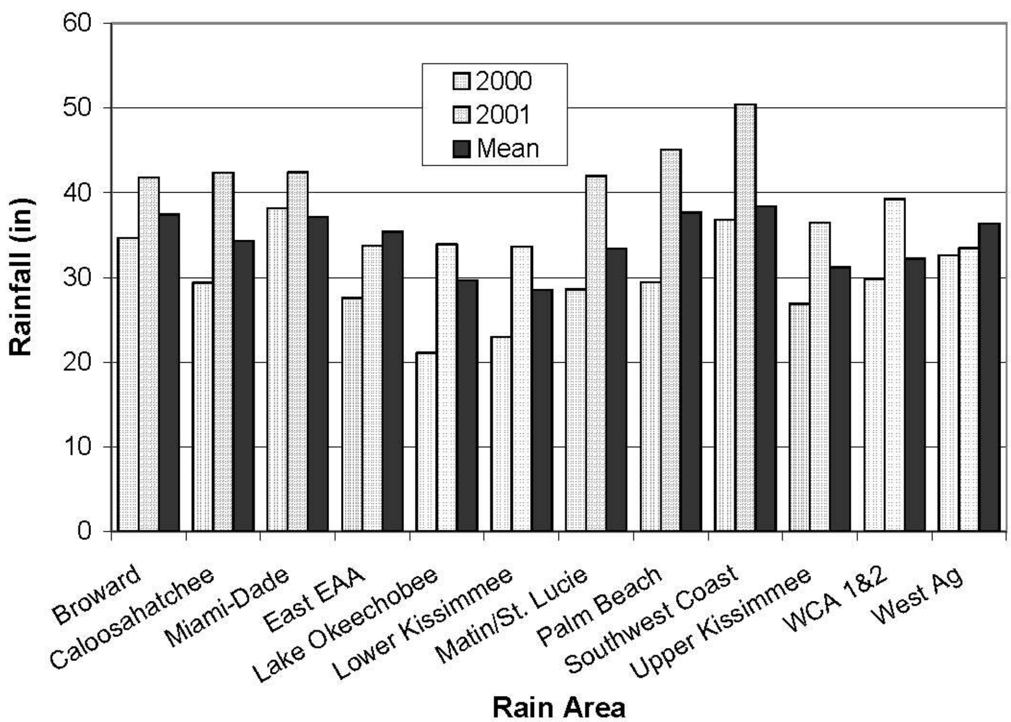

Figure 3. Wet season observed rainfall versus mean rainfall by rain area during 2000–2001

was very low with a dry frequency of 1 in 100 years and an average annual deficit of 35 percent below normal. The 2000 annual District-wide rainfall deficit was 25 percent of the historical average.

The drought persisted in most areas through August 2001. For the first eight months of 2001, the East EAA and West Ag rainfall areas had a severe rainfall deficit compared to the historical average for the same period. Hurricane Gabrielle passed through Central Florida in the middle of September 2001. This hurricane and the associated tropical system resulted in significant rainfall over a large area, contributing to drought relief.

IMPACTS AND RESOURCE MANAGEMENT

KISSIMMEE BASIN

The Kissimmee Basin planning area covers approximately 3,500 square miles and includes parts of Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties. This area was severely affected by the drought. From October 1, 1999 to September 30, 2001, Lake Kissimmee fluctuated between 52.6 and 48.3 feet National Geodetic Vertical Datum (ft NGVD), with the minimum level occurring on April 29, 2001.

Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Kissimmee through S-65 was 645,000 acre-feet (ac-ft). During the drought, there were eight consecutive months with no outflow from Lake Kissimmee (November 2000 to June 2001). The total outflow from October 1999 through September 2001 was 701,490 ac-ft, of which only 11,780 ac-ft was for the 12-month period from July 2000 through June 2001. This is the third lowest discharge volume for twelve consecutive months on record.

During the drought, the District tracked groundwater levels in the Upper Floridan aquifer in the Upper Kissimmee Basin in Orange County. This area is adjacent to the city of Orlando, which is a major water user of the Upper Floridan aquifer. During the drought, the water level in the Upper Floridan aquifer dropped below its average level in mid March 2000 and remained at this level through September 30, 2001. The water level in the aquifer briefly approached its normal level in late July 2001, but dropped below thereafter.

Water use declined in Upper Kissimmee Basin during the drought. A modified Phase II set of restrictions was developed for the northern part of the basin in conjunction with the St. Johns River Water Management District (SJRWMD). The modified restrictions allowed watering between 4 p.m. and 10 a.m. for two days per week, and varied from the rest of the District which had water use restricted from 6 a.m. to 10 p.m. for two days per week. The SFWMD rules focused on sinkhole development so that only Floridan aquifer sources were identified for restrictions. As a result of the restrictions, all consumptive use permit holders reported dramatic drops in pumpage. On average, the declines in water use hovered between 20 and 25 percent, which was substantial considering the District's stated objective of a 15-percent reduction.

No long-term environmental impacts of drought were observed in the Upper Kissimmee Basin, although water levels in the Upper Chain of Lakes were between 0.5–1.0 ft below regulation schedules. However, impediments to navigation as a result of low water levels during the drought were encountered. Continuous discharge from Lake Kissimmee to the Kissimmee River for environmental restoration was reestablished in June 2001. As a result, numerous initial positive responses were documented within the river/floodplain ecosystem.

LAKE ISTOKPOGA/INDIAN PRAIRIE BASIN

Drought conditions in the Lake Istokpoga and Indian Prairie Basin were severe. Lake Istokpoga fluctuated between 39.6 and 35.9 ft NGVD, with the minimum occurring on June 19, 2001. Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Istokpoga through structure S-68 was 192,000 ac-ft. The total outflow from October 1999 through September 2001 was 292,085 ac-ft, of which only 23,813 ac-ft was for the 12-month period from July 2000 through June 2001. The second lowest annual discharge volume of 32,175 ac-ft occurred in 2000.

In February 2001, the Florida Fish and Wildlife Conservation Commission (FWC), in partnership with the District, took advantage of low surface water elevations in Lake Istokpoga to expedite the drawdown of the lake's water level for muck removal. By the time the lake started to refill in June 2001, 1,300 acres, or two-thirds of the perimeter shoreline had been scraped and harvested and 2.4 million cubic yards of material were removed. The Lake Istokpoga drawdown occurred at a crucial point in the drought and provided necessary relief to permitted users in the basin. Without the additional water from the lake drawdown, the Istokpoga basin could have suffered tremendous losses of both agriculture and livestock. The importance of cooperation and daily communication between permitted users and District staff during this time was evident. Considering the severity of the drought, the number of water use violations encountered was not as high as it could have been. Many violations came from users who did not have a consumptive use permit.

LAKE OKEECHOBEE

The largest component of storage in the SFWMD water management system is Lake Okeechobee, which was greatly impacted by the drought. **Figure 4** depicts the lake's decline in water level during the 2000–2001 drought.

Lake Okeechobee's water level was at or below 11 ft NGVD for only 3 percent of the days from 1931 to 2001; the longest number of consecutive days (194 days) that the lake was below 11.0 ft NGVD was achieved in 2001. The lake's water level declined to 8.97 ft NGVD on May 24, 2001, the lowest water level ever recorded for the lake.

Total available water storage in Lake Okeechobee receded through June 2001 to exceptionally low levels due to releases and evaporation losses. The evaporation loss for the lake was 9.06 ft during the period from October 1, 1999 to September 30, 2001.

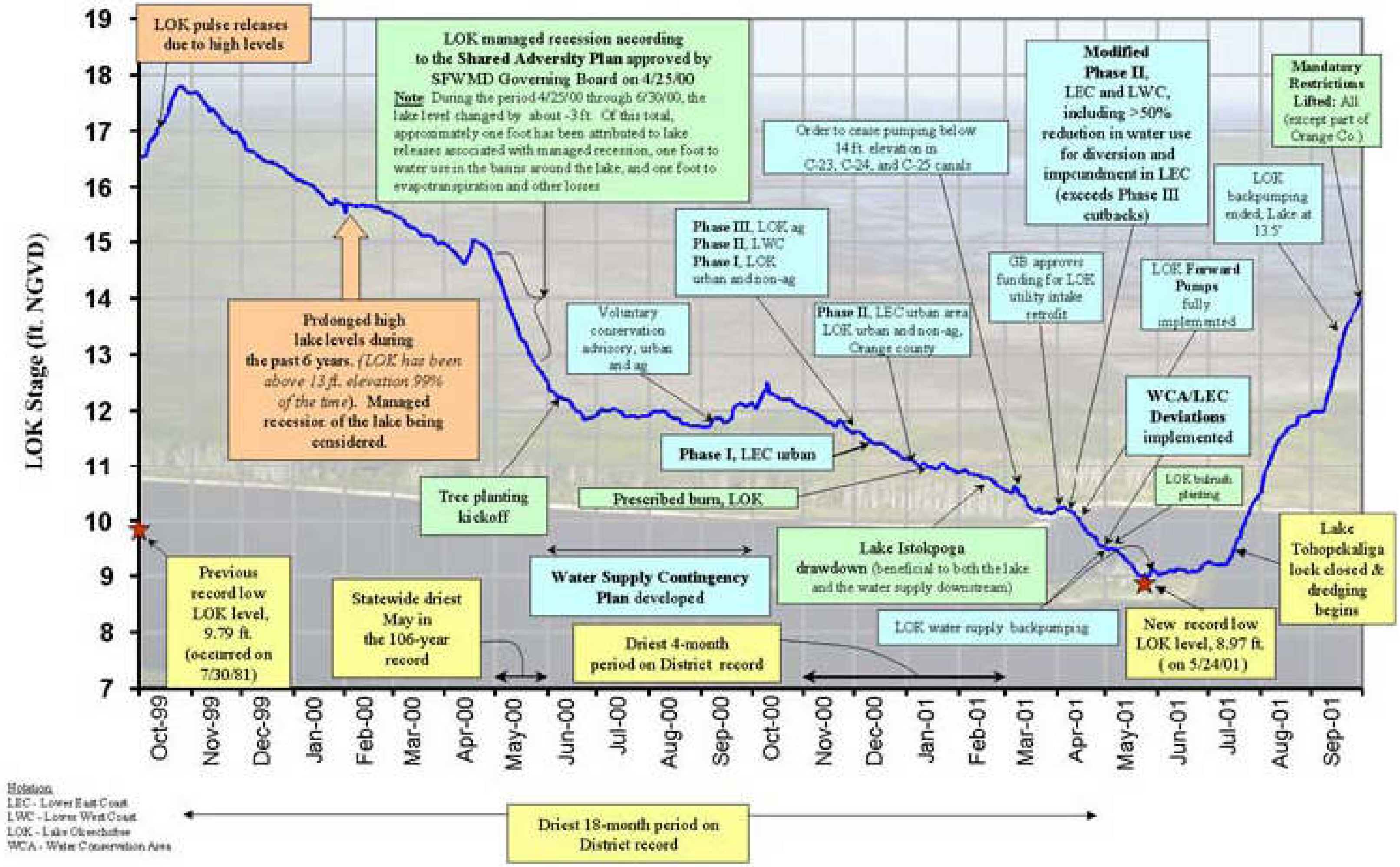

Figure 4. Chronology of the 2000-2001 drought

Figure 5 shows the trend in available storage for Lake Okeechobee from October 1999 to September 2001. In March 2001 as the lake's levels approached 10 ft, fourteen 100-cubic feet per second (cfs) pumps were installed at a total cost of $2.3 million. These pumps were necessary because water could not flow from the lake by gravity at these lower water levels. The pumps operated an average of three days per week and provided needed irrigation to the surrounding farm communities. The pumps were removed in August 2001 after delivering 92,904 ac-ft of water. In June 2001, the lake system began a rapid recovery to near-average seasonal levels by late September 2001.

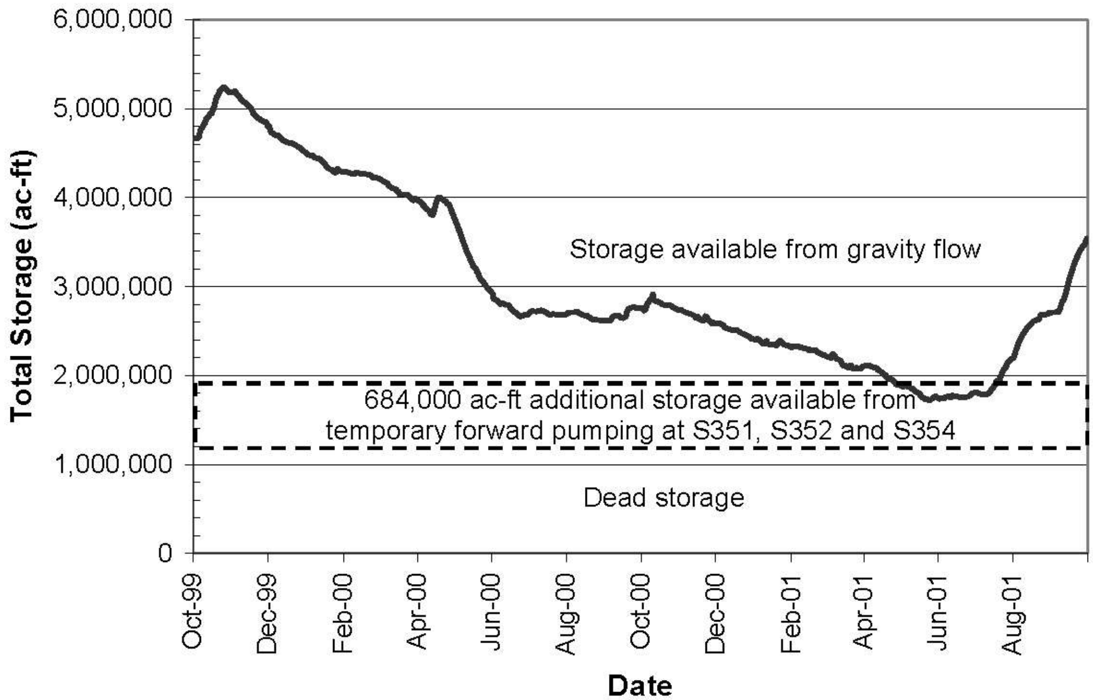

Figure 5. Lake Okeechobee available storage from October 1999–September 2001

The drought's effect on Lake Okeechobee inflows and outflows was significant. From December 1999 to June 2001 there were 19 consecutive monthly inflows below the historical average (**Figure 6**). Based on flows from 1972 to 2001, the average total annual inflow of surface water was 1,999,000 ac-ft, with an annual maximum of 3,520,000 ac-ft during the 1995 El Niño; a minimum annual inflow of 675,000 ac-ft occurred during the 2000–2001 drought.

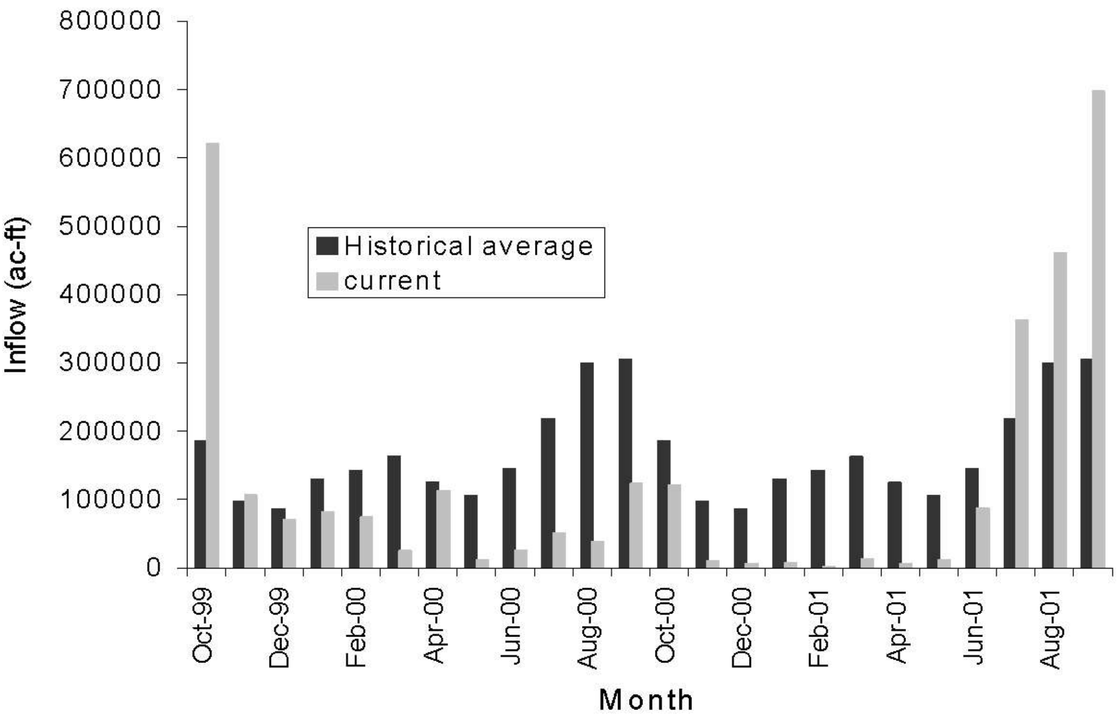

Figure 6. Comparison of historical average and Lake Okeechobee monthly inflows during the drought

Two Emergency Final Orders were issued by the Florida Department of Environmental Protection (FDEP) in April 2001 and August 2001. The first order authorized the District to initiate water supply back pumping into the lake through pump stations S-2 and S-3 at the south end of Lake Okeechobee. The second order allowed the District to continue back pumping and to augment the pumping by gravity flows of water through structures S-4, S-77, S-308, and S-352, and culvert 10-A. During the back pumping period from June 1, 2001 through September 21, 2001, back pumping and augmentation contributed 575,726 ac-ft, or approximately 39 percent of the total inflow to Lake Okeechobee.

Outflows from Lake Okeechobee are mainly to the south; the average historical annual outflow is 1,282,000 ac-ft. The large outflow in May 2000 (**Figure 7**) reflects the water released during the managed lake recession. From October 1999 to September 2001, 16 months of outflows from the lake were below the historical average.

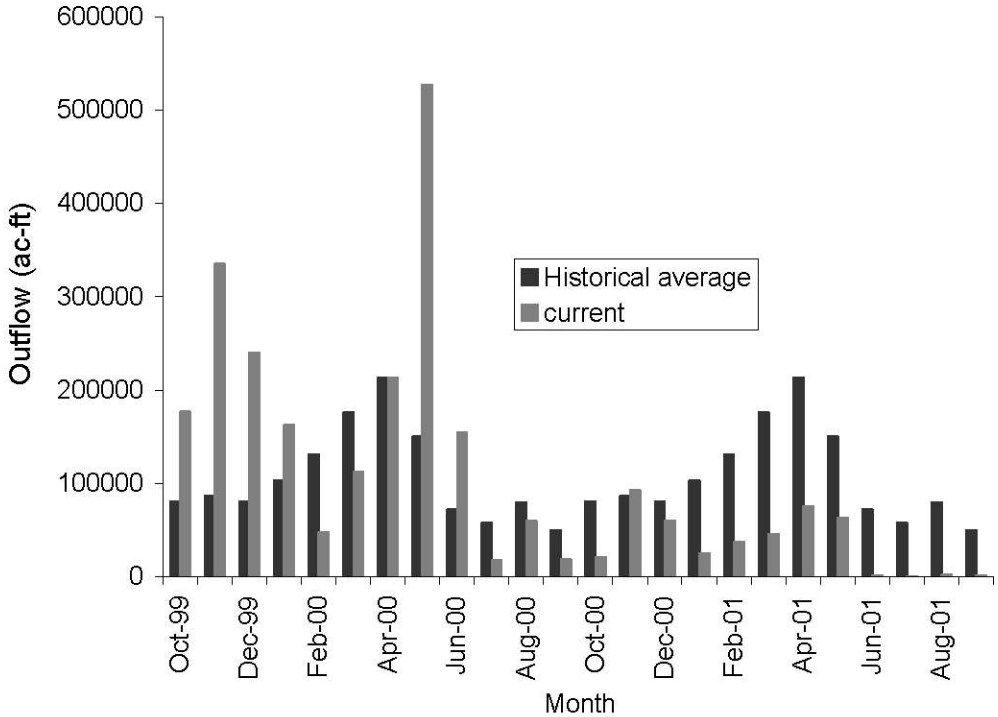

Figure 7. Comparison of historical average and Lake Okeechobee monthly outflows during the drought

Two water supply releases were made from Lake Okeechobee to flush marine chlorides from water supply intakes on the Caloosahatchee River at the Olga water treatment plant. The first occurred as a pulsed release over a five-day period in November 2000 (9,100 ac-ft) and the second release occurred in January 2001 (also about 9,100 ac-ft). Both releases were successful in maintaining water supplies.

The supply-side management (SSM) documentation produced after the 1990–1991 drought provides a scheme for the prudent management of surface water storage in Lake Okeechobee and was used extensively during the 2000–2001 drought. Supply-side management is based upon the concept that the amount of water available for use is a function of the anticipated rainfall, lake evaporation, and water needs for the balance of the dry season in relation to the amount currently in storage. Ten Lake Okeechobee Service Area sub-basins were identified during the SSM implementation in 2000–2001. Allocations for agricultural users in each of these sub-basins were calculated weekly throughout the 45-week period of SSM implementation, which began on November 29, 2000. Throughout this period, SSM calculations were performed weekly on Monday and were posted or communicated to users on Tuesday for implementation on Wednesday.

Lake Okeechobee stage and weekly allocation volumes for the 2000–2001 drought are shown in **Figure 8**. SSM calculations did not explicitly determine lake water allocation for non-agricultural uses, e.g., public water supply to the Lower East Coast Service Areas, releases to navigational lockages, and environmental deliveries to the Stormwater Treatment Areas (STAs). However, the SSM calculations did consider the amount of water consumed by these users in determining lake water allocations for agricultural users within the Lake Okeechobee Service Area. Because drought conditions in June 2001 were expected to be similar to those in May 2001, the methodology associated with dry season SSM was extended through June 2001. A modified method was used from July 2001 through October 2001 based on the South Florida Water Management Model (SFWMM).

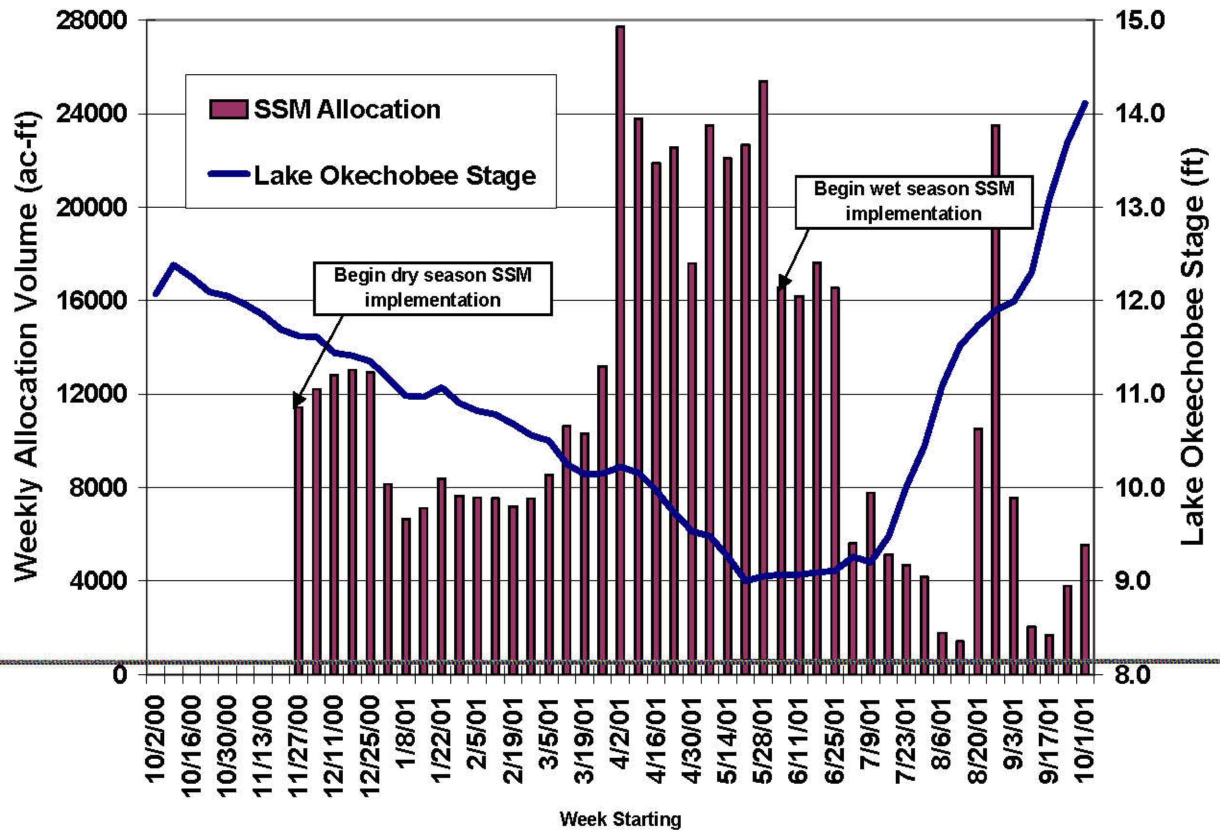

Figure 8. Lake Okeechobee stage and Lake Okeechobee service area allocation during the 2000–2001 drought

The ecology of Lake Okeechobee showed six positive changes in response to the low lake stages, reflecting the ecosystem's recovery after years of damage from high water levels. These included the following:

- Renewed growth of submerged plant beds
- Very clear water in the shoreline regions
- Excellent fishing in the shoreline area
- Widespread oxidation and compaction of organic muck
- Large-scale littoral zone fires that promoted potential re-colonization by native plants
- The opportunity to physically remove an organic berm along the western lakeshore

Another impact to the lake's ecology resulted from a decision to back pump water into Lake Okeechobee. From June 1 through September 21, 2001, back pumping from S-2 and S-3 contributed 22 percent, or approximately 325,000 ac-ft, of the total water inflow into the lake, but only 9 percent, or 37.9 metric tons (mt), of the total phosphorus (TP) contribution to the lake.

One significant negative ecological consequence of the extreme low lake stage was that torpedo grass expansion into native plant communities in the interior littoral zone was more rapid than in earlier years.

The monitoring programs specified by the emergency final orders allowing back pumping and flow augmentation also required additional water quality monitoring of the inflows into the lake for parameters other than nutrients, including pesticides, trace level mercury, and general water quality parameters. Although trace levels of pesticides were found in some samples, no pesticide concentrations exceeded Florida Class I water quality standards. Trace level mercury concentrations at structures associated with back pumping and augmentation of flow to Lake Okeechobee did not exceed the state water quality criterion of 12 nanograms per liter (ng/L) for total mercury. Biological monitoring indicated that there were no negative impacts on submerged aquatic vegetation (SAV) or water transparency from back pumping operations.

STORMWATER TREATMENT AREAS

In general, monthly inflows and outflows to the Stormwater Treatment Areas, located in the Everglades Agricultural Area (EAA), were reduced due to the drought. Efforts were made to prevent treatment cell dryout at Stormwater Treatment Area 1 West (STA-1W) and STA-5. Despite these efforts, both STA-5 and STA-6 did dry out during the most severe period of the drought from December 2000 through May 2001. This event was typical during the dry season for STA-6, but not for STA-5. A temporary pump was placed at STA-5 to keep Cell 1B wet to aid in maintaining the SAV that had been introduced into the cell after STA start-up in 1999–2000.

STA operations during the 2000–2001 drought were based on the philosophy of "shared adversity" with other water users. Due to extreme drought conditions, water levels dropped below the optimal water levels for phosphorus reduction within the STAs and below the minimum operational target of six inches in all the cells, a level typically associated with maintaining a net reduction of phosphorus. The "shared adversity" philosophy was manifested in an operation strategy designed to supply the minimum amount of water to maintain the vegetation present in the STAs.

Overall, the drought impacts on STA-1W, STA-2, STA-5, and STA-6 were minimal. During the drought, emergency water deliveries totaling approximately 1,600 ac-ft were made to STA-2 Cell 3 and roughly 3,000 ac-ft of water to STA-5 Cell 1B to protect the developing SAV community from drying out.

WATER CONSERVATION AREAS

The Water Conservation Areas (WCAs) are shallow impoundments of remnant Everglades marsh, with a total area of approximately 736,640 acres. Drought impacts to these areas were minimal. For example, the lowest water levels for the WCAs were not observed during the 2000–2001 drought.

Inflows to the WCA-1, WCA-2, and WCA-3 began to decline in October 1999 after Hurricane Irene. There was a brief recovery in April 2000 and again in September and October 2000 as tropical weather systems brought increased rainfall. Significant inflows to all WCAs began again in July 2001 and led to recovery of water levels in all WCAs by late September 2001.

The ability to release water from the WCAs for water supply purposes was severely restricted during 2001. Management of the WCAs and the South Dade Conveyance System (SDCS) during the drought involved operating according to approved schedules. Temporary deviations from approved schedules were obtained to maximize operational flexibility while protecting environmental resources. To a large extent, the successes in obtaining temporary deviations to the minimum water level regulation schedule relied on the timely predictive hydrologic modeling and ecological assessment reports prepared by the District. This information was provided to the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS). These reports revealed no significant ecological impacts due to the temporary deviations.

At WCA-1, water levels fell below the normal minimum water level regulation schedule for approximately four weeks during May 2001. During this time, WCA-1 was operated in accordance with the approved temporary minimum water level regulation schedule (lowering the minimum level from 14.0 to 11.0 ft NGVD). This avoided the need to bring water into this WCA from Lake Okeechobee or other sources while making water supply releases to the Lower East Coast Service Area 1. Rains that began in mid May 2001 returned WCA-1 to non-critical water levels by mid June 2001. Water levels within WCA-2 were already below both the normal and approved lower minimum water level when a temporary deviation was approved in late April 2001. The deviation temporarily lowered the minimum water level from 11.0 to 10.0 ft NGVD. After the rainfall in May 2001, water levels returned to normal in WCA-2 by mid June 2001. The request for a temporary deviation from the regulation schedule for WCA-3 was submitted but subsequently was determined to be unnecessary.

There were a number of excursions from Florida Class III water quality standards in the WCAs during the drought for parameters such as dissolved oxygen (DO), specific conductance, and alkalinity. The majority of these were in proportions no greater than those observed during non-drought years. Of the five parameters with Class III criteria, only DO levels did not comply with the Class III standard in the Everglades National Park (ENP or Park). During the drought, the average total phosphorus concentration at inflow sites was slightly higher than the mean annual concentrations reported during previous monitoring years. Otherwise, mean nutrient concentrations at other sub-regions of the ENP were similar to those reported previously.

UPPER EAST COAST

The Upper East Coast Planning Area encompasses Martin and St. Lucie counties, as well as the eastern portion of Okeechobee County, and covers approximately 1,200 square miles. The majority of water supply and flood protection in this area is achieved through four major canals. The C-44 basin is connected to Lake Okeechobee while most of the remaining area (C-23, C-24 and C-25 basins) is independent of the lake. As a result, the Upper East Coast was under three different water shortage orders during the drought.

Water users in the C-44 basin were allocated water three times a week, as prescribed under the Lake Okeechobee Supply-side Management Plan. Allocated pumping withdrawals depended on both canal and Lake Okeechobee stages. Ultimately, this planning area did not experience the significant water resource impacts that affected the majority of the District during the drought, primarily because the C-23, C-24, and C-25 basins were independent of the water shortage requirements associated with Lake Okeechobee.

Salinity in both the Caloosahatchee and St. Lucie estuaries increased until mid June 2001. Enhanced water clarity and reduced turbidity accompanied this increase. Although salinity was relatively high in the St. Lucie Estuary, it reached critical levels during the last few weeks of the drought.

The Surficial Aquifer System in the Upper East Coast Planning Area displayed two distinct periods of low water levels. One period occurred from early December 1999 through the end of October 2000. The other occurred between early November 2000 and early August 2001. Because this aquifer system is principally recharged by rainfall, these periods of low groundwater levels occurred during periods of below-normal rainfall.

LOWER EAST COAST

The Lower East Coast (LEC) Planning Area covers approximately 9,000 square miles and includes Palm Beach, Broward, and Miami-Dade counties, as well as portions of Monroe, Hendry, and Collier counties. Land use within the Lower East Coast ranges from urban in the east to undeveloped natural landscapes in the west with significant agricultural areas south of Lake Okeechobee and in southern Miami-Dade County. The area includes significant environmental resources, such as the Everglades ecosystem and Lake Okeechobee, the largest freshwater lake in the southern United States. In addition to the Lower East Coast, the Lake Okeechobee Service Area, which includes parts of Martin, Okeechobee, Glades, and Lee counties, relies on Lake Okeechobee for a portion of its water supply. Highly productive coastal estuaries, such as Biscayne Bay and Florida Bay, exist along the area's shores. Groundwater resources are the principal source of urban water supply for most of the LEC. These resources consist of the Surficial Aquifer System (SAS), which includes the Biscayne aquifer, and the Floridan Aquifer System (FAS). However, areas around Lake Okeechobee rely on the lake as a surface water source for potable water supply.

Two periods of high flow at SFWMD coastal structures in the Miami-Dade area (Lower East Coast, Service Area 3) occurred during the drought. The first was associated with flow from

Hurricane Irene, and the second was caused by an unnamed tropical depression. Otherwise, releases to tide were negligible during the drought.

The Surficial aquifer in Palm Beach County remained below the normal level during most of the drought from early December 1999 through late October 2000, and between early November 2000 and early August 2001. These periods of low groundwater levels occurred during periods of below-normal rainfall.

The Biscayne aquifer is a shallow, unconfined aquifer, which extends from southern Palm Beach County to Miami-Dade County. During dry periods, water stored in the WCAs is released into the District's canals and is used to maintain groundwater levels in the Biscayne aquifer. The water level in the Biscayne aquifer exhibited different trends in different areas during the drought. In northern Broward County, the water level exhibited a trend similar to the SAS in Palm Beach County. There were two periods during which water levels dropped below normal during the drought including from late December 1999 through the end of September 2000, and between early November 2000 and early August 2001. The water level in the Biscayne aquifer in southern Miami-Dade County near the coast generally remained at or above normal levels through the 2000–2001 drought.

As previously noted, Lake Okeechobee experienced extremely low water levels during the drought. A survey of the public water supply utilities that depend on withdrawal of water from the lake indicated that existing intake configurations would not be able to furnish water with Lake Okeechobee levels at or below an elevation of 10 ft NGVD. The District, in coordination with the state of Florida's Emergency Operations Center (EOC), took the engineering, contracting, and construction lead to ensure dependable intake capacity designed for lake levels as low as an elevation of 6 ft NGVD for the cities of Pahokee, Belle Glade, South Bay, Okeechobee, and Clewiston. The purpose of the project was to ensure that utilities using Lake Okeechobee as a surface water source had a continuous and uninterrupted water supply. The total cost for this work was $2.1 million.

A primary concern during the 2000–2001 drought along the Lower East Coast was the threat of saltwater intrusion into water supply wells. Rainfall has been the primary source of recharge for the Biscayne aquifer, but during a drought, seepage from the WCAs and recharge from Lake Okeechobee through canals are important sources of recharge. When the water level in Lake Okeechobee dropped to below 9.2 ft NGVD in May 2001, significant portions of the lake bottom were exposed, and gravity flows to the WCAs and canal system were not possible. Therefore, the District installed pumps that were capable of "forward pumping" water from Lake Okeechobee to the LEC. All flows out of Lake Okeechobee were monitored and compared against the Lake Okeechobee Service Area's weekly allocation. In addition, deliveries were also made to the EAA and WCAs consistent with modified operational schedules.

Pumpage information from selected public water supply wells was also collected and analyzed weekly. Specific wells were selected to monitor saltwater intrusion. Lee County Utilities and Ft. Myers were monitored closely because they were considered "at imminent risk" of saline intrusion into their intake structures due to the inability to release water from Lake Okeechobee to offset salinity coming into the Caloosahatchee River. In addition, utilities that withdrew surface water directly from Lake Okeechobee were considered "at risk" and were closely monitored.

LOWER WEST COAST

The four aquifers in the Lower West Coast (LWC) planning area are combined into two aquifer systems: the Surficial Aquifer System (SAS), consisting of the surficial and lower Tamiami aquifers; and the Intermediate Aquifer System (IAS), consisting of the sandstone and mid-Hawthorn aquifers. The IAS is the main source of potable water in the LWC.

The primary use of groundwater from the Surficial aquifer is agricultural irrigation. During the drought, there were two distinct periods of low water levels in the Surficial aquifer. One period occurred from early January 2000 through early August 2000. The other occurred between mid October 2000 and early August 2001. These periods of low groundwater levels occurred during periods of below-normal rainfall. Between October 1, 1999 and September 30, 2001, there were two distinct periods of declining water levels in the lower Tamiami aquifer. However, the only extended period of time when the water level in the aquifer was below normal was between mid November 1999 and mid April 2000. There were other, shorter periods during the drought when water levels were below normal for the aquifer. However, these periods were not greater than two months.

The Sandstone aquifer is the uppermost aquifer of the IAS. From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the Sandstone aquifer. One period occurred from early January 2000 through mid August 2000. The other occurred between early November 2000 and mid June 2001.

The mid-Hawthorn aquifer is confined and is the lowermost aquifer of the IAS. From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the mid-Hawthorn aquifer. The first period occurred from mid February through mid June 2000. The second occurred between early November 2000 and mid July 2001.

From December 1999 through September 2001, nine counties reported the quantities of water withdrawn for water supply purposes from the aquifers described above. Water restrictions imposed in 2001 were more effective in controlling groundwater withdrawals than those imposed in 2000. Generally, in 2000 the quantity of groundwater withdrawn during the drought was cyclical, i.e., decreasing in one month and then increasing during the next month. Throughout 2001, average daily groundwater withdrawals in each county decreased in each month. The effects of this decrease are noticeable in the semiconfined-to-confined aquifers in the LWC.

On November 29, 2000, the District issued Phase II water restrictions for the LWC and Phase III water restrictions for all uses of the Caloosahatchee River east of the W.P. Franklin Lock and Dam (S-79). By instituting the Phase II restrictions for the surficial, lower Tamiami, sandstone and mid-Hawthorn aquifers, the District was able to help stabilize groundwater levels. This was achieved by limiting groundwater use for irrigation to only two days per week. Salinity in the Caloosahatchee River at Ft. Myers exceeded critical levels from mid November 2000 to mid July 2001.

CHRONOLOGY OF WATER USE RESTRICTIONS

During the 2000–2001 drought, the District imposed Phases II and III mandatory water use restrictions over a large portion of the area under its jurisdiction. Local governments enforced the restrictions on small volume, non-permitted water users, whereas the District enforced restrictions on larger volume, permitted water users. The District also processed variance requests from water users seeking relief from the provisions of the mandatory water use restrictions. **Figure 9** shows the water use restrictions applied to different regions in the District in April 2001.

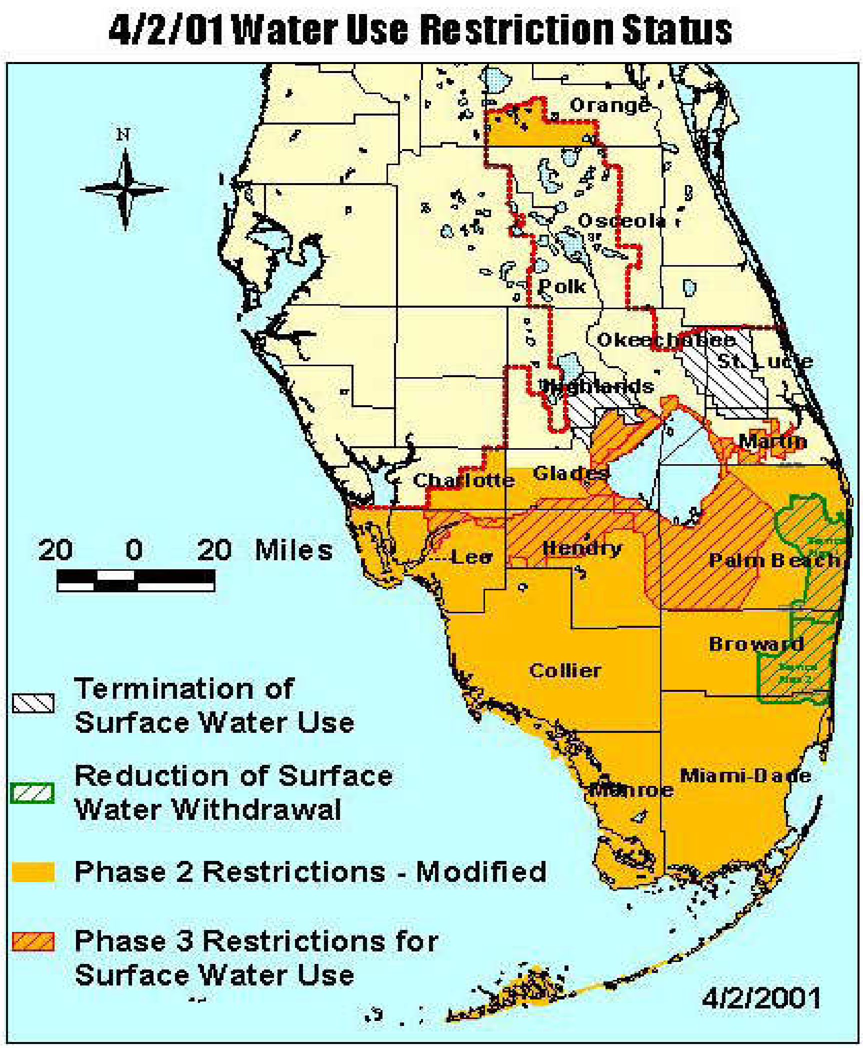

Figure 9. Water use restrictions map, April 2001

A chronological summary of District-related management actions and other drought-related activities are highlighted below.

- On November 29, 2000, the District's Executive Director declared a water shortage emergency for non-agricultural uses from Lake Okeechobee and connected surface waters within the Everglades Agricultural Area water use basin, lake shore perimeter water use basin, Caloosahatchee River water use basin, portions of the Indian Prairie water use basin, and the St. Lucie River water use basin. Phase I water use restrictions were imposed in these areas. A water shortage emergency was also declared for agricultural uses in these same water use basins and Phase III water use restrictions were imposed. Water shortage emergency and Phase II water use restrictions were imposed within the Caloosahatchee River water use basin, Caloosahatchee River watershed North, Caloosahatchee River watershed South, the western-most portion of south Hendry County/L-28 Gap water use basins, the Fakahatchee North water use basin, Fakahatchee South water use basin, the Big Cypress water use basin, and the coastal Collier County water use basin.
- On December 8, 2000, Phase I water use restrictions were imposed for the South Dade, Everglades National Park, WCA-1, WCA-2, WCA-3, 3, C-51, M Canal, C-18, Loxahatchee River, North Palm Beach County, and Interior Palm Beach County water use basins. The District's Governing Board at its meeting on December 14, 2000 approved these water emergency declarations.
- On January 11, 2001, the District's Governing Board declared a Phase II water shortage for both the Lower East Coast region and water use basins in the EAA, Indian Prairie, St. Lucie River, and Lake Okeechobee area. Modified Phase II restrictions were also imposed in the Orlando metropolitan area based on the threat of sinkhole formation from record low Floridan aquifer levels.
- On March 15, 2001 during the Governing Board meeting, the District's Executive Director asked the board to declare a Phase III water shortage emergency, an action enacted for the first time on "demand management" restrictions. Previous water shortages had included Phase III "supply-side" restrictions on water users taking water directly from Lake Okeechobee. The Governing Board approved a motion to impose Phase III restrictions, but this motion resulted in a strong, negative response from participants. Consequently, the Governing Board directed the District to analyze the economic threat/water-saving relationship and to meet with concerned industries to determine an alternative action.
- On March 21, 2001, a public meeting was conducted with District managers. During this meeting, many citizens voiced concern over the potential economic impact on their businesses and clients relative to the projected water savings in implementing Phase III restrictions.
- On March 27, 2001, protestors showed up at the District's special board meeting and picketers gathered outside the District auditorium. At this meeting, the District presented an alternative plan, which identified a modified Phase II declaration for the Lower East Coast and Lower West Coast regions. This plan met three criteria: (1) reduce economic impact; (2) meet or exceed the water saving potential of the existing Phase III restrictions; and (3) make the alternative restrictions enforceable to encourage compliance.

- In September 2001, the Governing Board voted to rescind restrictions for those public water suppliers using at least 20-percent alternative water supply technologies, including water reuse and aquifer storage and recovery (ASR).
- On October 10, 2001 during the Governing Board meeting, the board voted to rescind all water use restrictions and orders, except for those in place for the Orlando area (coordinating with the St. John's River Water Management District's modified Phase II restrictions, which remained in effect).

The District and the local governments within its jurisdiction shared responsibility for enforcing water shortage restrictions. **Table 1** shows the number of warnings and tickets issued during the water shortage.

Table 1. Number of warnings and tickets issued by county during the water shortage

County	Warnings	Tickets
Broward	7985	2579
Charlotte*	N/R**	N/R**
Collier	778	1498
Glades	N/R**	N/R**
Hendry	N/R**	N/R**
Highlands	N/R**	N/R**
Lee	510	2345
Martin	N/R**	N/R**
Miami-Dade	358	234
Monroe	304	3
Okeechobee	27	0
Orange	393	0
Osceola	N/R**	N/R**
Palm Beach	8268	969
Polk*	N/R**	N/R**
St. Lucie	N/R**	N/R**
Total	**18623**	**7628**

* Part of county within District boundary

** N/R - No Report

To track the effectiveness of utility water conservation programs and water supply delivery reductions during water shortages, the District's Water Supply Department produced monthly utility pumpage reports. The reports were produced the Friday before the next regularly scheduled Governing Board meeting to provide up-to-date information for the monthly Water Shortage Conditions Report presented to the Governing Board.

During the 2000–2001 drought, District staff in West Palm Beach and at the Ft. Myers Service Center reviewed 1,052 variance petitions. The West Palm Beach Service Center received and reviewed 85 percent of the petitions, while the Fort Myers Service Center received and reviewed 15 percent of the petitions. The disposition of these reviews is shown in **Table 2,** located on the following page.

Table 2. Petition breakdown for West Palm Beach and Fort Myers Service Centers

Approved	610
Denied	243
Withdrawn	71
Closed Without Action	128
Total	**1052**

Four of the most common use types for which a variance was requested (community/governmental/commercial landscape, 38 percent; single-family landscape, 29 percent; new landscape, 4 percent; and washing of vehicles and non-pervious surfaces, 11 percent) represented 82 percent of the total number of variance petitions received by the District. Agricultural users seeking relief from the daytime SSM requirements comprised 6 percent of variance requests. Public water supply utilities, represented as 1 percent, requested the enhancement of water main pressure and sought authorization to conduct water main flushing for safety purposes. Four motion picture crews working within the Lower East Coast requested permission to irrigate landscaping and to "slick down" roads for film production (< 1 percent).

EMERGENCY MANAGEMENT

The District's Comprehensive Emergency Management Plan establishes the policies and procedures that the District uses to prepare for, respond to, and recover from any and all emergencies. In September 2000, the water shortage was becoming a threat to agriculture, the environment, and water utilities. Based on these concerns and on the precipitation forecast, the District's Executive Director activated the Emergency Operations Center (EOC). The District's EOC served as the information clearinghouse, event coordination center, records management area, and central working area for the Water Shortage Team, consisting of directors from impacted departments. Key staff members from various departments and with various expertise were organized under the EOC sections of water operations, response, logistics, finance, legal, and public information. Many duties required full-time dedication to the water shortage situation, and regular duties were reassigned within the impacted department. The EOC operated approximately 12 hours per day and remained activated until July 2001.

Daily briefings were conducted for team members and a weekly briefing was held for the executive management group. Weekly situation reports summarizing key actions taken by the District were distributed to the Governing Board, the state of Florida's EOC, the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), and the governor of the state of Florida. A weekly action plan for the upcoming operational period was developed during a planning meeting that outlined specific assignments for each section. The District's EOC continuously remained in contact with the state's EOC during the water shortage emergency. The state's EOC continued to monitor the situation and prepared contingency plans for delivery of emergency water supplies in the case that a utility became inoperable. Statewide conference calls were held weekly with other water management districts, the FDEP, the Florida Department of Emergency Management (FDEM), FDACS, and the Federal Emergency Management Agency (FEMA).

OUTREACH AND COMMUNICATIONS

The 2000–2001 drought was a consuming issue for area media covering the District. The team's approach was crucial in organizing and communicating District strategies for handling drought-related issues, water restrictions enforcement, media interest, and public awareness. District staff worked seven days per week to respond to the intense interest that the story generated from all branches of the media, including television and radio stations, newspapers, and magazines. Area media became a valued partner in communicating the District's water conservation message to promote a higher level of awareness and understanding among South Florida's residents. That, in conjunction with a multi-tiered approach to communication, also gave the general public a better understanding of the District and its mission. The Office of Media Relations and the Department of Public Information used a variety of communication tools, including water shortage team meetings; press releases and news briefings; daily media contact; media buys, and media campaigns; fact sheets; a citizen information hotline (phone bank); a water shortage website; and other drought-related public information services. Daily media interest was so intense that the District held daily and weekly media briefings from May 4, 2001 through June 29, 2001. Some of the topics covered during the briefings included the latest Lake Okeechobee water levels, water restrictions enforcement, local government coordination, drought signage, drought publications, water conservation tips, and conservation information. These daily and weekly briefings kept local news reporters interested in covering the story of the drought.

The District's water shortage team also relied on a series of drought-themed campaigns for its radio and television "spots." The campaigns were sequenced according to the severity of the drought. The 2000–2001 drought also provided the District with an opportunity to newly educate many of South Florida's residents who, prior to the drought, was not informed about the District, its mission, and the value of water.

ECONOMIC IMPACTS

Although quantitative data are limited, the drought resulted in significant economic impacts to user groups throughout the District. Public water supply utilities experienced unanticipated revenue losses associated with reduced pumpage, and in some cases, higher production costs resulting from increased use of alternative water sources. Agriculture, plant nurseries, and the landscaping and golf course industries also experienced significant negative economic impacts. Small recreational and tourism businesses surrounding Lake Okeechobee were especially impacted by the drought. The drought emergency also took an unanticipated economic toll on the District. By the end of the fiscal year in September 2001, the District had spent $9.7 million of its unbudgeted funds on drought-related expenditures.

LESSONS LEARNED AND RECOMMENDATIONS

- A minimum of one severe drought can be expected every decade.
- It is essential to routinely monitor the following parameters:
  - rainfall deficit
  - Palmer Drought Severity Index (PSDI)
  - climatic forecasts
  - surface water levels
  - groundwater levels
  - water demand
- It is important to develop a drought monitoring system that will alert water managers and water users to the imminence of drought.
- Establishment of a multidisciplinary team to coordinate drought activities was essential to successful drought management. The team should meet at least once a week to develop a weekly action plan and outline specific assignments.
- Water reservations should be established for deliveries of supplemental water to Stormwater Treatment Areas. This is critical to ensure that the STAs meet their long-term phosphorus targets. There is sufficient flexibility to deliver water to the STAs during drought conditions except for STA-6.
- In the northern Kissimmee basin near Orlando, coordination of water use restrictions with the St. John's River Water Management District minimized public confusion over which District's restrictions applied. Water managers should consider a consolidated enforcement plan in this area prior to enacting restrictions.

- Daily communication between permitted users and District staff was important. In some agricultural areas, this was accomplished through a basin coordinator.
- The shoaling problem at the terminus of the C-40 and C-41 canals should be corrected so that the pumps at G-207 and G-208 can function at lower water levels.
- Provisions should be made to transfer water from the C-24 to the C-23 basin in cooperation with the city of Port St. Lucie.
- Alternate water supplies should be considered for utilities that withdraw water from Lake Okeechobee and along the coastal margin.
- Exploit opportunities for environmental restoration during drought conditions similar to those conducted for Lake Istokpoga and Lake Okeechobee.
- Public input on the nature and implementation of water use restrictions is critical.
- Establishment of the water shortage team, under the auspices of the Emergency Operations Center, can provide a necessary framework for internal and external communications.
- Establish better coordination between the District's Geographic Information System (GIS) experts and graphic designers to provide more timely information.
- The water shortage team should designate a "point person" for simplifying technical and legal issues presented to the media and public. The District should identify its "best experts" to help the media explain and clarify drought-related facts at the drought's onset. These experts can help elevate the public's awareness of drought conditions and the District's overall mission.
- Drought managers should invest in and rely on other methods of communicating with the public other than news media such as direct mail, newspaper inserts, advertisements, special events, web page promotion, billboards, signage, television and radio public service announcements, and joint partnerships with water utilities.
- The District must have an aggressive and involved media relations team in place for future droughts.
- Early coordination among the District, county governments, public utility departments, municipalities, and law enforcement agencies is necessary to prepare an effective media campaign.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

The 2000-2001 DROUGHT in South Florida

Part I: Hydrological Analysis

sfwmd.gov

of the 2000-2001 Drought in South Florida

Wossenu Abtew, R. Scott Huebner, and Simon Sunderland

PREFACE

The 2000-2001 drought in Central and South Florida was a significant hydrologic and water management event. During this period, critical water supply shortage was experienced by all sectors of water users. The continual monthly rainfall deficit compounded the decline in storage volume, forcing the Water Management District to declare a drought emergency and implement Water Use Restrictions. Water quality and biological monitoring were expanded, and daily, weekly, and monthly drought reports were generated to assist water management decision making and inform the public on the status of the hydrologic system. The South Florida Water Management District took the lead in facilitating a multi-agency response to this event, coordinating a series of decisions and actions to protect the public interest to the maximum extent possible.

Documentation of such an event is necessary to preserve the experience for the benefit of future managers of such events. Thus, the District is producing the *2000-2001 Drought Report*. The report is divided into three parts. *Part I: Hydrologic Analysis of the 2000-2001 Drought in South Florida* is presented here. Part I summarizes the hydrologic and water resources conditions from October 1, 1999 through September 30, 2001. Historical hydrologic analysis is also provided for a comparative understanding of the magnitude of the drought. *Part II: Water Management During the 2000-2001 Drought in South Florida* addresses water management during this period of record-low rainfall and highly restricted water supply. It provides a record and synoptic view of the drought management process, including valuable information for future drought monitoring and drought management. Finally, an Executive Summary will be produced containing a synopsis and summary of the major findings.

Many staff members worked to make the Drought Report a reality. Principal recognition for Part I goes to Wossenu Abtew, Lead Engineer with the Environmental Monitoring and Assessment Department and the primary author. Other key contributors include R. Scott Huebner, Lead Engineer with the Environmental Monitoring and Assessment Department, and Simon Sunderland, Staff Hydrogeologist with the Water Supply Department. Finally, special thanks go to the editorial team, chapter authors and support staff. Their assistance was invaluable.

Sincerely,

Naomi S. Duerr, P.G.
Director
Environmental Monitoring and Assessment Department

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Chapter 1: Introduction

Wossenu Abtew and R. Scott Huebner

SUMMARY

The 2000–2001 drought and water shortage in Central and South Florida was a significant hydrologic and water management event that warrants analysis and documentation for guidance during future droughts and in mitigation decision making. This report summarizes hydrologic and water resource conditions from October 1, 1999 through September 30, 2001. Historical hydrologic information is provided for a comparative understanding of the drought's magnitude.

CENTRAL AND SOUTH FLORIDA HYDROLOGIC SYSTEM

The South Florida Water Management District's jurisdiction extends from Orlando in Central Florida to the Florida Keys in southernmost Florida. (**Figure 1-1**). The center of the hydrologic system is Lake Okeechobee, with an area of 680 square miles and a mean depth of 8.86 feet. Historically, Lake Okeechobee attained a maximum water level of 18.76 feet NGVD (National Geodetic Vertical Datum) on November 2, 1947. The lowest water level ever recorded for the lake was 8.97 feet NGVD, set during the 2000–2001 drought on May 24, 2001. Lake Okeechobee provides water to surrounding communities, the Everglades Agricultural Area, and the St. Lucie and Caloosahatchee river basins. The lake also replenishes canal levels in Palm Beach, Broward and Miami-Dade counties. Lake Okeechobee has been managed under a regulation schedule that ranges between water supply and flood control. The history of water levels in the lake is a good indicator of wet conditions and drought, that is, low lake levels correspond to historical droughts.

The upper Kissimmee Chain of Lakes (lakes Myrtle, Alligator, Mary Jane, Gentry, East Tohopekaliga, Tohopokaliga, and Kissimmee) are principal sources of inflow to Lake Okeechobee. The upper Kissimmee watershed has an area of 1,596 square miles (Guardo, 1992). Inflow from the Kissimmee River (C-38 canal) at structure S-65 contributes, on average, 69 percent of the inflow into Lake Okeechobee through structure S-65E at the lake's northern end. The lower Kissimmee River Basin (727 square miles) also contributes flow through S-65E. The Lake Istokpoga Surface Water Management Basin (418 square miles) also drains into Lake Okeechobee. Lake Istokpoga is a 43.27 square-mile shallow lake, with outflow through structure S-68 into the Surface Water Management Basin. The remaining major water sources contributing to Lake Okeechobee inflow are direct rainfall, Fisheating Creek, the Taylor Creek-Nubbin Slough Basin, reverse flow from the Caloosahatchee River, the St. Lucie Canal, and back pumping from the Everglades Agricultural Area.

In the south, Water Conservation Areas WCA-1 (220 square miles), WCA-2A (164 square miles), and WCA-3A (767 square miles) are part of the water storage and distribution system. All have specific regulation schedules. From north to south, flood control and water supply are regulated through three systems of canals, stormwater detention ponds, lakes, impoundments, and water control structures. The major hydrologic components of the South Florida Water Management District are depicted in **Figure 1-1**.

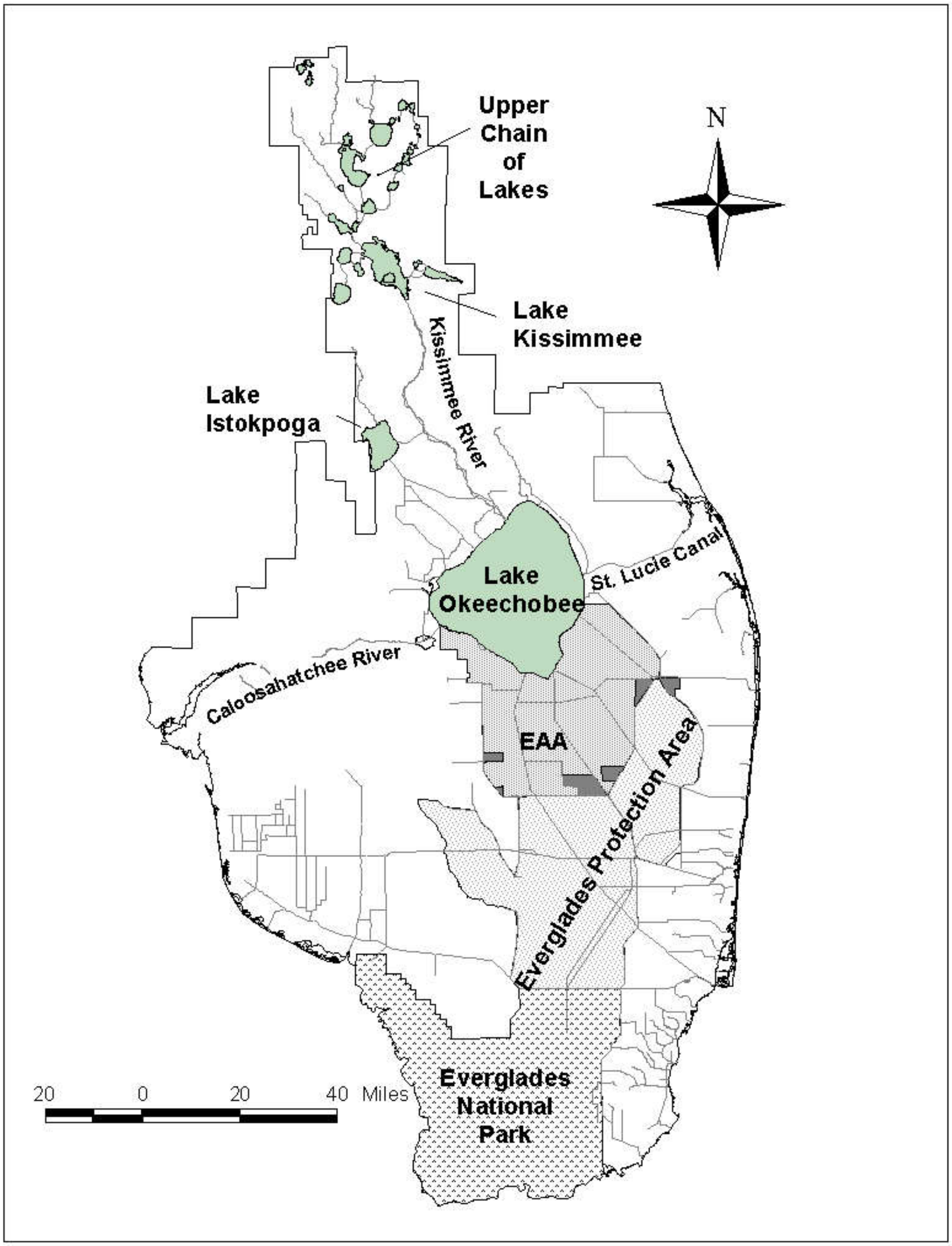

Figure 1-1. Major hydrologic components of the South Florida Water Management District

DROUGHTS IN SOUTH FLORIDA

TYPES OF DROUGHTS

Droughts are important meteorologic, social, and economic events in most parts of the world. Although the type and severity of drought varies from place to place, it is generally associated with a shortage of water for a given duration of time for a designated activity. Broadly, the water source could be soil moisture, rainfall, snow pack, stream flow, groundwater, and surface water storage. Droughts are classified as agricultural, meteorologic, hydrologic, and water management (Subrahmanyam, 1967; Benson and Gardner, 1974). Agricultural drought is an evapotranspiration deficit (Palmer, 1965). Agricultural drought is also characterized as short-term moisture deficiency in the shallow plant root zone. Meteorologic drought occurs when an extended period of below-normal precipitation prevails. Hydrologic drought is the result of reduction in surface water and groundwater due to the amount and/or spatial and temporal distribution of precipitation. Hydrologic drought has long-term effects on regional and local surface water and subsurface water supplies. Water management drought is characterized as water deficiency that occurs because of the inability to develop and manage an integrated surface and subsurface water supply system to overcome water deficits (Benson and Gardner, 1974). Other types of drought cited in the literature are climatological and atmospheric. A drought lasting from one to three months is considered short-term; a drought lasting from four to six months is considered intermediate; and a drought lasting more than six months is considered long term (Golden and Lins, 1986).

Drought can occur when one or more of three components are in place. The first component is a change in the magnitude and temporal distribution of water sources, such as precipitation; the second is a change in the amount and temporal variation of water use or demand; and the third component is society's inability to develop and optimally manage an integrated water supply system. Historical comparison of hydrometeorologic data must be coupled with historical changes in land use, water use (demand), and the water management system for comparative analysis of droughts. Drought impacts can be measured in loss of agricultural products, inadequate public water supply, loss of soil by wind erosion and subsidence, saltwater intrusion into freshwater aquifers, fires, other economic losses associated with water use, and ecological effects. This report summarizes historical and current droughts and water shortages in Central and South Florida.

HISTORICAL DROUGHTS

Drought is a relatively common phenomenon in North America, occurring almost every year in some part of the United States (Kogan, 1995) and in nearly every decade. In Central and South Florida, severe droughts were reported in 1932, 1955–1957, 1961–1963, 1971–1972, 1973–1974, 1980–1982, 1985, 1988–1989, 1990, and 2000–2001 (Benson and Gardner, 1974; Lin et al., 1984; Marban et al., 1989; CSFFCD, 1972, 1974; SFWMD, 1985). Historical droughts and water shortages are marked by declines in lakes, reservoirs, and groundwater levels, declines in rainfall and runoff, and increases in the number and magnitude of wildfires. Analysis of these parameters clearly indicates drought and water shortage occurrences and provides information for anticipation of future drought events.

The severe drought of 1971 resulted in a water restriction declaration on May 3, 1971 (CSFFCD, 1972). Lake Okeechobee reached a minimum stage of 10.29 feet NGVD on June 7, 1971. A rainfall deficit of 43 percent was reported as average for Lake Okeechobee and the Northern, Central, and Southern Everglades for the eight-month period from October 1970 to May 1971. For the same period, the Lake Okeechobee Service Area water demand and delivery was reported to be 734,477 ac-ft. The 1973–1974 drought is comparable to the 1971–1972 drought. For the same months, the rainfall deficit was 47 percent, but with different distribution. Lake Okeechobee Service Area water delivery was 774,568 ac-ft for the period of October 1973 to May 1974 (CSFFCD, 1974). The minimum lake stage of 10.98 feet NGVD was reached on May 31, 1974.

The 1980–1982 drought was one of the most severe droughts ever in South Florida. A more than 20-inch rainfall deficit over two years resulted in the decline of the Lake Okeechobee stage from 17.46 feet NGVD on January 1, 1980 to 9.79 feet NGVD on July 31, 1981. The 7.7-foot drop in water level was attributed to a decrease in rainfall and increases in evaporation and water use. The drought for the Lower East Coast and Water Conservation Areas was relieved by Tropical Storm Dennis (Lin et al., 1984).

The 1984 wet season and the 1984–1985 dry season had rainfall deficiencies that resulted in the 1985 drought. The upper Kissimmee, lower Kissimmee, and Lake Okeechobee rain areas had an average deficit of 14 inches. The Lake Okeechobee water level declined from 15.14 feet NGVD to 11.82 feet NGVD from January 1, 1985 to June 12, 1985. The South Florida Water Management District suspended the interim action plan and initiated backpumping to increase water supply. A water shortage plan was also implemented (SFWMD, 1985).

South Florida experienced a severe drought from September 1988 to August 1989, during which there was a 21-inch rainfall deficit in the Everglades Agricultural Area and the Lower East Coast. The Lake Okeechobee water level declined from 15.95 feet NGVD on September 1, 1988 to 11.06 feet NGVD on August 8, 1989. During the same period a record storage depletion was reported for Lake Okeechobee (1.89 million ac-ft) and the Water Conservation Areas (1.15 million ac-ft) (Marban et al., 1989). The 1990 drought was a continuation of the 1988–1989 drought. From June 1989 through May 1990, nine inches of rainfall deficit occurred District-wide and was most severe in Everglades National Park. Lake Okeechobee supply-side management and water restrictions were implemented to conserve lake water (Trimble et al., 1990). The Lake Okeechobee water level declined from 12.25 feet NGVD on January 1, 1990 to 10.47 ft NGVD on June 21, 1990.

PALMER DROUGHT SEVERITY INDEX

The Palmer Drought Severity Index (PDSI) is used to monitor long-term drought conditions, that is, those occurring over a period of several months (Palmer, 1965). The PDSI uses antecedent moisture conditions, precipitation, temperature, field capacity, and weather trends to compute an index value. Near normal conditions are represented by an index value between ± 0.49; severe droughts have an index value of -3.0 or less. Index values are maintained by the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA). Monthly values are available from 1895 to present.

The index is standardized to local conditions, allowing it to be used nationally for drought reporting. It is applied to 350 climatic divisions in the United States and Puerto Rico. Florida has seven climatic divisions. The South Florida Water Management District is in Florida divisions 3 through 7 (**Figure 1-2**).

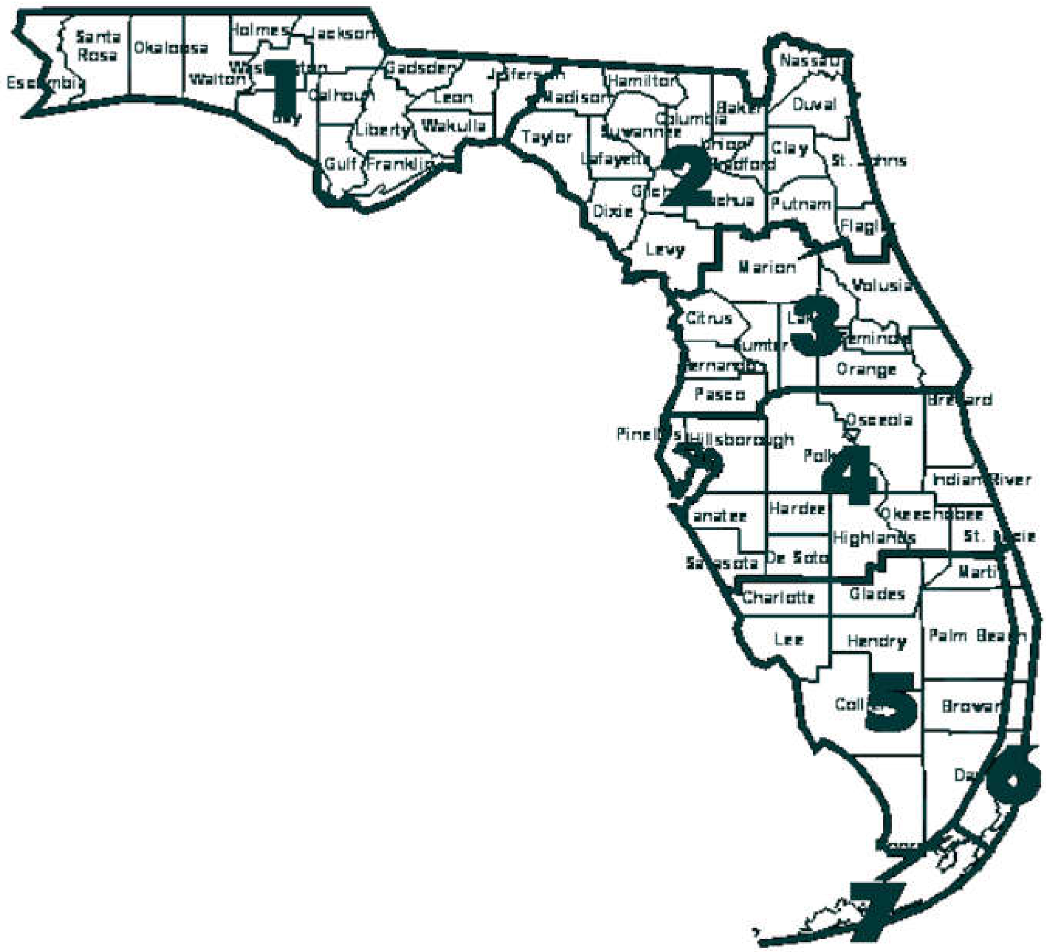

Figure 1-2. Florida climatic divisions (NOAA, Climatic Prediction Center)

Figure 1-3 shows the index values for the five divisions covering the District at the onset of the most recent drought through February 2001. The drought index started declining at the end of 1999 and was most severe in division 3, the region covering the upper Kissimmee area. The index for the upper Kissimmee area began showing drought beginning in the spring of 1998. Two of the divisions, those covering the upper Kissimmee and lower Kissimmee areas, experienced extreme drought conditions during this period.

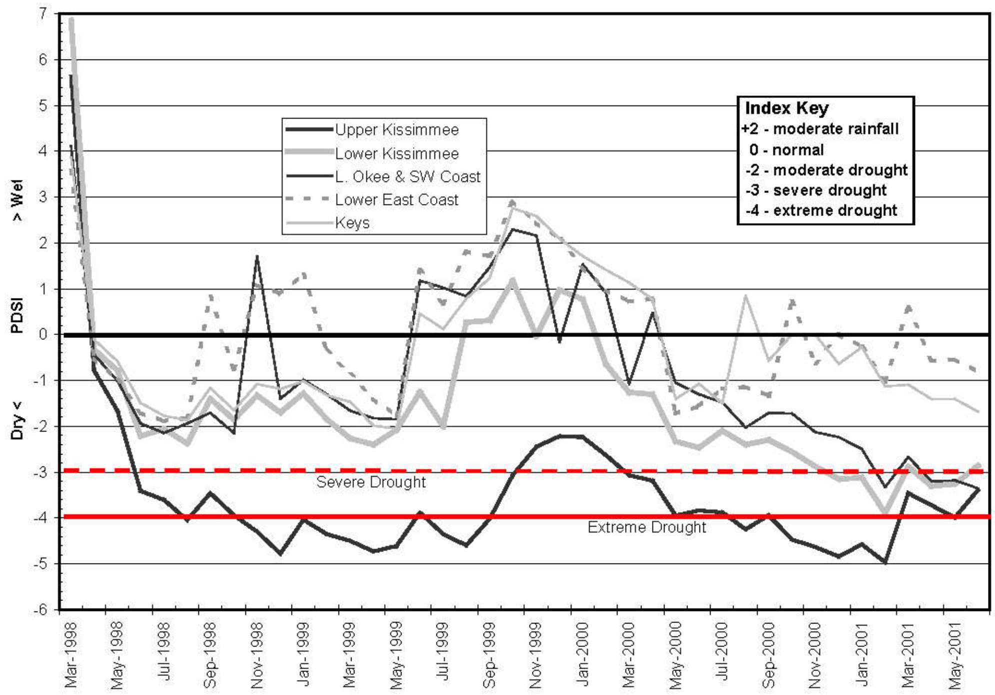

Figure 1-3. Palmer Drought Severity Index, Florida climatic divisions 3, 4, 5, 6, and 7 (March 1998 to June 2001)

Figure 1-4 shows the PDSI for the entire period of record for division 3 (the Upper Kissimmee area). As shown in **Figure 1-3**, this climatic division had the longest and most severe drought during the most recent drought period. Prior to that, the area had not experienced an extreme drought since 1932. The variation in the PDSI from 1895 to September 2001 for the lower Kissimmee area (division 4), Lake Okeechobee, the Lower West Coast, the Agricultural (Ag) areas and the Everglades (division 5), the Lower East Coast (division 6), and the Florida Keys (division 7) is shown in **Figures 1-5** through **1-8**. Severe and extreme droughts are marked.

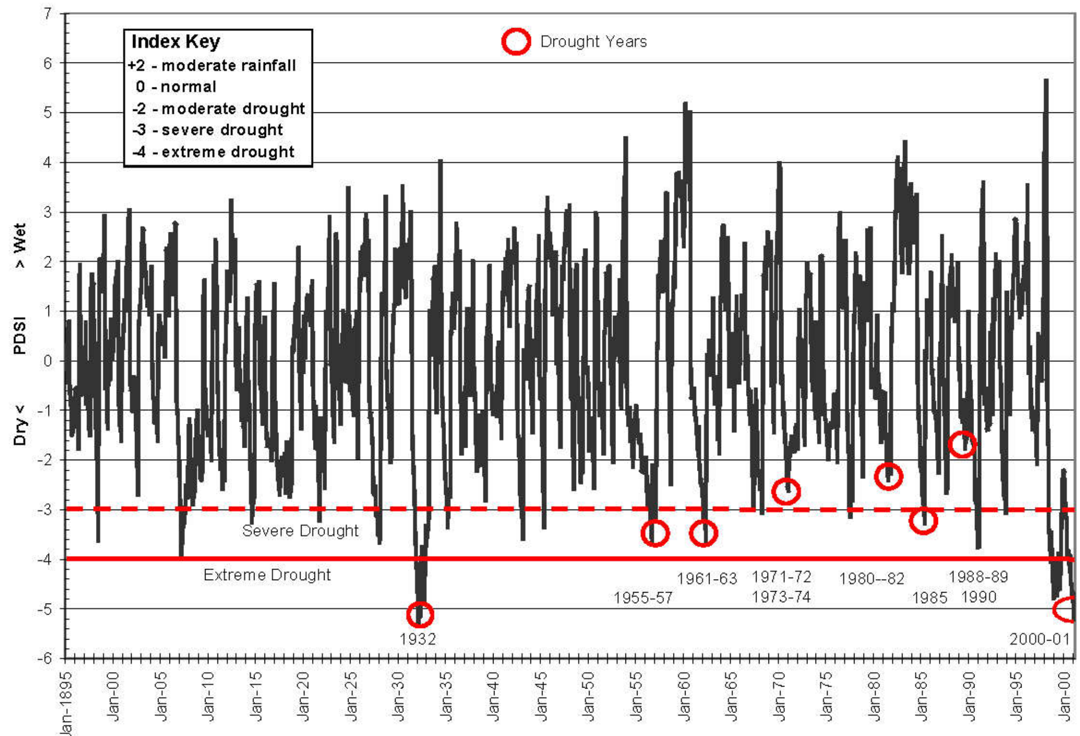

Figure 1-4. Palmer Drought Severity Index, Florida climatic division 3 (upper Kissimmee area), 1895-2001

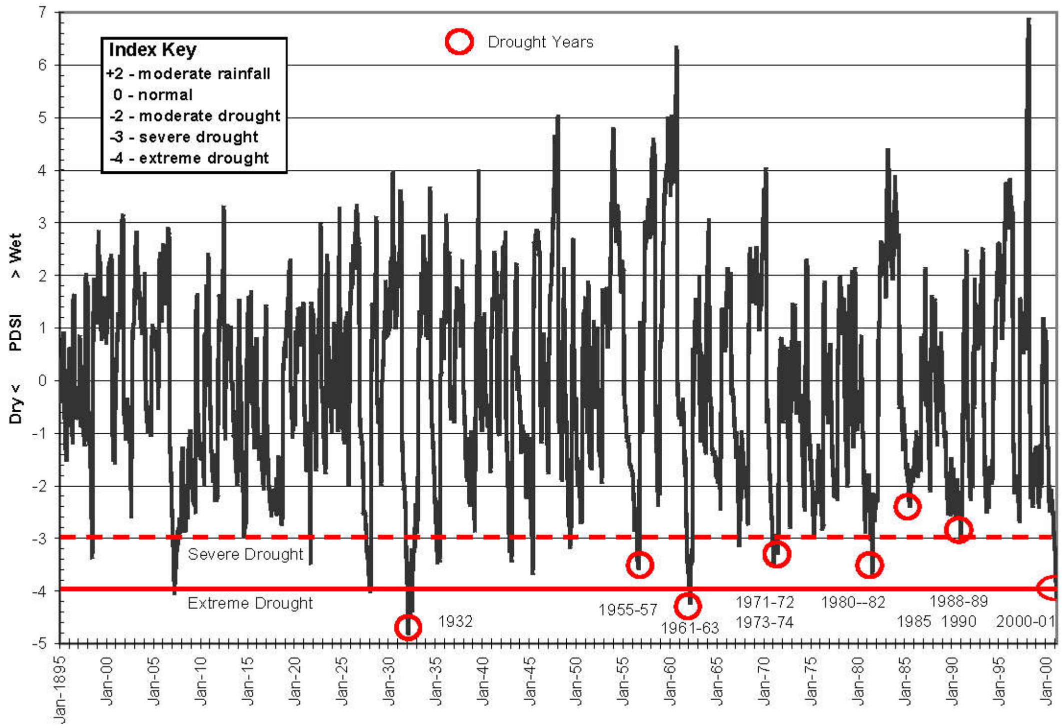

Figure 1-5. Palmer Drought Severity Index, Florida climatic division 4 (lower Kissimmee area), 1895-2001

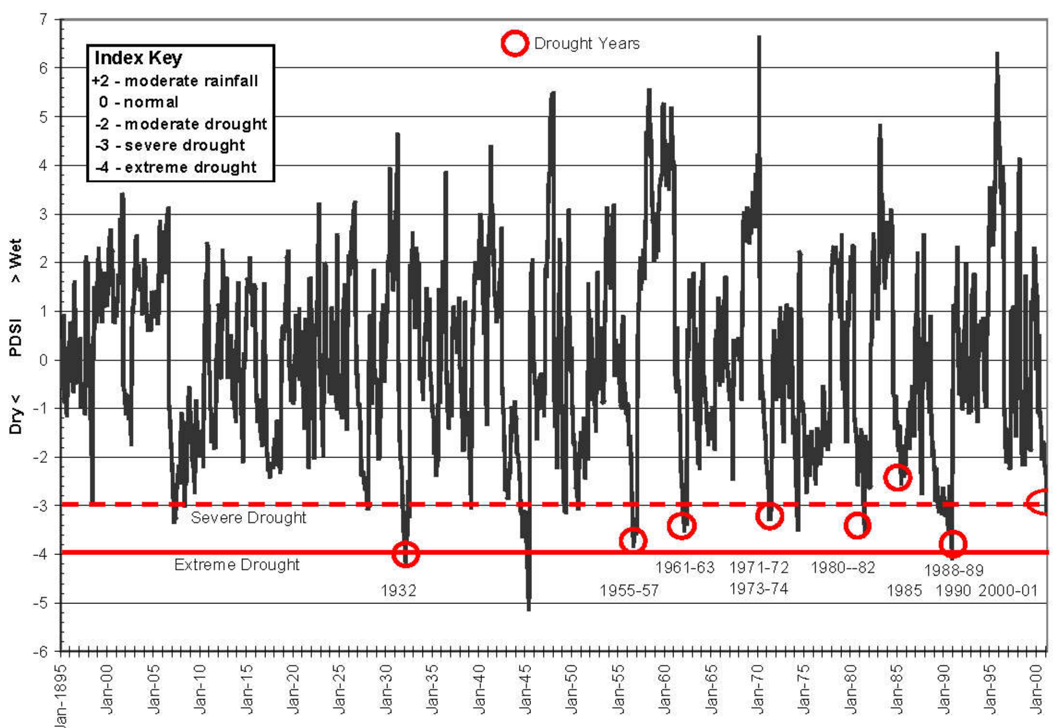

Figure 1-6. Palmer Drought Severity Index, Florida climatic division 5 (Lake Okeechobee, the lower West Coast, the Agricultural areas, and the Everglades), 1895-2001

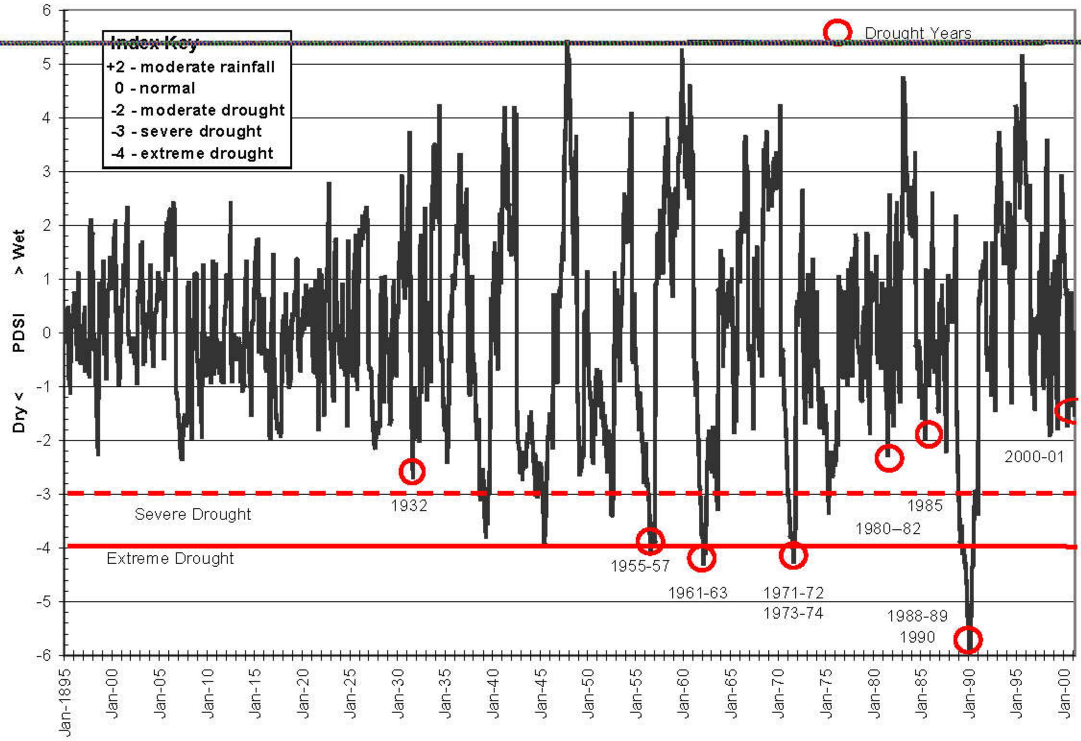

Figure 1-7. Palmer Drought Severity Index, Florida climatic division 6 (lower East Coast), 1895-2001

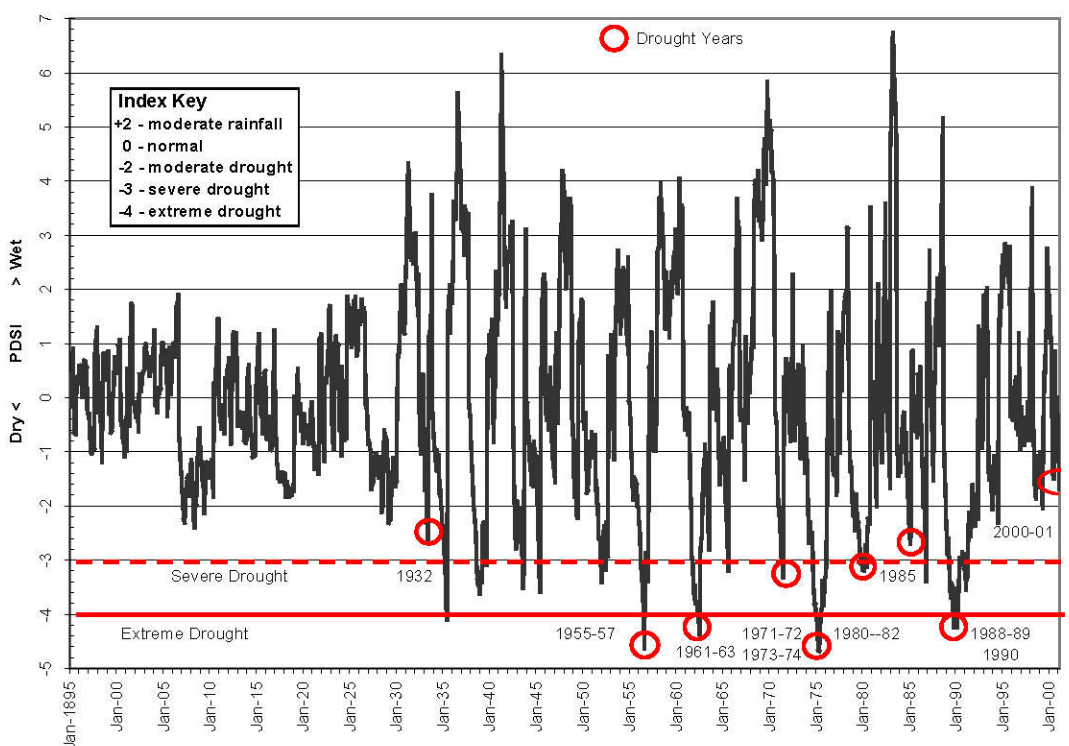

Figure 1-8. Palmer Drought Severity Index, Florida climatic division 7 (Florida Keys), 1895-2001

WILDFIRES

One of drought's more significant impacts on natural resources is the development of conditions that promote the spread of wildfires. **Figure 1-9** shows the number of acres burned per year as the result of wildfires for the period 1981-2001 (Florida DOACS, Division of Forestry, 2001). The data are for all causes of wildfires, including those that were anthropogenic. The largest number of acres burned corresponds directly to drought years (1981, 1985, and 1989). The effects of the La Niña weather pattern that brought lower-than-expected rainfall to the District in 1998 are also shown in **Figure 1-9**, although there was no declared drought that year. **Figure 1-10** depicts acres burned per wildfire in Florida. The year 2001 ranks third in the 21 years of record.

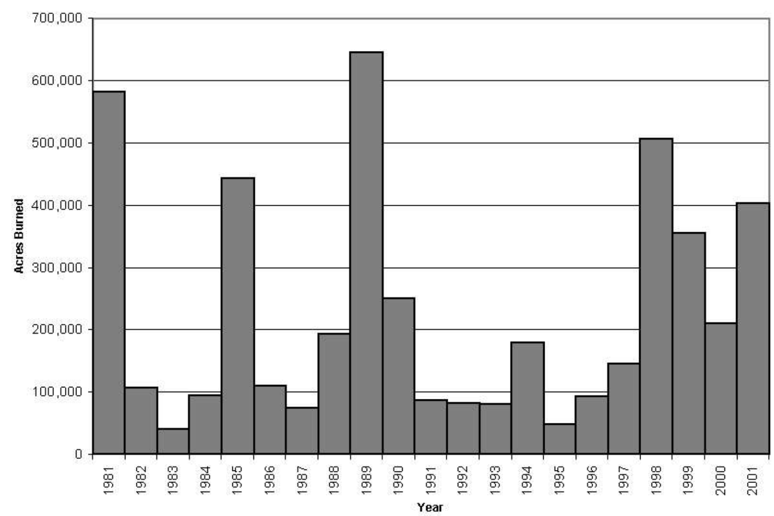

Figure 1-9. Acres burned per year by wildfires in Florida

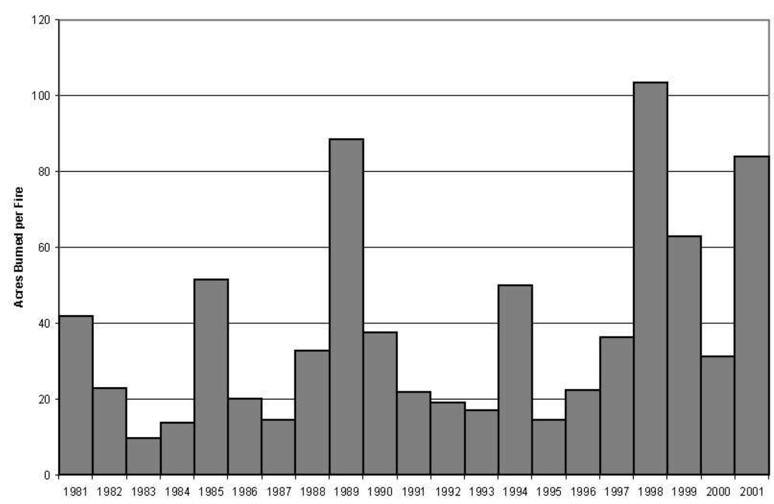

Figure 1-10. Acres burned per wildfire in Florida (1981-2001)

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Chapter 2: Hydrology of the Drought

Wossenu Abtew and R. Scott Huebner

SUMMARY

This chapter provides rainfall analysis for the drought period. Frequency of occurrence of rainfall over the District rainfall areas is presented along with historical rainfall records. Drought period inflows and outflows to major hydrologic components, water levels and storage are presented in comparison with historical records.

RAINFALL

The South Florida Water Management District is divided into 14 rainfall areas for operational purposes. The rainfall areas are shown in **Figure 2-1**. The region is a high-rainfall area, with frontal, convective and tropical system-driven rainfall events. The heaviest rains in South Florida are produced by mesoscale convective systems – extra-tropical in the dry season and tropical in the rainy season (Rosenthal, 1994). In Central and South Florida (excluding the Florida Keys), 57 percent of total summer rainfall occurs on undisturbed sea breeze days, 39 percent on disturbed days and 4 percent on highly disturbed days (Burpee and Lahiff, 1984). The average rainfall in the South Florida Water Management District is 52.8 inches per year. Monthly rainfall statistics for 12 of the rainfall areas are shown in **Table 2-1**. Generally, June is the wettest month, followed by September. The wet season lasts from June through October and accounts for 66 percent of annual rainfall. The driest month is December, followed by January. Generally, runoff generated from wet season rainfall and dry season high-rainfall events is stored in ponds, lakes, impoundments, and aquifers. Excess water is discharged to the ocean to control flooding. At times, critical decision making is required to manage flooding and avoid potential water shortages. Both water shortage and flooding have the potential to occur in any month of the year. Dry periods in Florida result from stable atmospheric conditions that are often associated with high-pressure systems (Winsberg, 1990). These conditions can occur in any season, but are most common in winter and spring.

The Palm Beach rain area has the highest rainfall, followed by the Broward and Miami-Dade rain areas. It can be concluded that the East Coast gets more rain than the inland and West Coast [illegible] Since there are no large impoundments in the coastal urban area, runoff is discharged to the ocean. The historical rainfall record of each rainfall area indicates that drought years have a significant decline from the mean annual rainfall. **Figures 2A-1-1** to **2A-1-12** depict historical annual rainfall for each rain area, along with annual average rainfall amounts. Reported regional drought years since 1932 are marked, and previous drought years can be picked from figures where data is available. These figures show the high frequency of droughts and the variation between rain areas. With the current water management system, drought at the headwaters of Lake Okeechobee would have more impact in terms of water shortage during the dry season than the coastal rain areas.

Figure 2-2 depicts rainfall deficit for each rain area for the 2000 drought and the frequency of occurrence in years of return period. Fifteen percent or higher annual rainfall deficit could result in drought. Temporal and spatial distributions of rainfall and water management are additional factors that determine water availability. The overall impact of drought is dependent on the spatial and temporal distributions of rainfall deficit through the District area. Analysis of the 2000 and 2001 rainfall for each rain area indicates the severity of drought in the rain area and the drainage receiving basins. Comparison of cumulative actual monthly rainfall with cumulative average monthly rainfall for each rain area for the latest drought years is shown in **Figures 2-3** to **2-25**.

Figures 2-4 to **2-26** depict the month-after-month rainfall deficit. The Upper Kissimmee, Lower Kissimmee, Lake Okeechobee, Martin/St. Lucie, East EAA, West Ag., East Caloosahatchee, Southwest Coast and Palm Beach rain areas, with few exceptions, depict mostly deficits since November 1999. Broward, Miami-Dade and WCA-1 and WCA-2 rain areas were relatively less affected by the drought. The Upper Kissimmee, Lower Kissimmee, and Lake Okeechobee areas of the District are the watersheds that contribute most of the inflows to Lake Okeechobee. The 2000 annual rainfall for the three areas had a dry frequency of 1 in 100 years, further indicating the drought's magnitude. The average annual deficit for the three areas was 35 percent. The 2000 annual District-wide rainfall deficit was 25 percent of the historical mean. The drought persisted in most areas through August 2001. For the first eight months of 2001 the East EAA and West Ag. rainfall areas had 31 and 43 percent rainfall deficits, respectively, compared to the average for the same period. Hurricane Gabrielle passed through Central Florida in the middle of September. The hurricane and the associated tropical system resulted in significant rainfall over a large area, contributing to drought relief.

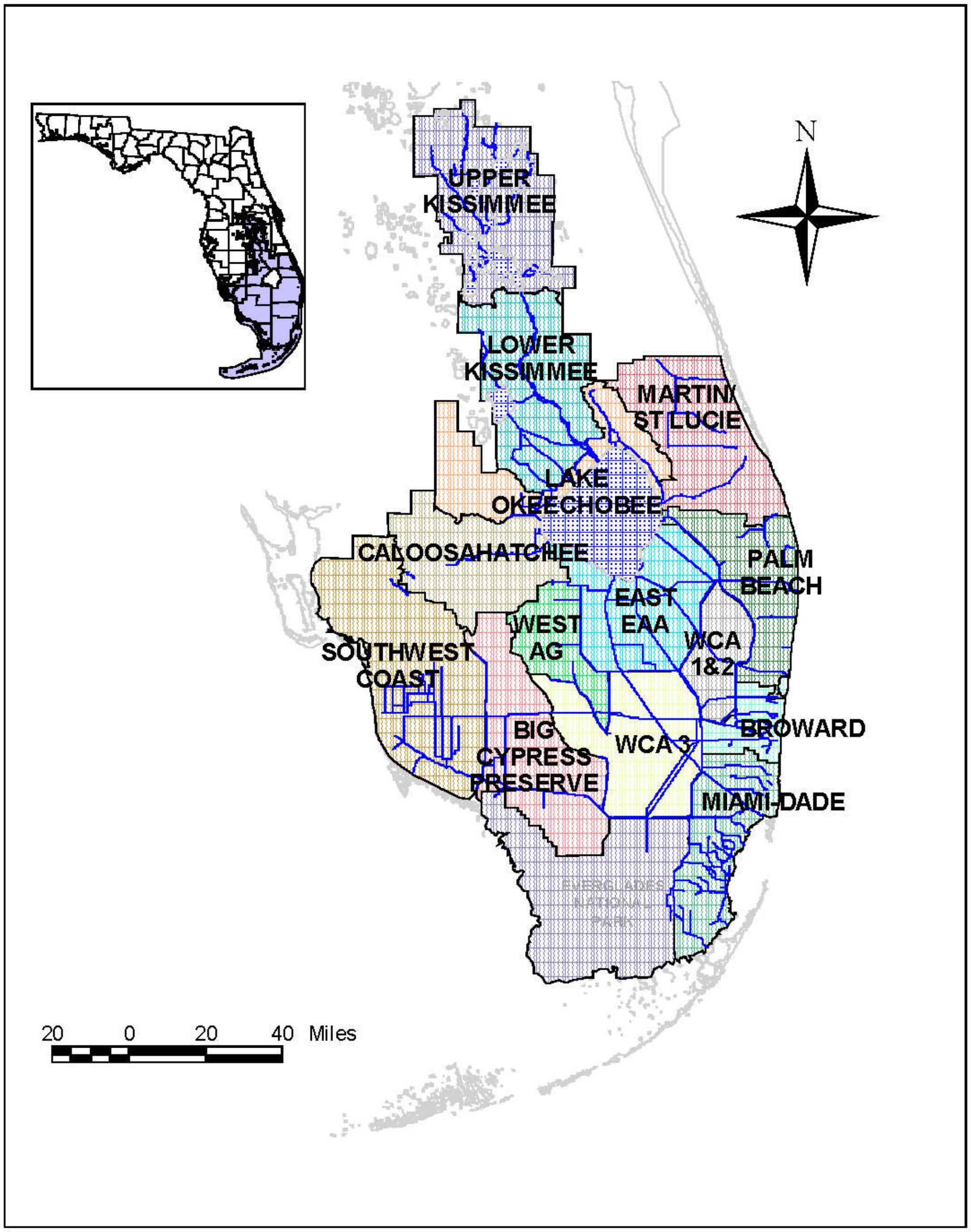

Figure 2-1. South Florida Water Management District rain areas

Table 2-1. Monthly average rainfall (inches) for each rainfall area and the District (Ali and Abtew, 1999)

Month	Upper Kissimmee	Lower Kissimmee	Lake Okeechobee	Martin/ St. Lucie	East EAA	West AG	Caloosa-hatchee	Southwest Coast	Palm Beach	Broward	Dade	WCA1&2	District
January	2.25	1.85	1.85	2.48	2.04	2.48	1.76	1.92	3.03	2.18	2.09	2.25	2.2
February	2.64	2.37	2	2.56	1.94	2.39	2.06	2.15	2.74	2.26	2.01	2.29	2.36
March	3.18	2.76	2.95	3.1	2.78	3.04	2.74	2.46	3.36	2.46	2.28	2.54	2.94
April	2.55	1.92	2.38	3.02	2.76	2.53	2.59	2.21	3.29	3.06	3.02	2.49	2.58
May	4.08	3.84	4.03	4.53	4.77	4.36	4.27	4.03	5.19	5.46	6.06	5.22	4.66
June	7.28	7.26	6.92	6.51	8.41	9.58	8.52	9.13	8.1	8.35	8.28	8.19	7.85
July	7.44	6.58	6.06	6.11	7.5	8.15	7.36	8.73	6.46	6.53	6.21	6.16	6.98
August	6.87	6.2	6.37	6.15	7.61	7.54	7.48	8.26	6.92	7.18	6.99	6.38	7.03
September	6.37	5.33	6.49	7.86	7.61	7.25	7.18	8.2	8.41	7.96	8.32	6.44	7.23
October	3.24	3.07	3.83	6.77	4.29	3.83	3.78	4.05	7.8	7.39	7.32	5.04	4.72
November	2.17	1.84	1.58	2.96	2.06	1.84	1.58	1.55	3.77	3.14	2.78	2.91	2.3
December	2.02	1.43	1.51	2.09	1.71	1.96	1.36	1.43	2.47	2.16	1.75	2.05	1.9
YEAR	50.09	44.45	45.97	54.14	53.48	54.95	50.68	54.12	61.54	58.13	57.11	51.96	52.75

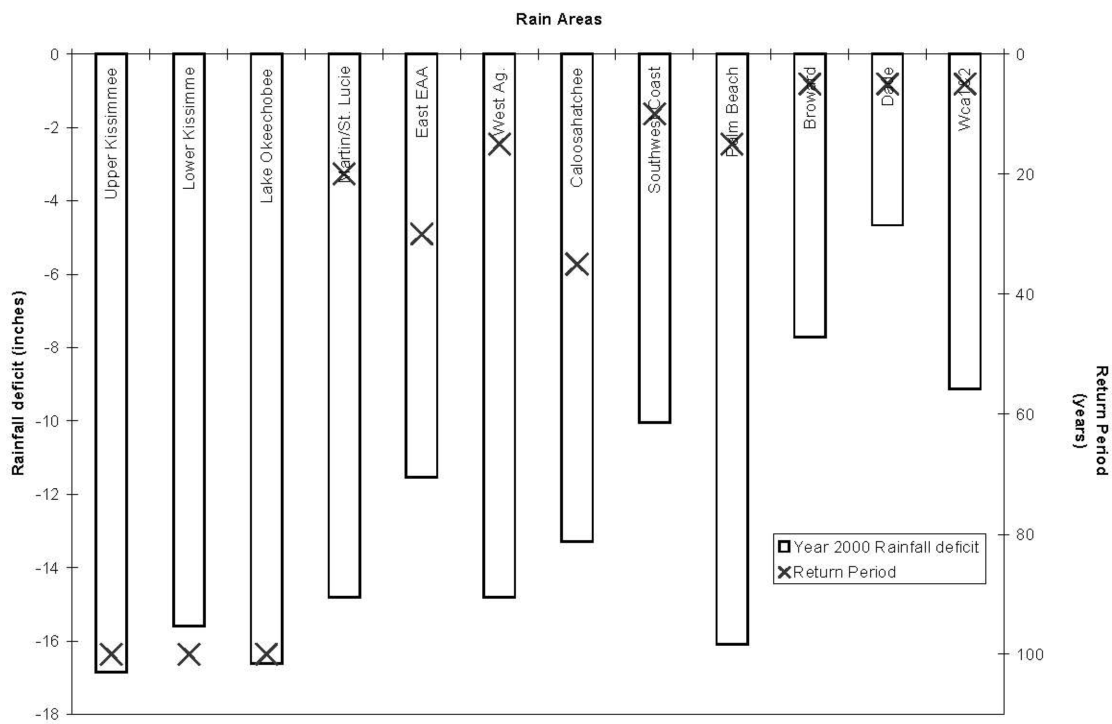

Figure 2-2. Rainfall deficit and return periods for each rain area for 2000

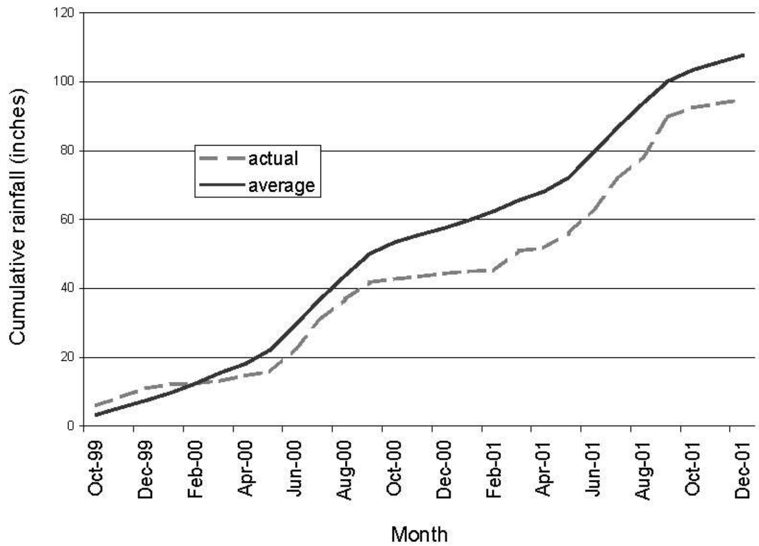

Figure 2.3. Upper Kissimmee rain area actual and average cumulative rainfall

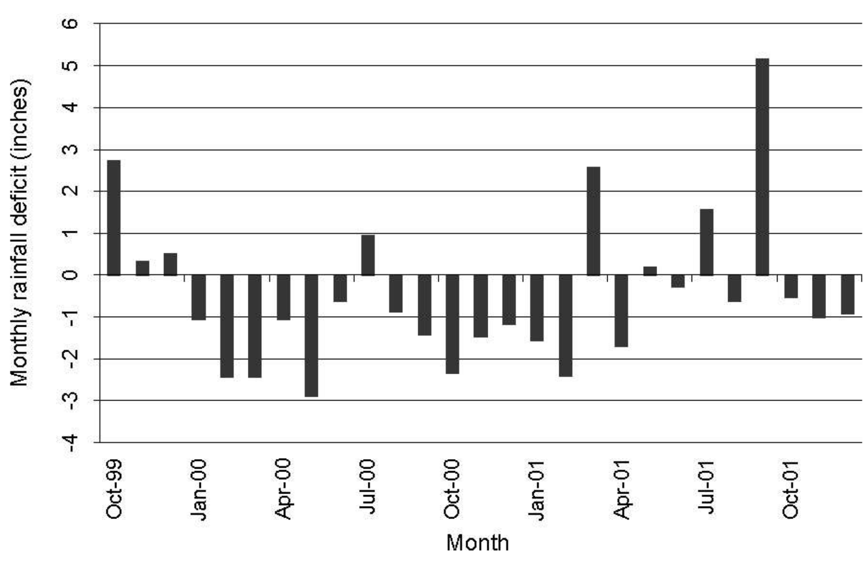

Figure 2-4. Upper Kissimmee rain area monthly rainfall deficit

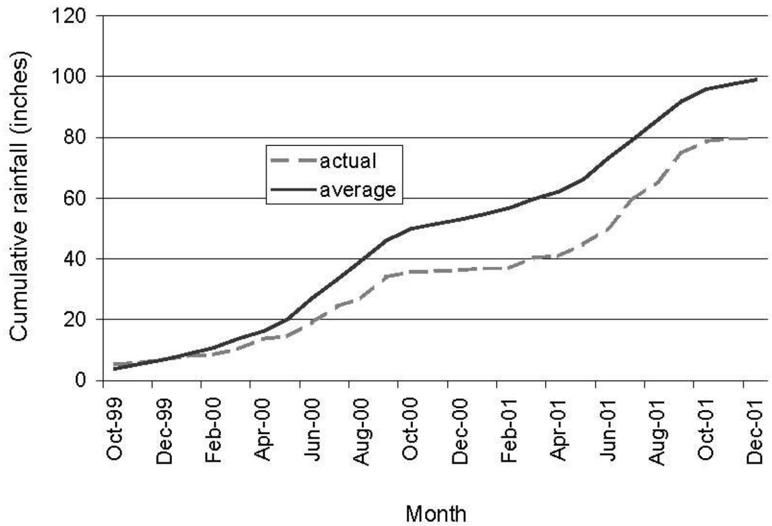

Figure 2-5. Lower Kissimmee rain area actual and average cumulative value

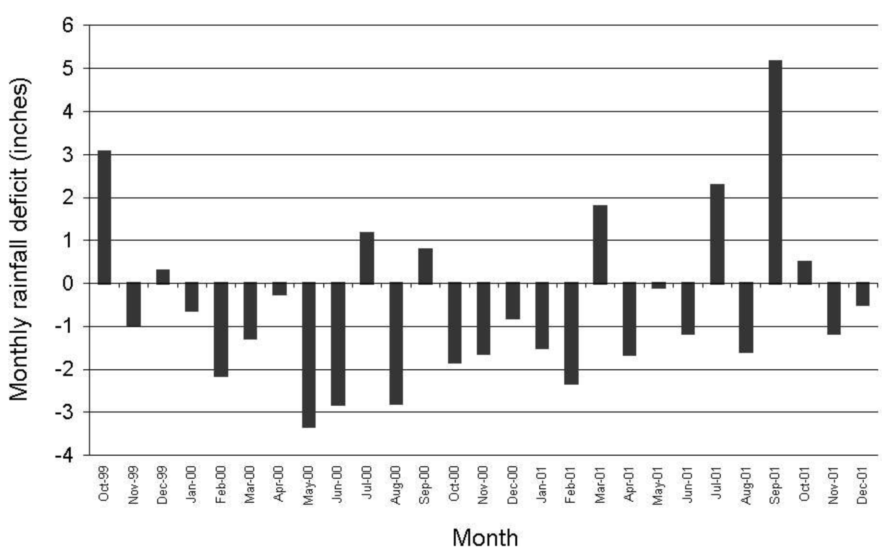

Figure 2-6. Lower Kissimmee rain area monthly rainfall deficit

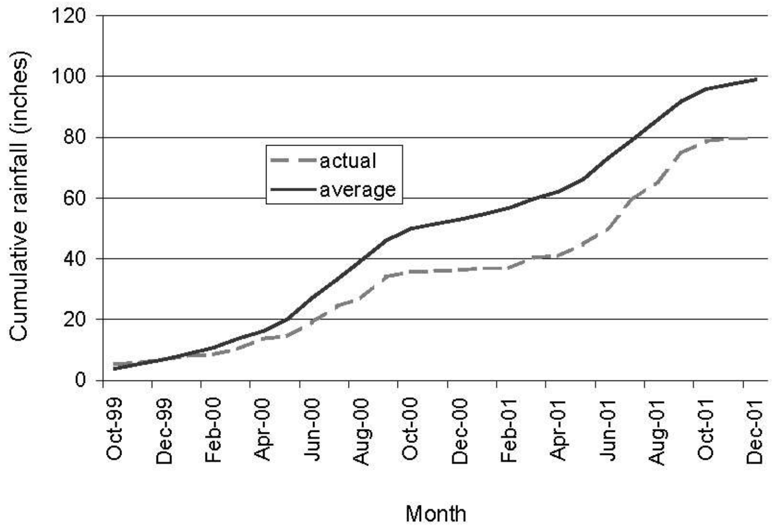

Figure 2-7. Lake Okeechobee rain area actual and average cumulative rainfall

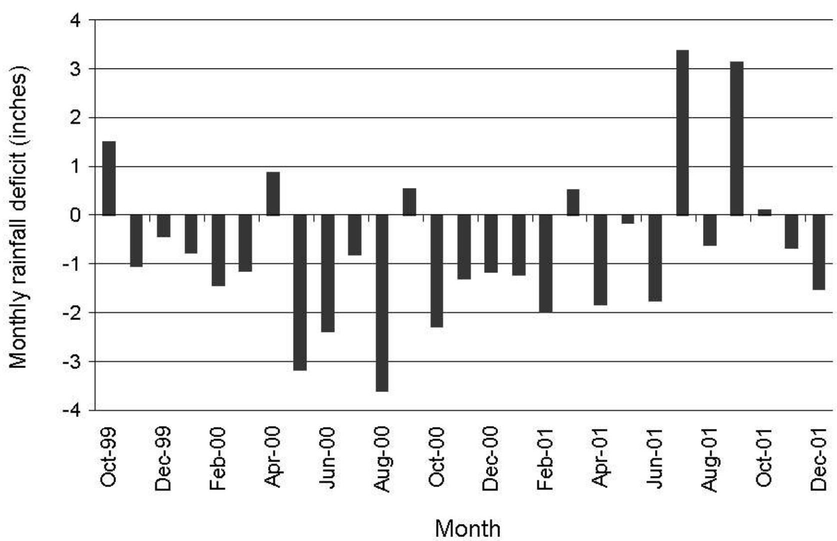

Figure 2-8. Lake Okeechobee rain area monthly rainfall deficit

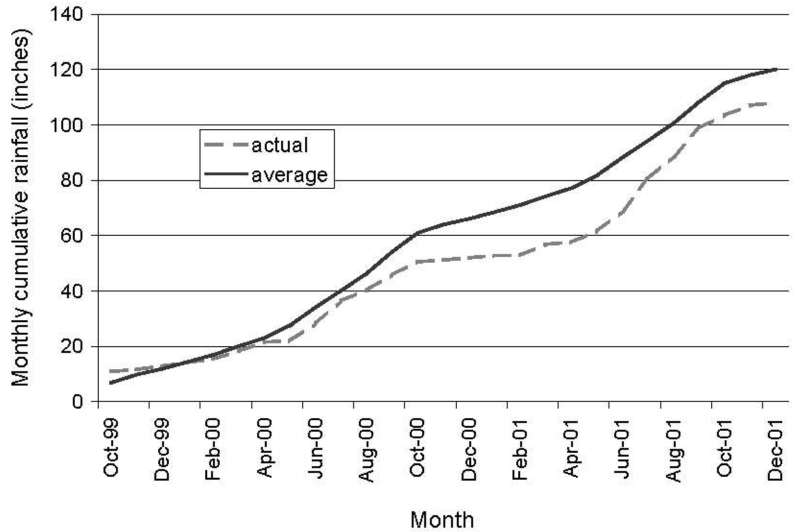

Figure 2-9. Martin/St. Lucie rain area actual and average cumulative rainfall

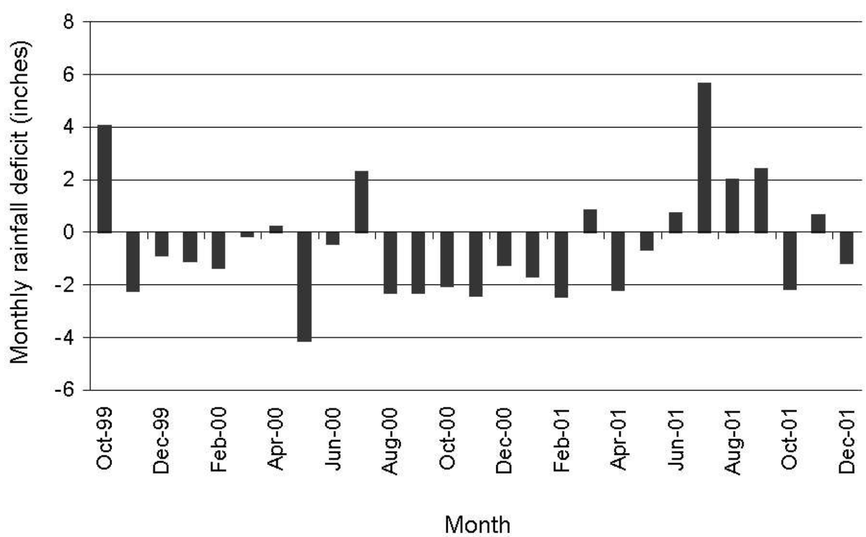

Figure 2-10. Martin/St. Lucie rain area monthly rainfall deficit

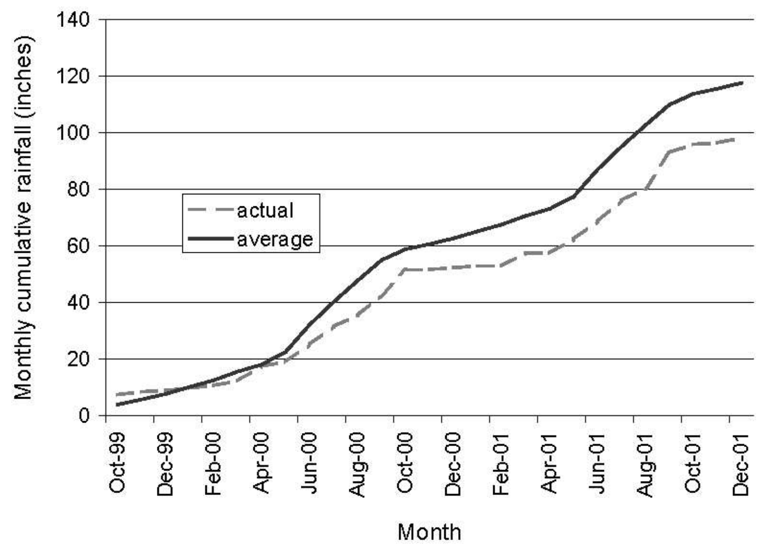

Figure 2-11. East EAA rain area actual and average cumulative rainfall

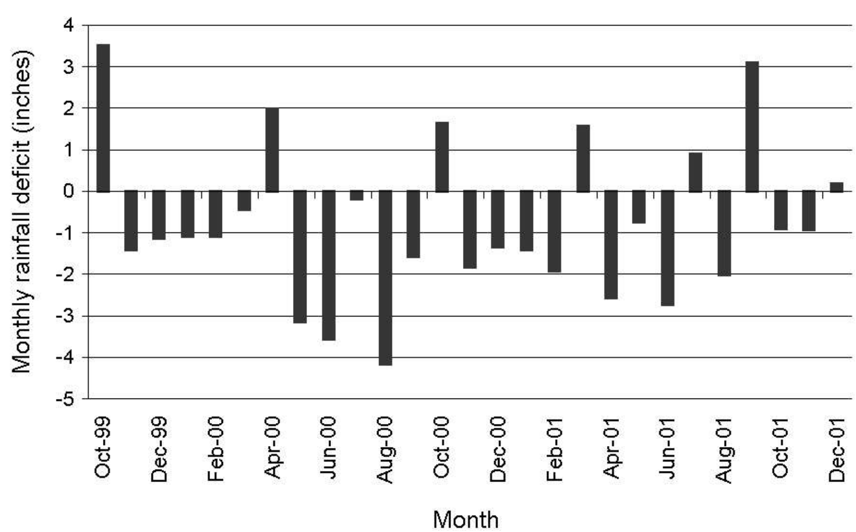

Figure 2-12. East EAA rain area monthly rainfall deficit

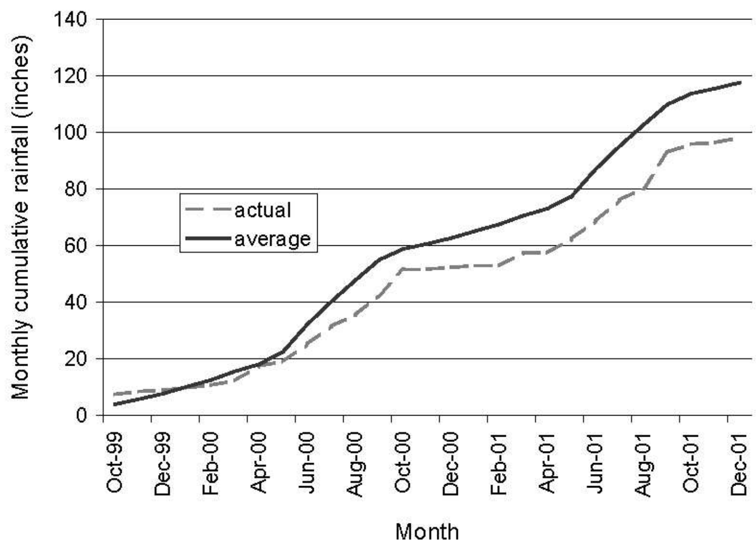

Figure 2-13. West Ag. rain area actual and average cumulative rainfall

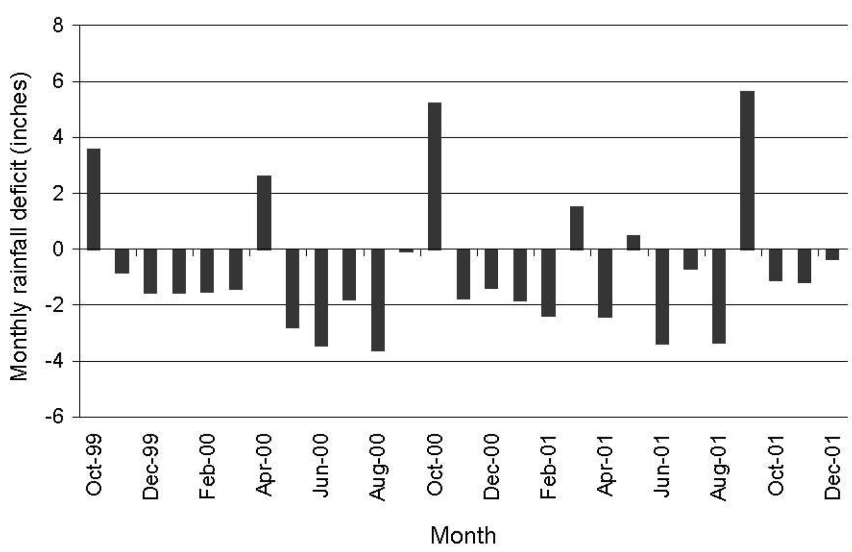

Figure 2-14. West Ag. rain area monthly rainfall deficit

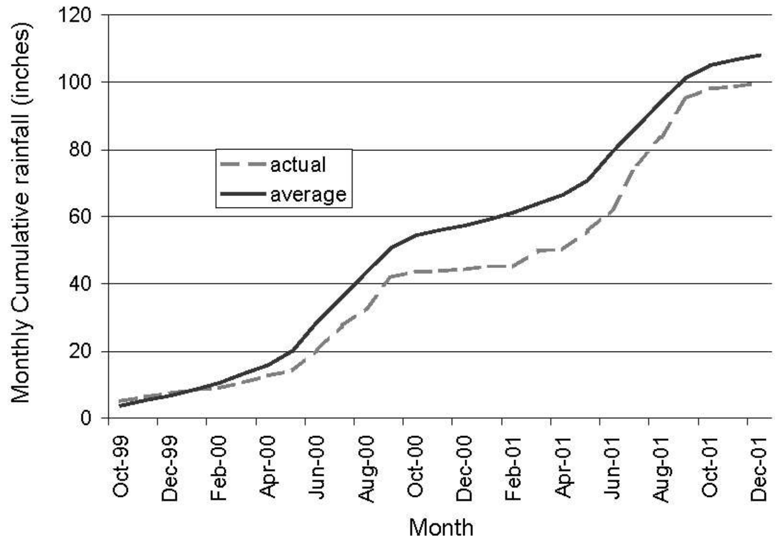

Figure 2-15. Caloosahatchee rain area actual and average cumulative rainfall

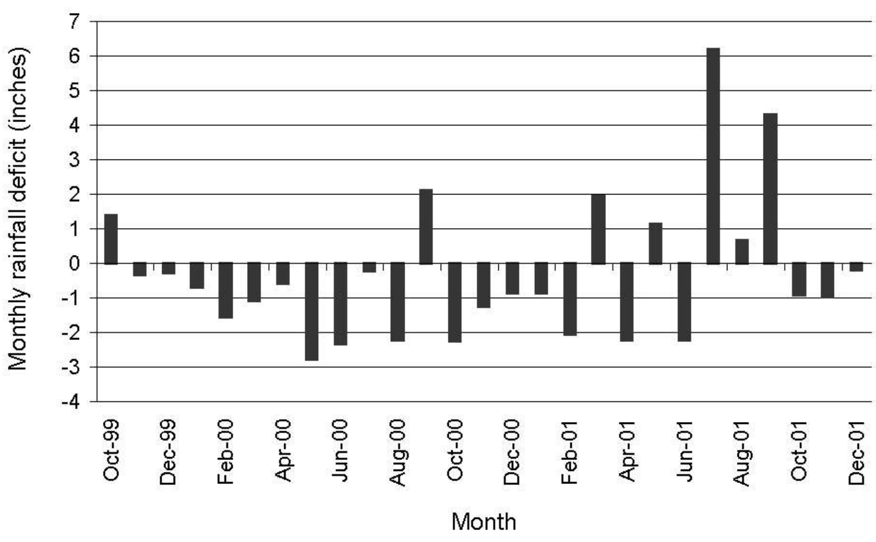

Figure 2-16. Caloosahatchee rain area monthly rainfall deficit

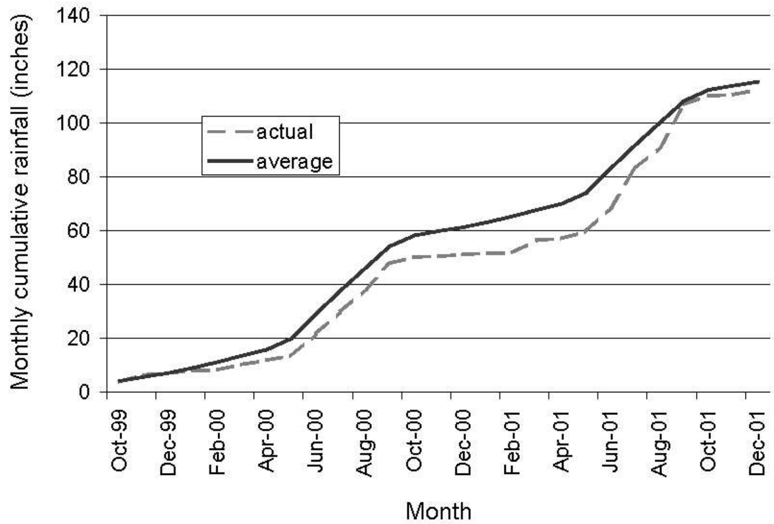

Figure 2-17. Southwest Coast rain area actual and average cumulative rainfall

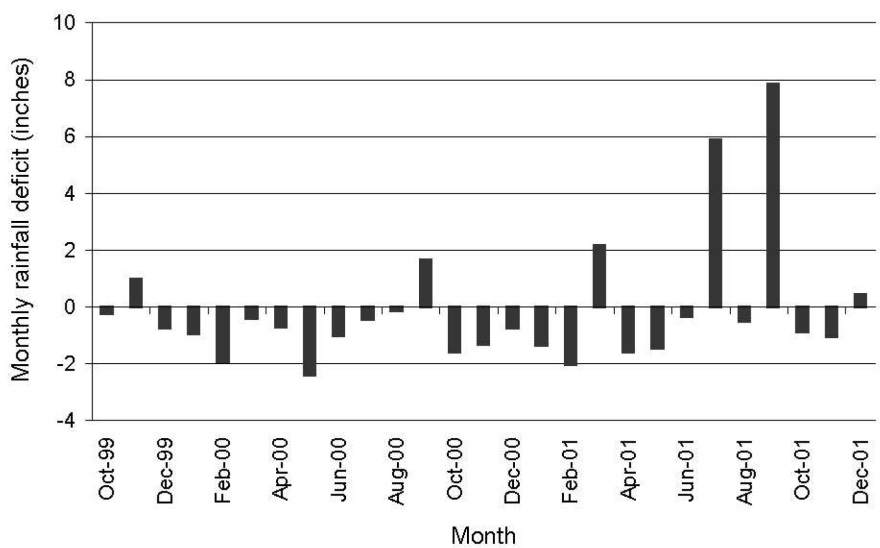

Figure 2-18. Southwest Coast rain area monthly rainfall deficit

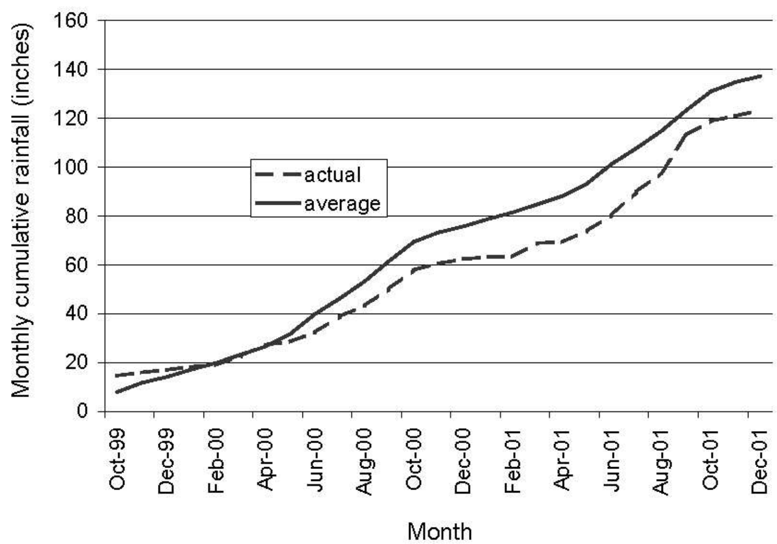

Figure 2-19. Palm Beach rain area actual and cumulative rainfall

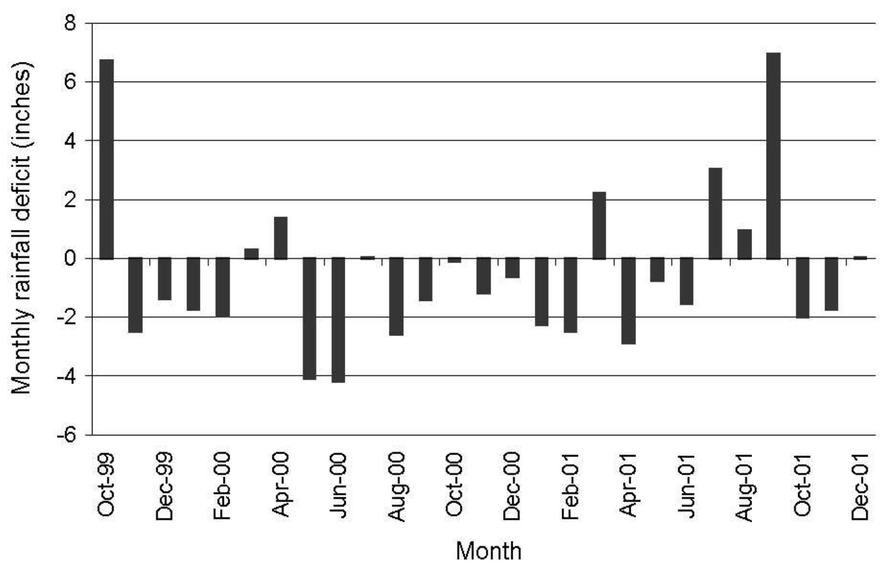

Figure 2-20. Palm Beach rain area monthly rainfall deficit

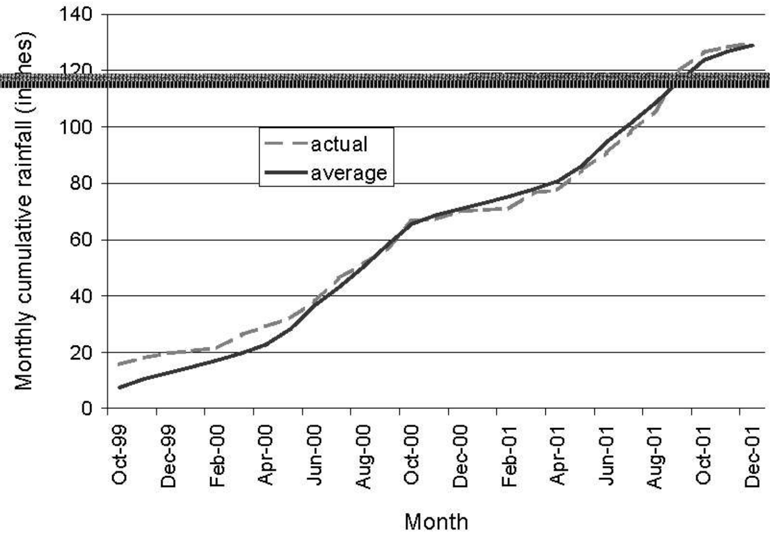

Figure 2-21. Broward rain area actual and average cumulative rainfall

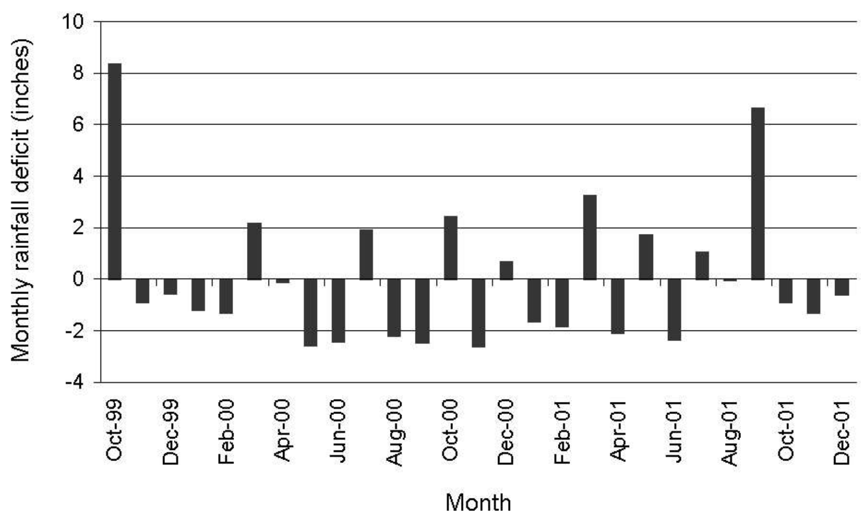

Figure 2-22. Broward rain area monthly rainfall deficit

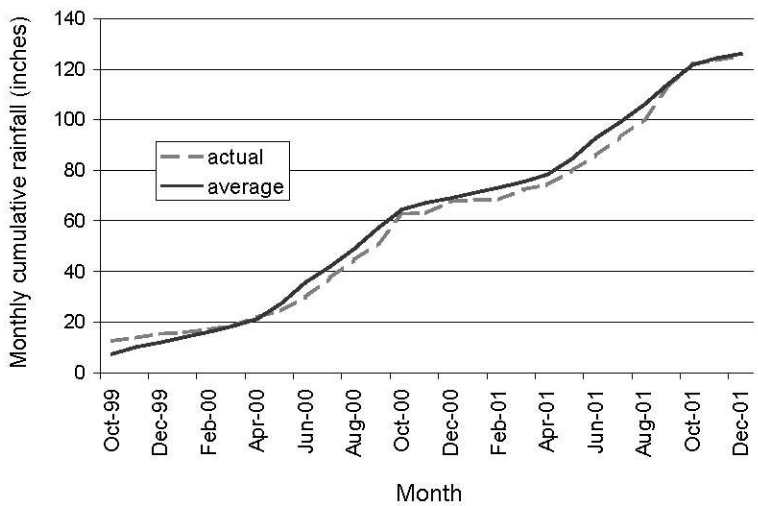

Figure 2-23. Miami-Dade rain area actual and average cumulative rainfall

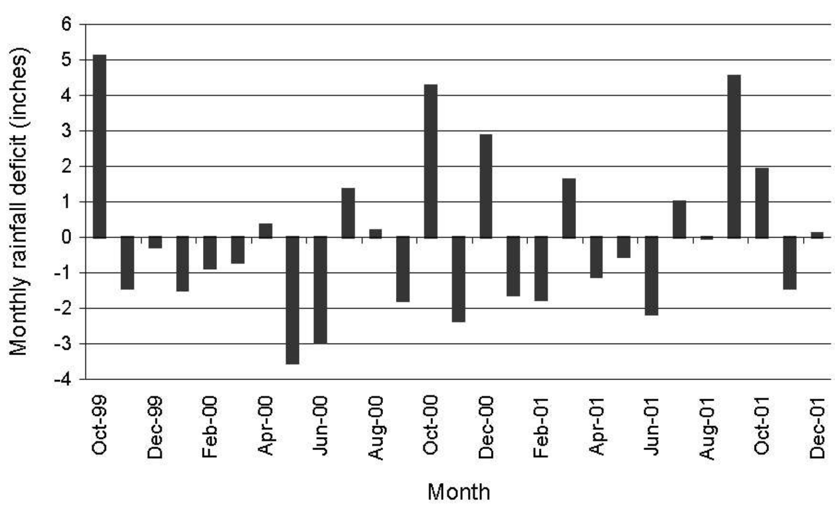

Figure 2-24. Miami-Dade rain area monthly rainfall deficit

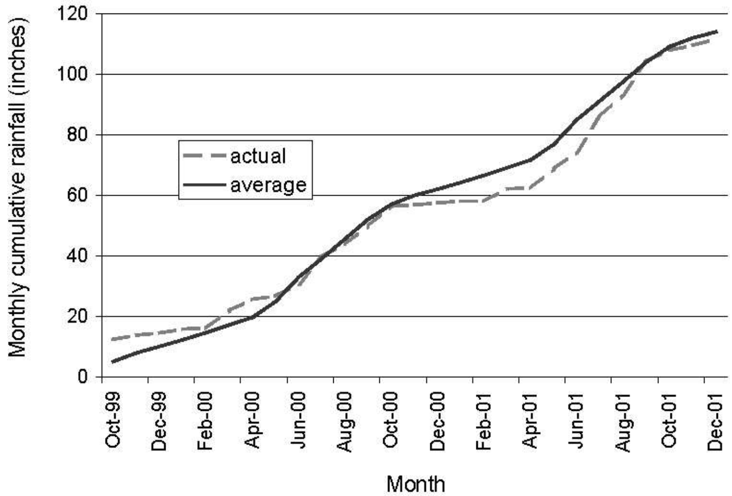

Figure 2-25. Water Conservation Areas 1 and 2 rain areas' actual and average cumulative rainfall

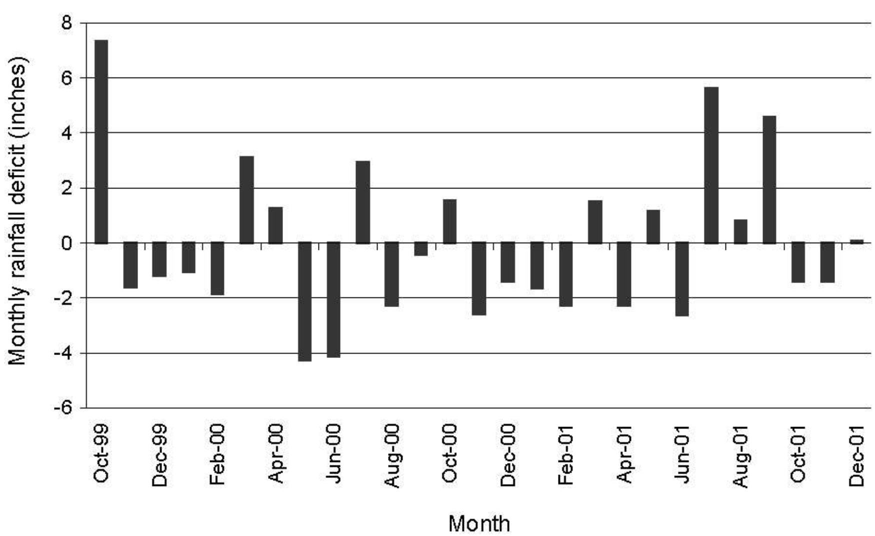

Figure 2-26. Water Conservation Areas 1 and 2 rain areas' monthly rainfall deficit

In general, monthly rainfall was below mean values for most of 2000 and 2001; the beginning of the drought can be traced back to November 1999. **Figures 2-27** and **2-28** show the dry season and wet season rainfall amounts for each rain area, respectively. The dry season extends from November through May. The wet season runs from June to October. Rainfall during the dry season was below expected values in 2000 and 2001. During the 2000 wet season, rainfall was below expected amounts for all rain areas, except Miami-Dade.

Table 2-2 depicts the return period in years associated with monthly rainfall amounts for each rain area. White squares indicate a month where rainfall was greater than expected (labeled with a "W"). Black and gray squares indicate dry months. The black squares show exceptionally dry months, where the rainfall amount had a return period of greater than 10 years (or the amount had a 10-percent chance or less of occurring). Of the 36 months examined, most rain areas experienced 10 to 14 wet months and 22 to 26 dry months. The West Ag rain area, however, had only eight wet months during a three-year period from 1999 to 2001. In contrast, WCAs 1 and 2 had 16 wet months. The Lower Kissimmee rain area had nine exceptionally dry months during this period. The Upper Kissimmee rain area had four exceptionally dry months and a total of 24 dry months, and the Lake Okeechobee rain area had three extremely dry months, with a total of 24 dry months

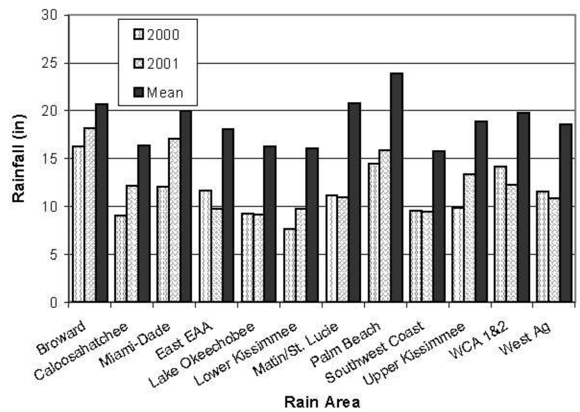

Figure 2-27. Dry season observed rainfall versus expected rainfall by rain area, 2000–2001

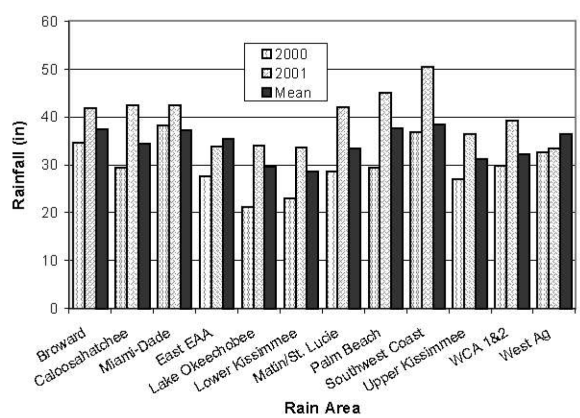

Figure 2-28. Wet season observed rainfall versus expected rainfall by rain area, 1999–2001

Table 2-2. Return period (years) of monthly rainfall observed during 1999-2001 by rain area

Month	Broward	Caloosahatchee	Miami-Dade	East EAA	Lake Okeechobee	Lower Kissimmee	Matin/St. Lucie	Palm Beach	Southwest Coast	Upper Kissimmee	WCA 1&2	West Ag
JAN-99 T_R	W 5-10	W 5-10	W 5-10	W 2-5	W 2-5	W 2-5	W 2-5	W 10-20	W 2-5	W 2-5	W 2-5	2-5
FEB-99 T_R	5-10	20-50	10-20	5-10	5-10	50-100	5-10	5-10	2-5	2-5	W 2-5	5-10
MAR-99 T_R	5-10	5-10	5-10	10-20	5-10	10-20	10-20	10-20	2-5	5-10	10-20	10-20
APR-99 T_R	2-5	2-5	2-5	2-5	W 2-5	W 2-5	2-5	2-5	2-5	2-5	2-5	5-10
MAY-99 T_R	2-5	2-5	2-5	2-5	2-5	2-5	2-5	5-10	2-5	W 2-5	2-5	W 2-5
JUN-99 T_R	W 20-50	W 10-20	W 5-10	W 5-10	W 10-20	W 10-20	W 5-10	W 10-20	W 2-5	W 5-10	W 20-50	W 5-10
JUL-99 T_R	5-10	2-5	2-5	2-5	2-5	10-20	5-10	5-10	2-5	>100	10-20	2-5
AUG-99 T_R	W 10-20	W 5-10	W 5	5-10	W 2-5	W 5-10	W 5-10	W 5	W 2-5	W 2-5	W 2-5	W 2-5
SEP-99 T_R	W 2-5	W 5-10	2-5	W 2-5	W 2-5	W 5-10	2-5	2-5	W 2-5	W 2-5	W 2-5	W 10-20
OCT-99 T_R	W 10-20	W 2-5	W 5-10	W 5-10	W 2-5	W 10-20	W 5-10	W 10-20	2-5	W 5-10	W 10-20	W 5-10
NOV-99 T_R	2-5	2-5	2-5	2-5	2-5	2-5	5-10	5-10	W 5-10	W 2-5	2-5	2-5
DEC-99 T_R	2-5	2-5	2-5	2-5	2-5	W 2-5	2-5	2-5	2-5	W 2-5	2-5	2-5
JAN-00 T_R	2-5	2-5	5-10	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5
FEB-00 T_R	2-5	5-10	2-5	2-5	2-5	>100	2-5	5-10	10-20	20-50	5-10	2-5
MAR-00 T_R	W 5-10	2-5	2-5	2-5	2-5	2-5	2-5	W 2-5	2-5	5-10	W 10-20	2-5
APR-00 T_R	2-5	2-5	W 2-5	W 5-10	W 2-5	2-5	W 2-5	W 2-5	2-5	2-5	W 2-5	10
MAY-00 T_R	2-5	5-10	5-10	10-20	20-50	50-100	>100	20-50	5-10	10-20	20-50	10-20
JUN-00 T_R	2-5	2-5	2-5	5-10	2-5	5-10	2-5	5-10	2-5	2-5	5-10	2-5
JUL-00 T_R	W 2-5	2-5	W 2-5	2-5	2-5	W 2-5	W 5-10	W 2-5	2-5	W 2-5	W 5-10	2-5
AUG-00 T_R	2-5	5-10	W 2-5	50-100	20-50	10-20	2-5	2-5	2-5	2-5	5-10	5-10
SEP-00 T_R	2-5	W 2-5	2-5	2-5	W 2-5	W 2-5	2-5	2-5	W 2-5	2-5	2-5	2-5
OCT-00 T_R	W 2-5	2-5	W 5-10	W 2-5	2-5	5-10	2-5	2-5	2-5	5-10	W 2-5	W 10-20
NOV-00 T_R	10-20	5-10	10-20	10-20	5-10	10-20	10-20	2-5	10	2-5	10-20	10-20
DEC-00 T_R	W 2-5	2-5	W 10-20	5-10	5-10	2-5	2-5	2-5	2-5	2-5	2-5	2-5
JAN-01 T_R	5-10	2-5	5-10	2-5	2-5	5-10	5-10	5-10	2-5	5-10	5-10	5-10
FEB-01 T_R	5-10	>100	20-50	>100	>100	>100	>100	50	20-50	20-50	50-100	>100
MAR-01 T_R	W 10-20	W 5-10	W 5-10	W 5-10	W 2-5	W 5-10	W 2-5	W 5-10	W 5-10	W 5-10	W 5-10	W 2-5
APR-01 T_R	2-5	10-20	2-5	20-50	5-10	10-20	5-10	10-20	2-5	5-10	10-20	>100
MAY-01 T_R	W 2-5	W 2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	W 2-5	W 2-5	W 2-5
JUN-01 T_R	2-5	2-5	2-5	2-5	2-5	2-5	W 2-5	2-5	2-5	2-5	2-5	2-5
JUL-01 T_R	W 2-5	W 20-50	W 2-5	W 2-5	W 10-20	W 5-10	W 20-50	W 5-10	W 20-50	W 2-5	W 20-50	2-5
AUG-01 T_R	2-5	W 2-5	2-5	2-5	2-5	2-5	W 2-5	W 2-5	2-5	2-5	W 2-5	5-10
SEP-01 T_R	W 10-20	W 5-10	W 5-10	W 5-10	W 5-10	W 50-100	W 2-5	W 10-20	W 20-50	W 10-20	W 10-20	W 10-20
OCT-01 T_R	2-5	2-5	W 2-5	2-5	W 2-5	W 2-5	2-5	2-5	2-5	2-5	2-5	2-5
NOV-01 T_R	2-5	2-5	2-5	2-5	2-5	2-5	W 2-5	2-5	2-5	2-5	2-5	2-5
DEC-01 T_R	2-5	2-5	W 2-5	W 2-5	2-5	2-5	2-5	W 2-5	W 2-5	2-5	W 2-5	2-5
# Dry Months	23	25	22	26	24	23	24	24	26	24	20	28
# Extreme Dry	1	3	3	6	3	9	4	4	2	4	6	6
# Wet Months	13	11	14	10	12	13	12	12	10	12	16	8

T_R exceptionally dry months; T_R dry months; W T_R wet months

INFLOWS AND OUTFLOWS FROM MAJOR HYDROLOGIC COMPONENTS

The main storage component in the hydrologic system is Lake Okeechobee. Inflows come from the Upper and Lower Kissimmee watersheds, the Nubbin Slough and Taylor Creek basins, the Lake Istokpoga Water Management Area, Fisheating Creek, the Caloosahatchee Canal, the St. Lucie Canal, the Everglades Agricultural Area, and other smaller drainage basins. The main storage in the Upper Kissimmee Basin is Lake Kissimmee, with 55.5 square miles area and a watershed of 269.1 square miles (Ali, 1998).

LAKE KISSIMMEE FLOWS

Lake Kissimmee outflow is regulated through structure S65. The lake's regulation schedule varies from 49.25 ft NGVD in spring to 52.5 ft NGVD in winter. Flow data for discharge from Lake Kissimmee into the Kissimmee River (C-38 Canal) are available since 1934 (**Figure 2A-1-13**). Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Kissimmee was 645,000 ac-ft, with standard deviation of 363,000 ac-ft. The maximum discharge of 1,460,000 ac-ft occurred during the 1995 El Niño year. The minimum annual flow of 7,900 ac-ft occurred during the 1981 drought. Flows during the 2000-2001 drought months are shown in **Table 2-3**. There were eight consecutive months with no outflow from Lake Kissimmee (November 2000 to June 2001). The total outflow from October 1999 through September 2001 was 701,490 ac-ft, of which 11,780 ac-ft was for the 12 months of July 2000 through June 2001. This is the third-lowest discharge volume for 12 consecutive months, with the record-lowest occurring during the 1971-1972 drought and the second-lowest occurring during the 1980-1982 drought.

LAKE ISTOKPOGA FLOWS

Lake Istokpoga outflow is regulated through structure S-68. The lake's regulation schedule varies between 37.5 ft NGVD and 39.5 ft NGVD. Historical annual flow data is depicted in **Figure 2A-1-14**. Based on flow data from January 1, 1972 to September 30, 2001, the average annual outflow from Lake Istokpoga was 192,000 ac-ft, with standard deviation of 125,000 ac-ft. The maximum discharge of 562,000 ac-ft occurred during the 1998 El Niño year. The minimum annual flow of 18,000 ac-ft occurred during the 1981 drought. Flows during the current drought months are shown in **Table 2-3**. The total outflow from October 1999 through September 2001 was 292,085 ac-ft, of which 23,813 ac-ft was for the 12 months of July 2000 through June 2001. The second-lowest annual discharge volume of 32,175 ac-ft occurred during the current drought in 2000.

Table 2-3. Flows of Lake Istokpoga, Lake Kissimmee, and Lake Okeechobee during the 2000-2001 drought (ac-ft)

		Lake Kissimmee	Lake Istokpoga	Lake Okeechobee								
Year	Month	outflow (S65)	outflow (S68)	inflow from North	total backflow	total inflow	outflow to South	outflow to North	outflow to East	outflow to West	total outflow	forward pumping
1999	October	182,244	64,827	566,384	53,958	620,322	11,681	0	40,991	124,227	176,889	0
1999	November	31,803	23,077	99,543	6,346	105,889	31,388	18	89,323	214,341	335,070	0
1999	December	47,291	11,355	66,850	2,369	69,219	86,553	18	53,007	100,643	240,221	0
2000	January	70,216	9,642	79,738	1,343	81,080	89,925	14	25,661	47,033	162,632	0
2000	February	74,478	5,059	72,383	1,082	73,465	28,535	14	9,650	8,864	47,063	0
2000	March	41,899	4,483	22,427	2,438	24,865	75,168	2621	5,161	29,207	112,157	0
2000	April	89,146	3,252	86,913	25,460	112,373	82,047	3981	38,754	88,476	213,258	0
2000	May	1,063	5,352	2,522	8,323	10,845	212,275	6997	107,698	200,308	527,278	0
2000	June	3,404	3,521	1,800	23,942	25,742	119,972	5079	2,254	26,922	154,228	0
2000	July	0	566	23,705	26,167	49,872	1,666	1303	13,912	1,206	18,087	0
2000	August	0	0	23,159	14,257	37,416	22,826	3296	15,317	18,456	59,895	0
2000	Septembr	5,234	2	63,865	58,812	122,677	9,116	790	6,016	2,535	18,459	0
2000	October	6,494	0	30,981	89,795	120,775	6,178	2443	1,785	10,818	21,225	0
2000	November	0	0	465	9,399	9,865	41,311	6607	17,978	26,512	92,409	0
2000	December	0	297	15	5,736	5,750	36,351	1601	5,064	17,189	60,205	0
2001	January	0	0	97	6,863	6,959	17,710	1081	4,864	1,220	24,847	0
2001	February	0	20,301	114	985	1,099	22,984	253	6,985	6,976	37,197	0
2001	March	0	1,526	567	11,691	12,258	27,129	1485	9,657	7,457	45,728	442
2001	April	0	1,119	1,337	3,981	5,317	46,755	2154	2,707	23,790	75,406	41,261
2001	May	0	0	34	11,603	11,637	51,599	1077	806	9,965	63,407	50,058
2001	June	0	0	8,871	77,732	86,603	1,116	0	422	0	1,538	905
2001	July	4,861	1,578	177,773	184,272	362,045	463	0	0	224	687	238
2001	August	50,099	27,794	250,693	209,887	460,579	1,533	0	254	75	1,862	0
2001	Septembr	93,258	108,334	525,120	172,144	697,264	785	1	904	0	1,691	0
Total		**701,490**	**292,085**	**2,105,356**	**1,008,585**	**3,113,916**	**1,025,066**	**40,833**	**459,170**	**966,444**	**2,491,439**	**92,904**

LAKE OKEECHOBEE FLOWS

Based on flow data from January 1, 1972 to September 30, 2001, major surface inflows are from the Upper and Lower Kissimmee watersheds through structure S-65E (47.5 percent), the Lake Istokpoga Water Management Area (9.1 percent), and Fisheating Creek (8.6 percent). Reverse flows are from the Everglades Agricultural Area, the Caloosahatchee and St. Lucie canals (16.8 percent), and 18 percent from other structures around the lake. Inflow is from the north and northwest, and reverse inflow is from the south, southwest, and southeast. The average total annual inflow of surface water was 1,999,000 ac-ft, with an annual maximum of 3,520,000 ac-ft during the 1995 El Niño, minimum of 675,000 ac-ft during the 2000 drought and a standard deviation of 834,000 ac-ft. Average annual reverse inflow from the EAA, the Caloosahatchee Canal and the St. Lucie Canal was 333,000 ac-ft, with a standard deviation of 146,000 ac-ft. **Figure 2-29** depicts historical inflow and outflow from Lake Okeechobee indicating drought years. **Figure 2-30** depicts mean monthly historical inflows and outflows.

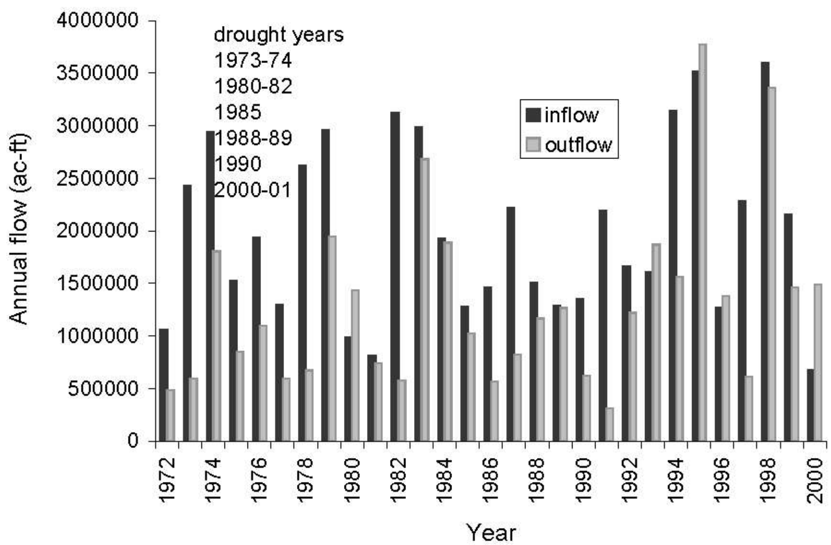

Figure 2-29. Historical inflows and outflows for Lake Okeechobee

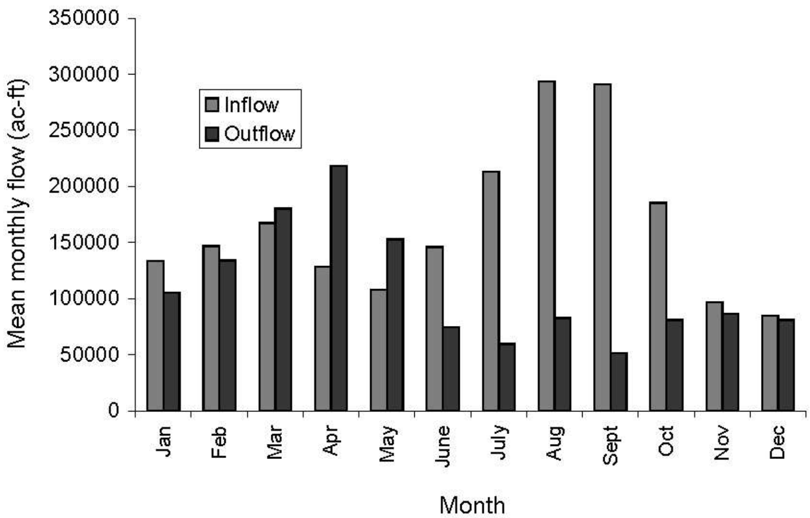

Figure 2-30. Monthly average inflows and outflows for Lake Okeechobee, January 1972-2001

The drought's effect on Lake Okeechobee inflows and outflows is significant. From December 1999 to June 2001 there were 19 consecutive monthly inflows below the historical average (**Table 2-3** and **Figure 2-31**). The significant increase in lake inflow from July to September 2001 is apparent and corresponds with an increase in rainfall and a decrease in drought effect. Through the same period, backflow into the lake through pumping and gravity was 32 percent (**Table 2-3**), and the remaining inflow of 68 percent was from the north. Historical backflows to Lake Okeechobee from the south, southeast, and southwest are depicted in **Figure 2-32**. The maximum annual backflow occurred in the nine months of 2001 (679,157 ac-ft). The total backflow to the lake for the period October, 1999 to September 2001 was 1,017,224 ac-ft of which 420,701 was back pumping through S-2 and S-3 pump stations. **Table 2-4** depicts monthly back pumping and backflow into Lake Okeechobee.

Table 2-4. Back pumping and backflow to Lake Okeechobee (ac-ft)

Year	Month	S3 backpump ac-ft	S2 backpump ac-ft	S352 backflow ac-ft	S308 backflow ac-ft	S77 backflow ac-ft	L8 backflow ac-ft	Indust. backflow ac-ft	S4 backpump ac-ft	C10 to Lake ac-ft	C12 to Lake ac-ft	C12A to Lake ac-ft	C4A to Lake ac-ft	S236 to Lake ac-ft
1999	October	2821	28973	0	0	0	0	0	6578	6354	4177	4617	1752	2713
1999	November	0	0	0	0	0	0	0	1572	657	597	2201	254	613
1999	December	147	0	0	0	0	0	0	196	0	0	1068	0	420
2000	January	0	0	0	0	0	0	0	0	376	0	687	0	309
2000	February	0	139	0	0	0	0	0	0	365	0	502	0	188
2000	March	0	301	0	0	0	54	0	0	486	569	977	44	0
2000	April	1188	5889	0	0	0	4729	4250	2795	2077	1652	1668	602	1845
2000	May	0	0	0	7323	0	1000	0	0	0	0	0	0	0
2000	June	131	0	0	17324	0	3033	2805	0	0	155	43	0	431
2000	July	167	0	0	14551	0	4619	1352	0	652	1044	1575	280	1785
2000	August	0	194	0	2251	0	9220	258	0	298	354	859	605	83
2000	September	446	772	0	37617	0	5806	6183	288	2227	2276	1859	1109	1519
2000	October	7045	24913	105	14320	0	34836	2713	199	1834	2088	1405	516	945
2000	November	0	145	0	0	0	9139	28	88	0	0	0	0	0
2000	December	0	0	0	325	2055	3106	139	74	0	0	24	0	0
2001	January	0	194	0	0	5818	576	275	0	0	0	0	0	0
2001	February	0	0	0	0	0	464	156	0	0	0	243	0	0
2001	March	3171	5216	0	815	113	800	312	0	215	381	318	404	0
2001	April	637	731	0	647	1079	725	30	0	0	0	53	53	0
2001	May	145	0	0	3973	7450	0	35	0	0	0	0	0	0
2001	June	7587	16150	0	14781	37179	0	1158	0	0	0	218	218	332
2001	July	39414	64004	0	30518	29237	14710	1806	0	337	669	970	622	1834
2001	August	39523	75964	0	29150	4596	38422	2638	10001	1635	2536	1755	428	3989
2001	September	46477	48219	0	22721	0	34680	7699	4100	2320	1867	1163	1156	3475
Total		**148899**	**271802**	**105**	**196316**	**87526**	**165917**	**31836**	**25891**	**19835**	**18365**	**22205**	**8045**	**20481**

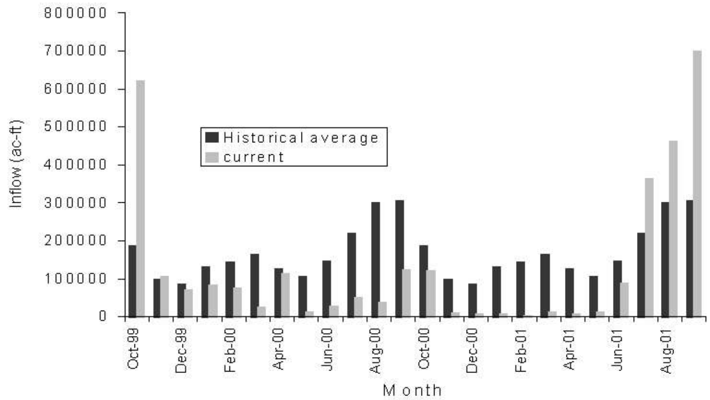

Figure 2-31. Comparison of historical average and current Lake Okeechobee monthly inflows

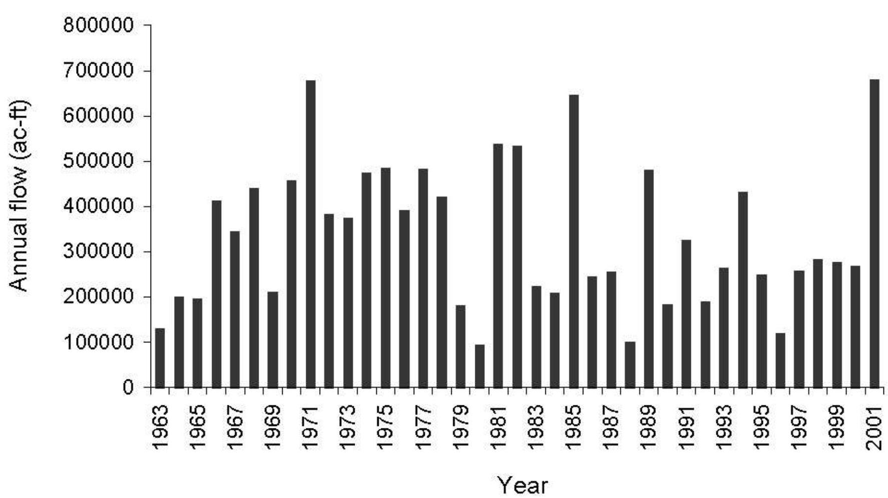

Figure 2-32. Annual backflow to Lake Okeechobee through pumping and gravity (nine months for 2001)

Outflows are mainly through the south, southeast, and southwest structures. The average historical (1972 to 2001) annual outflow was 1,282,000 ac-ft, with a standard deviation of 838,000 ac-ft; maximum annual outflow was 3,771,000 ac-ft during the 1995 El Niño, and minimum was 314,115 ac-ft in 1991. Monthly mean historical inflows and outflows are depicted in **Figure 2-30**. Comparison of monthly Lake Okeechobee outflows to the historical average is shown in **Figure 2-33**. A significant portion of the discharge during the managed lake recession is shown in May 2000 flows. For the period from October 1999 to September 2001, 16 months of outflows from the lake were below the historical average. **Table 2-3** shows a breakdown of monthly outflows to the east through S-308 (18 percent); to the north through G-207 and G-208 (2 percent); to the west through S-77 (39 percent), and to the south through the EAA structures (41 percent). When the lake stage reached 10.1 ft NGVD, temporary forward pumps were activated at the S-351, S-352, and S-354 structures to discharge water to the south (**Table 2-3**). The pumps were operated irregularly from March 28, 2001 to July 3, 2001, for a total discharge of 92,904 ac-ft.

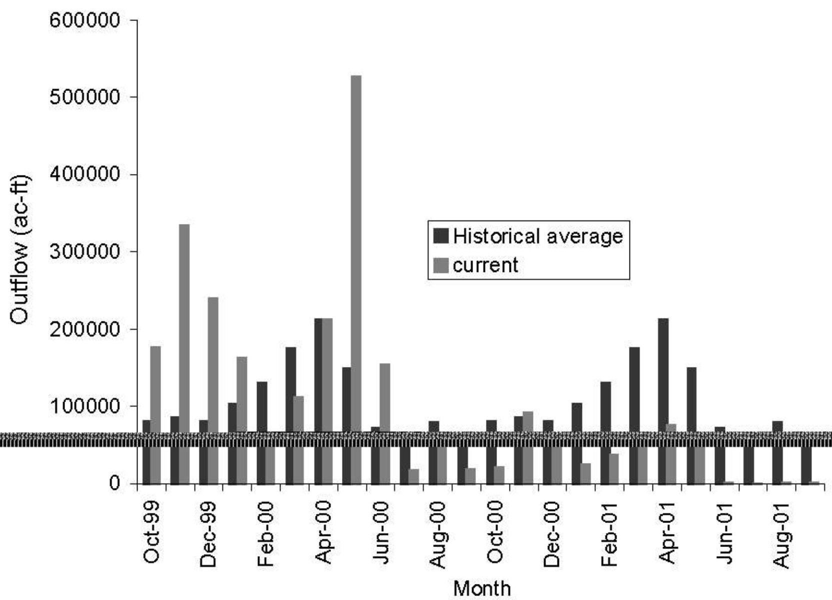

Figure 2-33. Comparison of historical average and current Lake Okeechobee monthly outflows

INFLOWS AND OUTFLOWS FOR STORMWATER TREATMENT AREAS

In general, monthly inflows and outflows to Stormwater Treatment Areas (STAs), located in the Everglades Agricultural Area (EAA), were reduced due to the drought. Monthly inflow and outflow at STA-1W, STA-5 and STA-6 are shown, respectively, in **Figures 2-34**, **2-35**, and **2-36**. The monthly summary of flow through each structure is shown in **Tables 2A-2-1**, **2A-2-2**, and **2A-2-3**. Efforts were made to prevent treatment cell dry-out at STA-1W and STA-5. During the most severe period of the drought, December 2000 through May 2001, both STA-5 and STA-6 dried out. This was typical during the dry season for STA-6, but a temporary pump was located at STA-5 to keep Cell 1-B wet to help maintain the submerged aquatic vegetation (SAV) that had been introduced into the cell after STA start-up in 1999-2000. STA-1W received 295,162 ac-ft of inflow from October 1999 through September 2001, and 321,344 ac-ft were discharged during the same period. Inflow to STA-5 was 166,701 ac-ft and outflow was 158,693 ac-ft. STA-6 received 89,079 ac-ft and discharged 64,877 ac-ft of water during the same 24-month period. All the STAs began to receive significant inflow beginning in June and July 2001, which aided in their recovery from the drought.

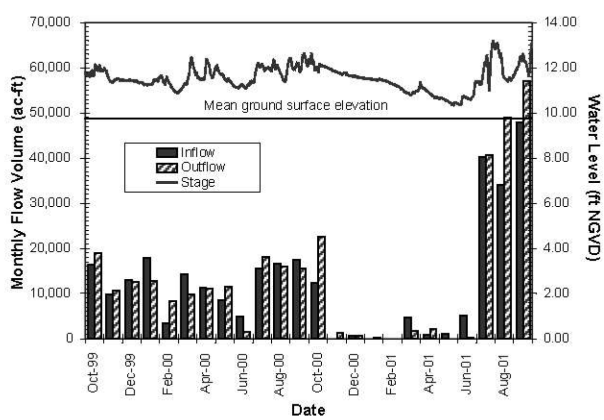

Figure 2-34. STA-1W inflow, outflow, and water level

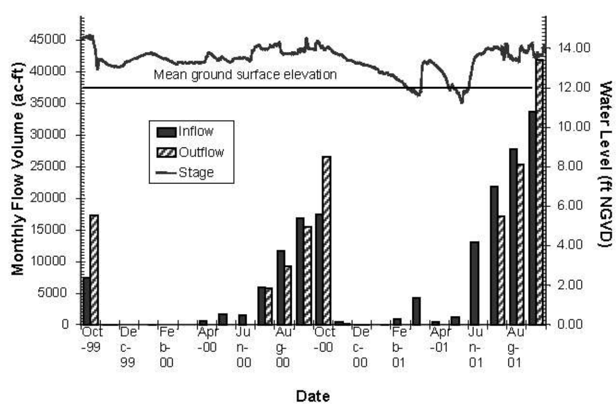

Figure 2-35. STA-5 inflow, outflow, and water level

INFLOWS AND OUTFLOWS TO THE WATER CONSERVATION AREAS

Inflows to the Loxahatchee National Wildlife Refuge (Water Conservation Area 1), WCA 2, and WCA-3 began to decline beginning in October 1999 after the passage of Hurricane Irene. There was a brief recovery in April of 2000 and again in September and October 2000 as tropical weather systems brought increased rainfall. Significant inflows to all the WCAs began again in July 2001 and led to recovery of water levels in all the WCAs by the end of September 2001. The ability to release water from the WCAs for water supply purposes was severely restricted during 2001. Inflow and outflow volumes for Water Conservation Area 1 were 841,576 ac-ft and 885,941 ac-ft, respectively, for the period from October 1999 through September 2001. Inflow and outflow volumes for Water Conservation Area 2 were 915,197 ac-ft and 884,803 ac-ft, respectively, for the same period. Inflow and outflow volumes for Water Conservation Area 3 were 1,323,856 ac-ft and 1,706,935 ac-ft, respectively, for the same period. **Figures 2-37**, **2-38**, and **2-39** show the monthly inflow and outflow volumes for each WCA. Monthly summary of flow through each structure is shown in **Tables 2A-2-4**, **2A-2-5**, and **2A-2-6**.

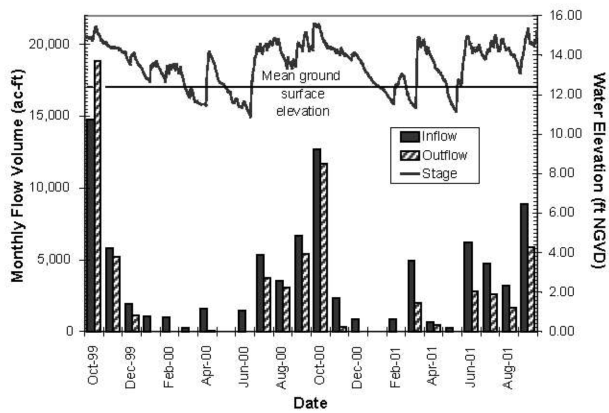

Figure 2-36. STA-6 inflow, outflow, and water level

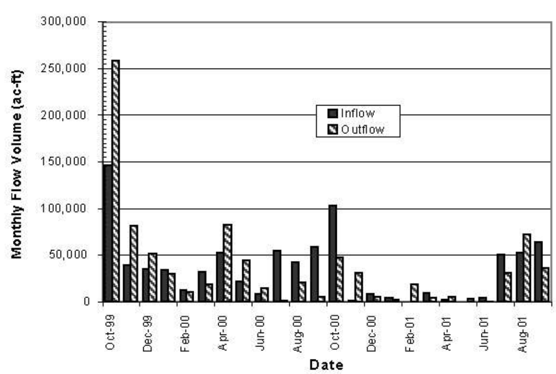

Figure 2-37. Loxahatchee National Wildlife Refuge (Water Conservation Area 1) inflow and outflow

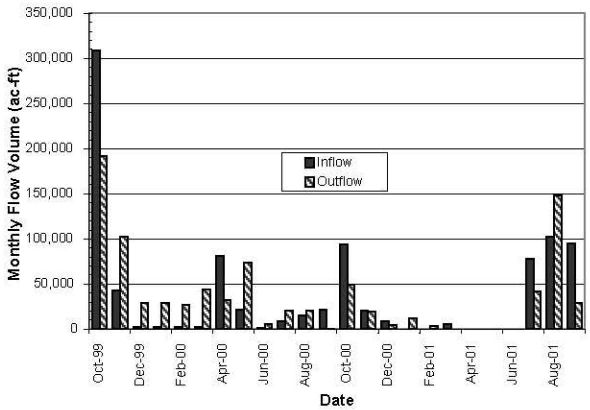

Figure 2-38. Water Conservation Area 2 inflow and outflow

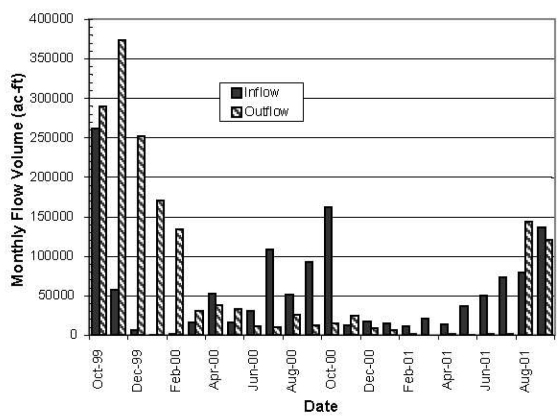

Figure 2-39. Water Conservation Area 3 inflow and outflow

COASTAL OUTFLOWS

Monthly flow volumes at SFWMD coastal structures are summarized by service area in **Figure 2-40**. **Table 2-5** shows the total flow volume discharged to tide for the 24-month period. Two periods of high flow are shown, the first being associated with flow from Hurricane Irene, and the second, which affected the Miami-Dade area (Lower East Coast, Service Area 3), was caused by an un-named tropical depression. Releases to tide were negligible during the height of the drought in the first several months of 2001. A monthly summary of flow through each structure is shown in **Table 2A-2-7**.

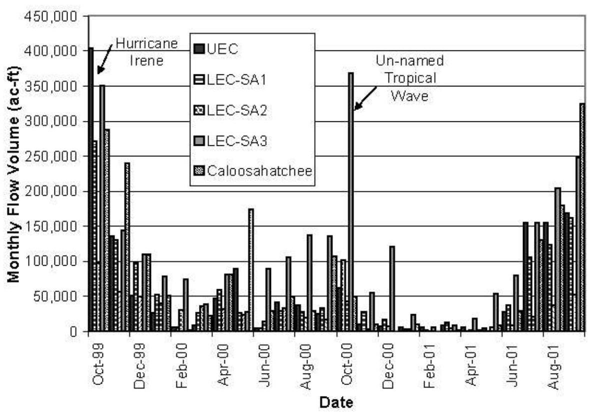

Figure 2-40. Monthly coastal outflow volumes by service area, 1999-2000

Area	Volume (ac-ft)
UEC	1,489,148
LEC-SA1	1,357,643
LEC-SA2	636,185
LEC-SA3	2,709,720
Caloosahtachee	1,924,825
Total	8,117,521

Table 2-5. Coastal structure monthly outflow volume, 1999-2001

INFLOWS TO THE EVERGLADES NATIONAL PARK

Figure 2-41 depicts monthly inflow volumes to Everglades National Park (ENP) from October 1999 to September 2001. The monthly flow pattern corresponds to flows in Water Conservation Area 3. Inflow was minimal from January 2001 through June 2001 and increased starting in August 2001. Total inflow for the 24-month period was 2,555,198 ac-ft. Monthly summary of flow through each structure is shown in **Table 2A-2-8**.

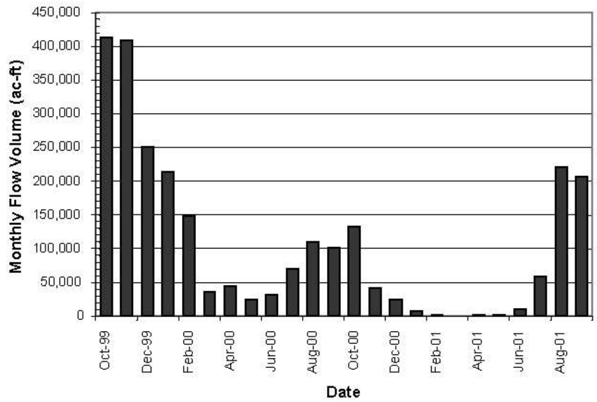

Figure 2-41. Everglades National Park inflow

DYNAMICS IN SYSTEM STORAGE AND HYDROLOGIC SUMMARY

System storage was reported daily. The main components of storage in the SFWMD system are Lake Okeechobee and Water Conservation Areas 1, 2, and 3. Total available system storage for Lake Okeechobee peaked in November 1999 and began to recede through June 2001 to exceptionally low levels due to releases and evaporation losses. As the system approached zero gravitationally available storage in May 2001, temporary forward pumps were placed at the S-351, S-352, and S-354 structures for water supply. The forward pumping effectively added approximately 684,000 ac-ft of potential available storage, although a smaller volume was pumped out. Starting in June 2001 the system began a rapid recovery to near-average seasonal levels by the end of September 2001. **Figure 2-42** shows the trend in available storage for Lake Okeechobee from October 1999 to September 2001.

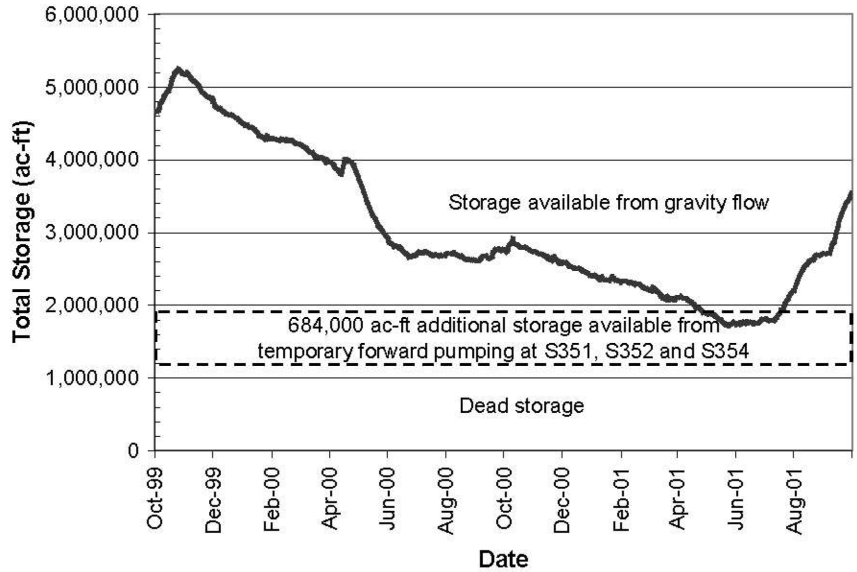

Figure 2-42. Lake Okeechobee available storage, October 1999 to September

WATER LEVELS

Water levels in lakes and reservoirs are gauges for drought and water shortage conditions. The major lakes and water holding areas (impoundments) in the South Florida Water Management District are Lake Okeechobee, Lake Istokpoga, Lake Kissimmee, Lake Myrtle, Alligator Lake, Lake Gentry, Lake Mary Jane, East Lake Tohopekaliga, Lake Tohopekaliga, and water conservation areas 1, 2, and 3. Water level data for Lake Okeechobee are available since 1931. **Figure 2-43** shows daily water levels for Lake Okeechobee, and reported drought years are marked. The minimum lake level for the period of record of 8.97 ft NGVD was reached on May 24, 2001. The maximum water level of 18.77 ft NGVD was achieved on November 2, 1947. The lake's water level was at or below 11 ft NGVD for 3 percent of days since 1931. **Figure 2-44** shows the number of consecutive days the lake was below 11.0 ft NGVD; the longest, 194 days, was achieved in 2001.

The consecutive number of days the lake stage has been below 11.00 ft NGVD matches the drought years. The mean lake stage and standard deviation at the beginning of each month are shown in **Figure 2-45**. A stage decline of two standard deviations from the mean can be taken as a measure of the criticality of Lake Okeechobee's storage decline. Also, the number of days below a given stage (e.g., 11 ft NGVD) can be used as a measure of the criticality of Lake Okeechobee's storage decline.

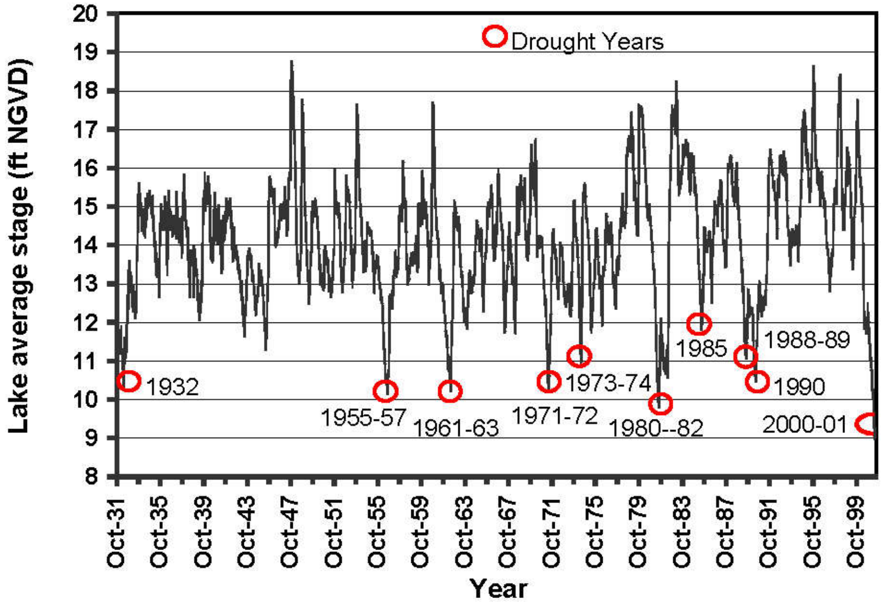

Figure 2-43. Average daily water level for Lake Okeechobee

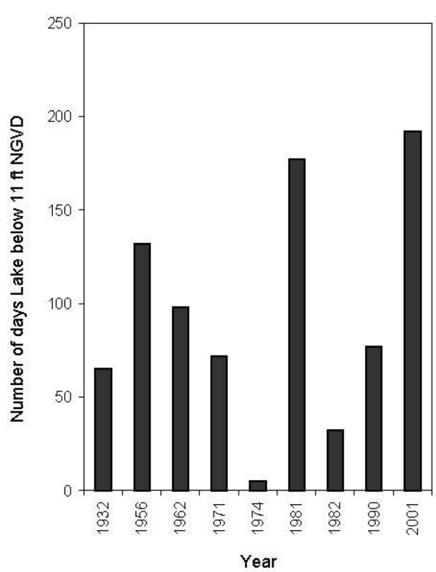

Figure 2-44. Number of days Lake Okeechobee water level was below 11 ft NGVD

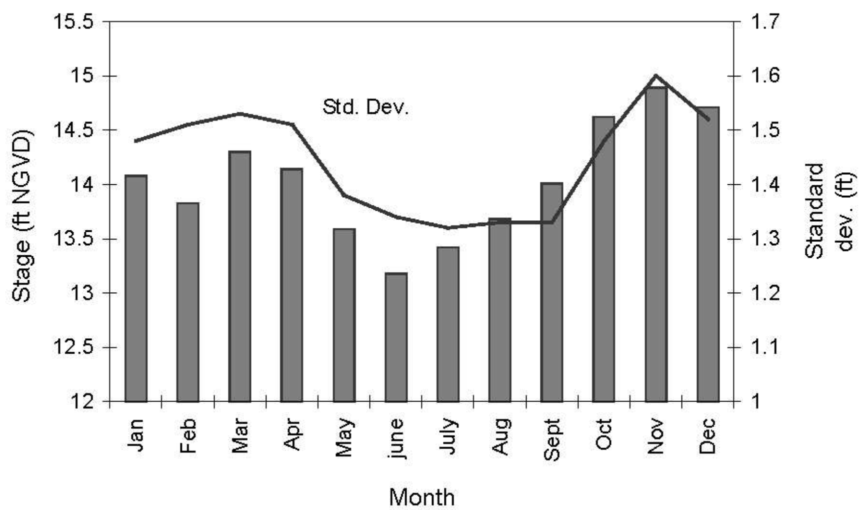

Figure 2-45. Mean lake water level and standard deviation for Lake Okeechobee at the beginning of each month

Lake Okeechobee's daily water level and evaporation losses are shown in **Figure 2-46**. The lake's water level declined from 16.53 NGVD on October 1, 1999 to 8.97 ft NGVD on May 24, 2001. The total decline was 7.56 ft. The evaporation loss for Lake Okeechobee for the period from October 1, 1999 to September 30, 2001 was 9.06 ft. Decreased inflow and rainfall increase in discharge and evaporation correspond to the lake's stage decline. Increased inflow from the north, backflow to the lake, and reduced discharge from the lake correspond to a gain in stage.

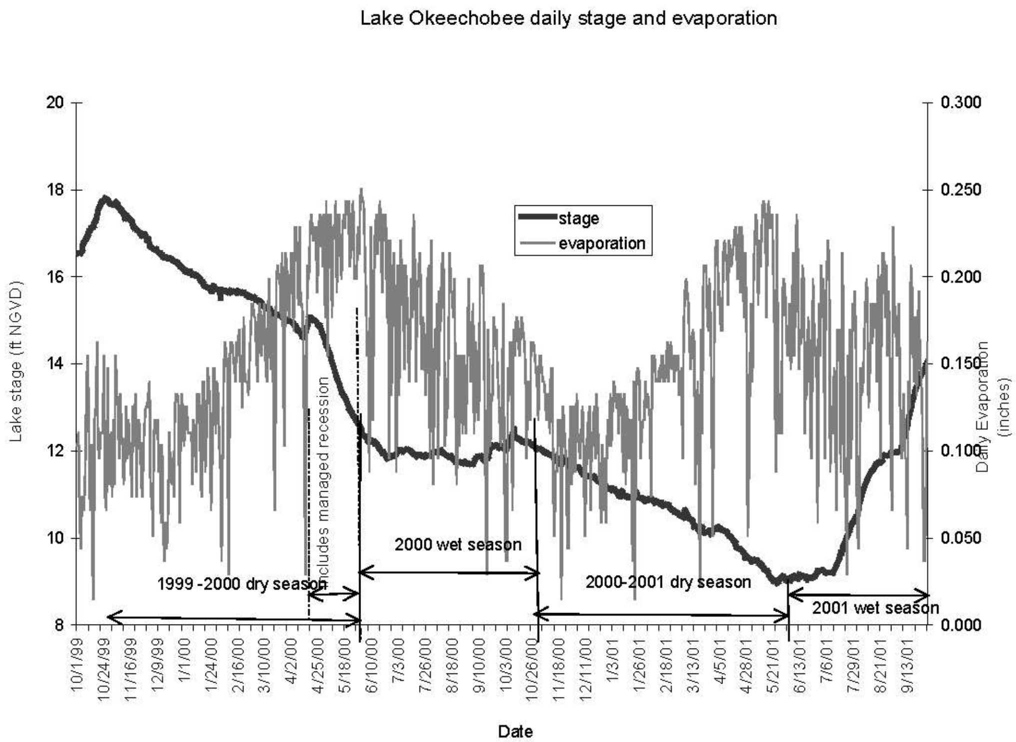

Figure 2-46. Lake Okeechobee daily water level and evaporation

Historical daily average water levels for Lake Kissimmee and Lake Istokpoga are shown in **Figures 2A-1-15** and **2A-1-16**. Lake Kissimmee, with an area of 35,520 acres, has been regulated by the S-65 structure since 1964 with in a little more than three feet fluctuation. Lake Kissimmee attained a maximum daily average water level of 56.64 ft NGVD on October 12, 1953 and a minimum of 42.87 ft NGVD on May 25, 1977. The historical average lake level is 50.38 ft NGVD. Lake Istokpoga, with an area of 28,160 acres, has been regulated by the S-68 structure since the early 1960s within three feet of fluctuation. Lake Istokpoga attained a maximum daily average water level of 42.9 ft NGVD on September 17, 1945 and a minimum of 35.4 ft NGVD on May 29, 1962. The historical average lake level is 38.59 ft NGVD. **Figure 2-47** depicts water level fluctuations of Lake Kissimmee and Lake Istokpoga from October 1, 1999 to September 30, 2001. Lake Kissimmee fluctuated between 52.57 and 48.28 ft NGVD, with the minimum level occurring on April 29, 2001. Lake Istokpoga fluctuated between 39.55 and 35.88 ft NGVD, with the minimum occurring on June 19, 2001.

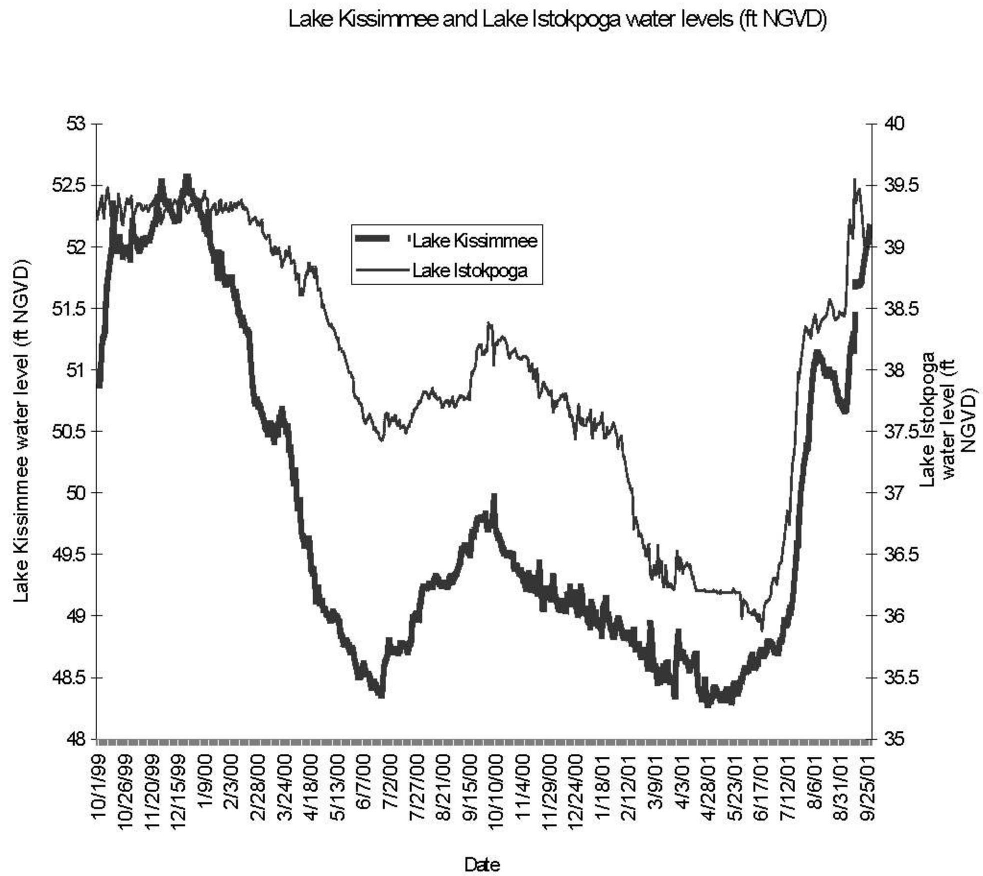

Figure 2-47. Lake Kissimmee and Lake Istokpoga daily water levels

The Water Conservation Areas are shallow impoundments, with a total area of approximately 736,640 acres. Water Conservation Area 1 (Loxahatchee National Wildlife Refuge) is 140,800 acres in area, with a daily average water level of 15.55 ft NGVD. The maximum daily average water level of 18.19 ft NGVD was attained on October 16, 1999, and the minimum level of 10 ft NGVD was reached on June 1, 1962. Average depth is 15.5 ft. Water Conservation Area 2A is 105,408 acres in area, with an average water level of 12.59 ft NGVD. The maximum water level of 15.64 ft NGVD was attained on November 18, 1969 and the minimum level of 9.33 ft NGVD was reached on April 29, 1989 during a drought year. Water Conservation Area 3A is 491,072 acres in area, with an average water level of 9.46 ft NGVD. The maximum water level of 12.79 ft NGVD was attained on January 22, 1995 during an El Niño year, and the minimum level of 4.78 ft NGVD was reached on June 19, 1962 during a drought year. Historical daily water levels for the water conservation areas are shown in **Figures 2A-1-17**, **2A-1-18**, and **2A-1-19**. Daily water level fluctuations for the three water conservation areas during the current drought period are shown in **Figure 2-48**.

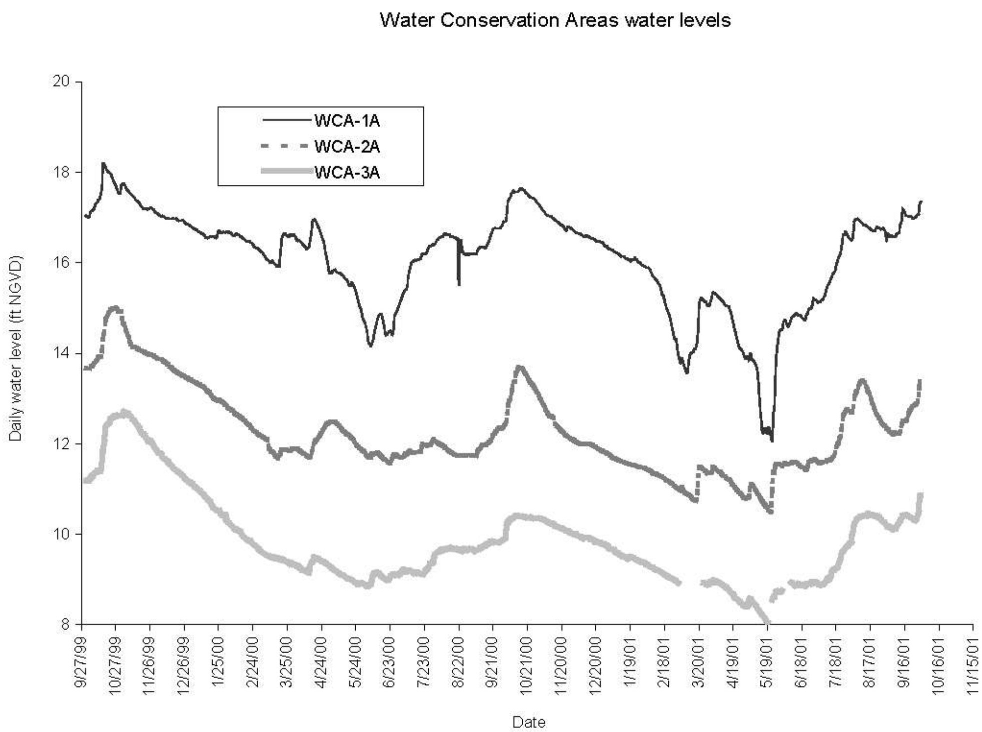

Figure 2-48. Water Conservation Areas' daily water levels

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Chapter 3: Groundwater Responses to the Drought

Simon Sunderland

SUMMARY

This section provides a summary of groundwater levels in key aquifers around the District between October 1, 1999 and September 30, 2001. A District hydrogeologist reviewed water level data from a network of 81 real-time monitoring wells on a weekly basis during this period. **Figure 3-1** shows the layout of the real-time monitoring well network. This network was set up and is currently monitored under a cooperative agreement with the United States Geological Survey (USGS), Miami sub-district.

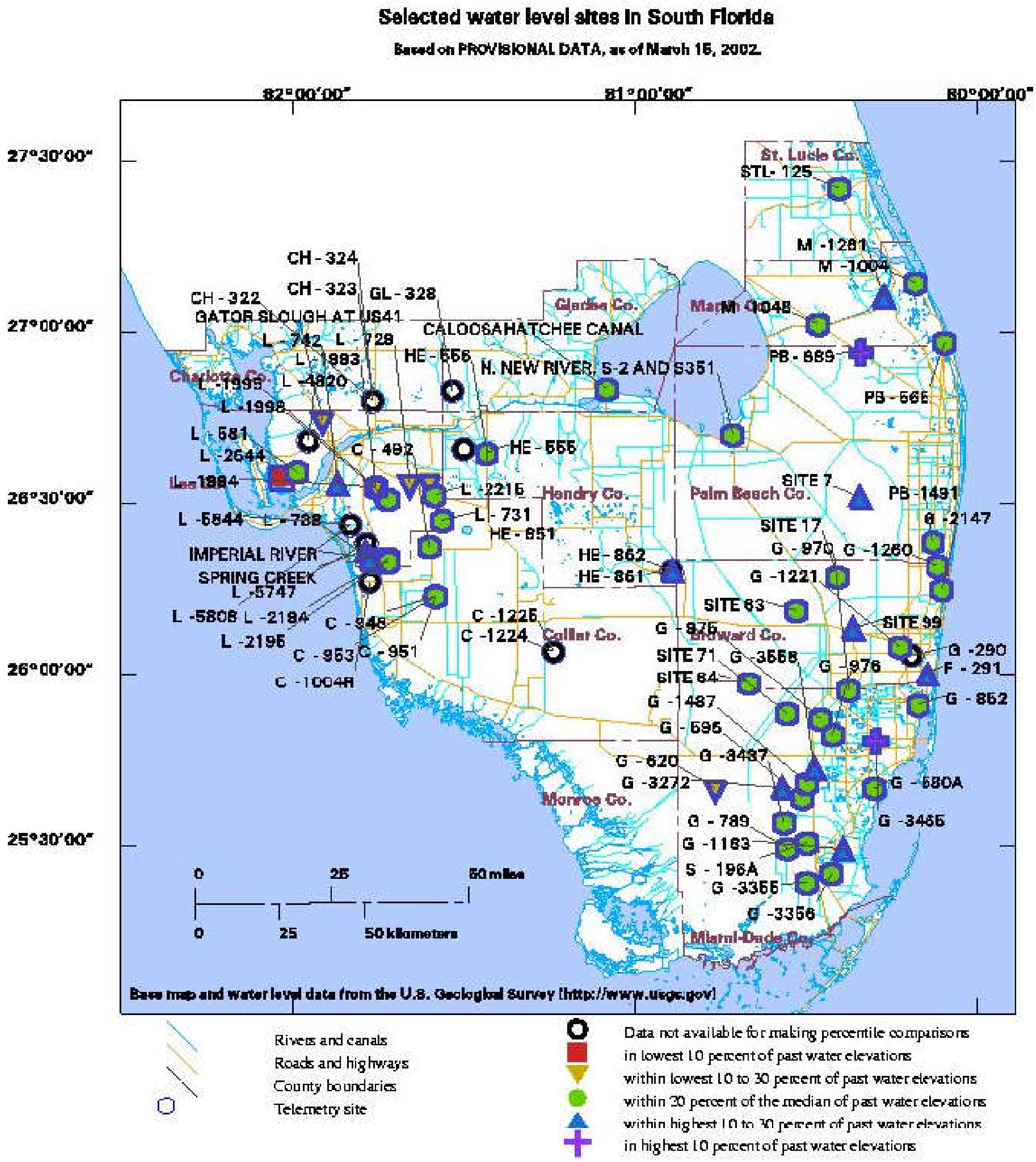

Figure 3-1. USGS real-time monitoring well network

This report contains several hydrographs that show water level trends in various aquifers around the District between October 1, 1999 and September 30, 2001. The hydrographs for monitoring wells in the Lower East Coast and Lower West Coast planning areas show water level trends and water levels estimated by statistical analysis. Data for these hydrographs were obtained from the USGS Statistical Overview of Selected USGS Water Level Monitoring Sites website. The hydrographs show the daily maximum water level elevation, as well as several statistical trends. The lowest colored line on each graph represents the first percentile of data, and represents a value below which only one percent of water level values for the well occurred. The line above that is the tenth percentile, below which ten percent of water levels occurred. Sequentially, above the tenth percentile are lines for the 30th percentile, median, 70th, 90th, and 99th percentiles, respectively, below which 30, 50, 70, 90, and 99 percent of water level values occurred. The 50th percentile represents an estimate of the mean water level for the well.

The average water level change per month in each aquifer around the District is shown in **Table 3-1**. This table indicates the average water level change in one month in each aquifer from November 2000 to September 2001.

Table 3-1. Average monthly water level changes by aquifer

Changes by Aquifer	Nov 00	Dec 00	Jan 01	Feb 01	Mar 01	Apr 01	May 01	Jun 01	Jul 01	Aug 01	Sep 01
LEC											
Biscayne in Broward	0.91	.03	0.60	0.68	.59	0.78	.06	0.16	.82	1.27	0.85
Biscayne in Dade	0.44	.13	0.48	0.53	0.39	1.06	.85	.15	.37	0.17	0.24
LWC											
Surficial	0.90	0.39	0.53	0.23	0.05	0.99	.04	.03	.58	0.90	0.51
Lower Tamiami	.47	.80	0.26	1.47	0.17	6.19	.46	.12	.21	1.37	1.17
Mid-Hawthorn	4.26	.82	.57	0.40	.40	.04	1.13	.65	.00	.24	2.96
Sandstone	4.01	3.48	.14	3.61	.71	5.99	.43	.11	.42	1.03	1.51
UEC											
Surficial	0.80	0.28	0.30	0.31	0.33	0.74	.13	.64	.67	0.67	0.59
Kissimmee Basin											
Floridan								.78	.64	0.56	2.59
Palm Beach County											
Surficial	1.00	.14	0.39	0.86	.74	0.92	0.12	.50	.73	1.60	1.05

KISSIMMEE BASIN

During the drought, the District reviewed only groundwater levels in the Floridan Aquifer in the Upper Kissimmee Basin in Orange County. This area was of interest to the District because it is adjacent to the city of Orlando, which is a major water user of the Floridan Aquifer. Land use in the Southern Kissimmee Basin is primarily agricultural, and water use demands are not as significant as those from the municipalities in the northern part of the region. Also, the District/USGS real-time monitoring well network does not extend into the southern portion of the Kissimmee Basin. Because of this, no water level data was available.

Upper Floridan Aquifer

The upper Floridan Aquifer in the Upper Kissimmee Basin consists of a thick series of carbonate rocks. Permeability in the aquifer is a result of fractures or solution cavities in the limestone that yield large quantities of water to wells (Shaw and Trost, 1984). The aquifer is the main source of potable water for the region.

Water level data for the upper Floridan Aquifer in this region were sparse because a substantial real-time monitoring-well network is not in place. Data retrieved from the USGS National Water Information System (NWIS) database does not yield continuous data, but rather monthly averaged values. Data between October 1, 1999 and September 30, 2001 was plotted on a hydrograph and is depicted in **Figure 3-2**. A District hydrogeologist calculated the average water level by month and included this trend on the hydrograph. The purpose of depicting the monthly average was to indicate how the drought affected the water level in the upper Floridan Aquifer relative to the normal water level in the aquifer. The location of the well used to show water level trends in the aquifer is shown in **Figure 3.3**.

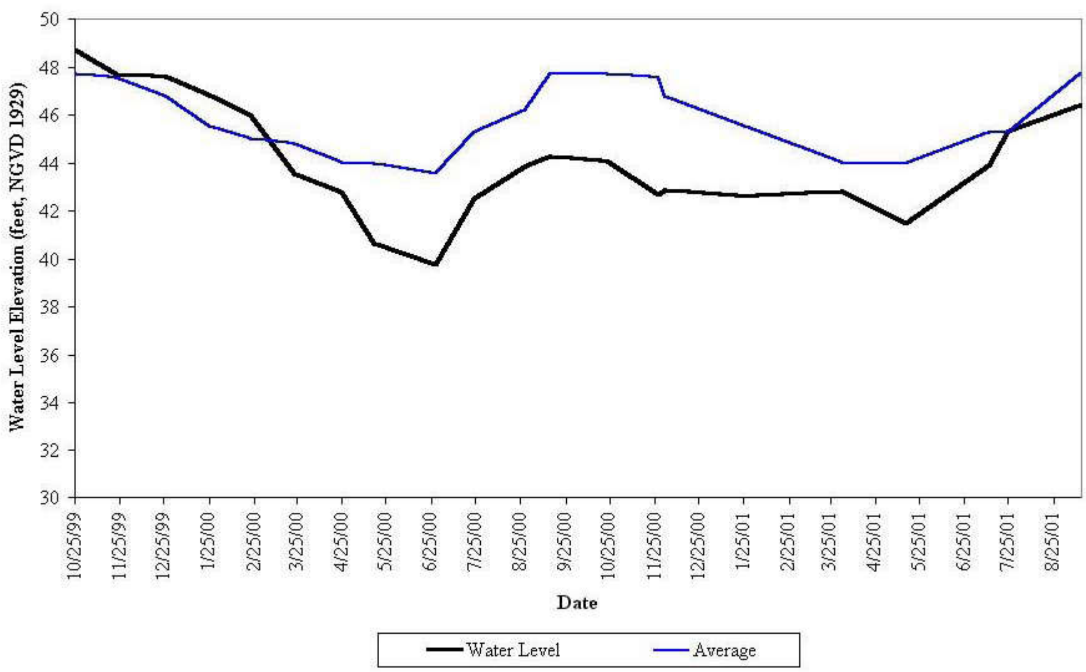

Figure 3-2. Hydrograph for the Boggy Creek Floridan Aquifer monitoring well, October 1, 1999 to September 30, 2001

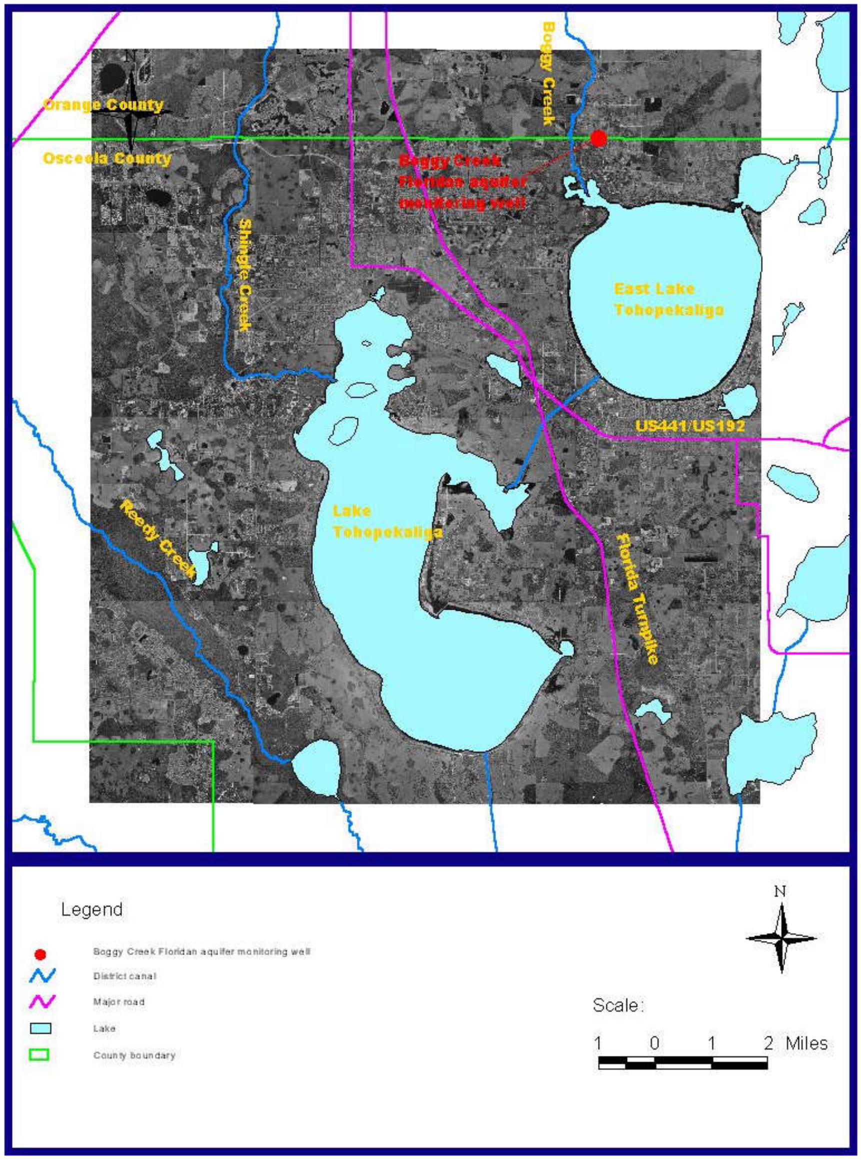

Figure 3-3. Location of the Boggy Creek Floridan Aquifer monitoring well

During the drought, the water level in the upper Floridan Aquifer dropped below its average level in mid-March 2000 and remained there through September 30, 2001. The water level in the aquifer briefly approached its normal level in late July 2001, but dropped below thereafter.

UPPER EAST COAST PLANNING AREA

Surficial Aquifer System

The Surficial Aquifer System (SAS) in the Upper East Coast (UEC) Planning Area is a shallow, unconfined aquifer. The SAS consists of unconsolidated fine-to-medium quartz sand, with inter-bedded layers of limestone, sandstone, shells, and clay. It is the sole source of potable water in the area (Lukasiewicz and Switanek, 1995). Between October 1, 1999 and September 30, 2001, water level trends in the aquifer were based on four real-time monitoring wells in the area (**Figure 3-1**).

During the drought, there were two distinct periods of low water levels in the SAS. One period occurred from early December 1999 through the end of October 2000. The other occurred between early November 2000 and early August 2001. Since the SAS is unconfined, it is principally recharged by rainfall. These periods of low groundwater levels occurred during periods of below-normal rainfall. **Figures 3-4** and **3-5** are hydrographs for monitoring wells STL-125 (St. Lucie County) and M-1004 (Martin County), respectively. In **Figure 3-5**, water level fluctuations during the drought are not as dramatic as those in **Figure 3-4** (STL-125). This phenomenon can be explained by the aquifer's lower permeability in the vicinity of M-1004. These wells are presented in this report because they are the best representatives of the aquifer's water level trends that resulted from the drought that occurred between October 1, 1999 and September 30, 2001.

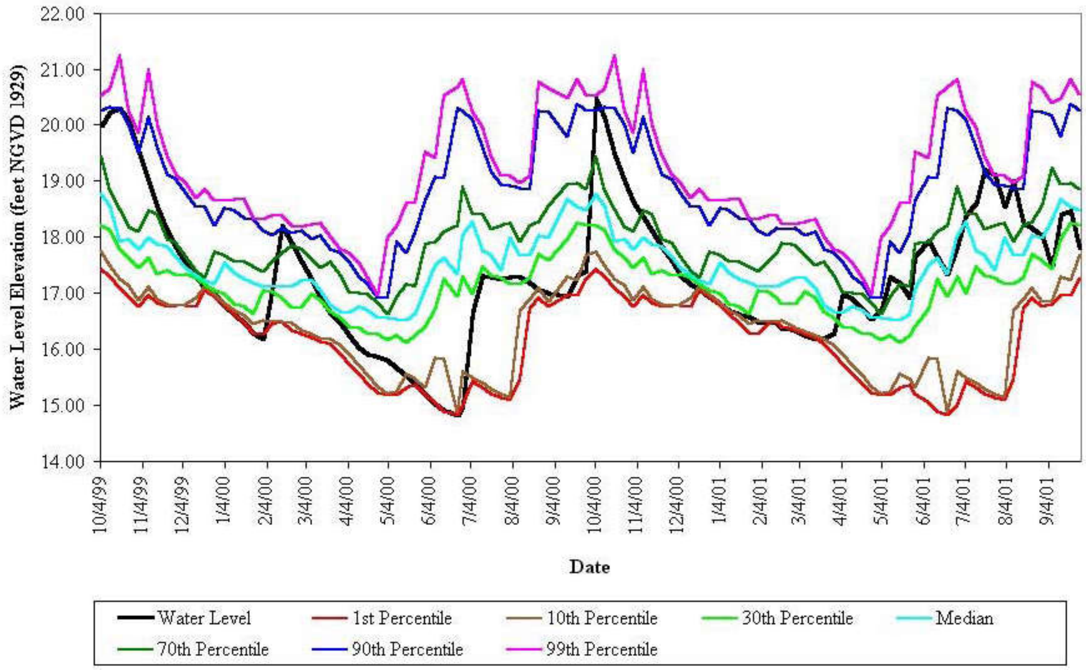

Figure 3-4. Hydrograph for STL-125 Surficial Aquifer monitoring well, October 1, 1999 to September 30, 2001

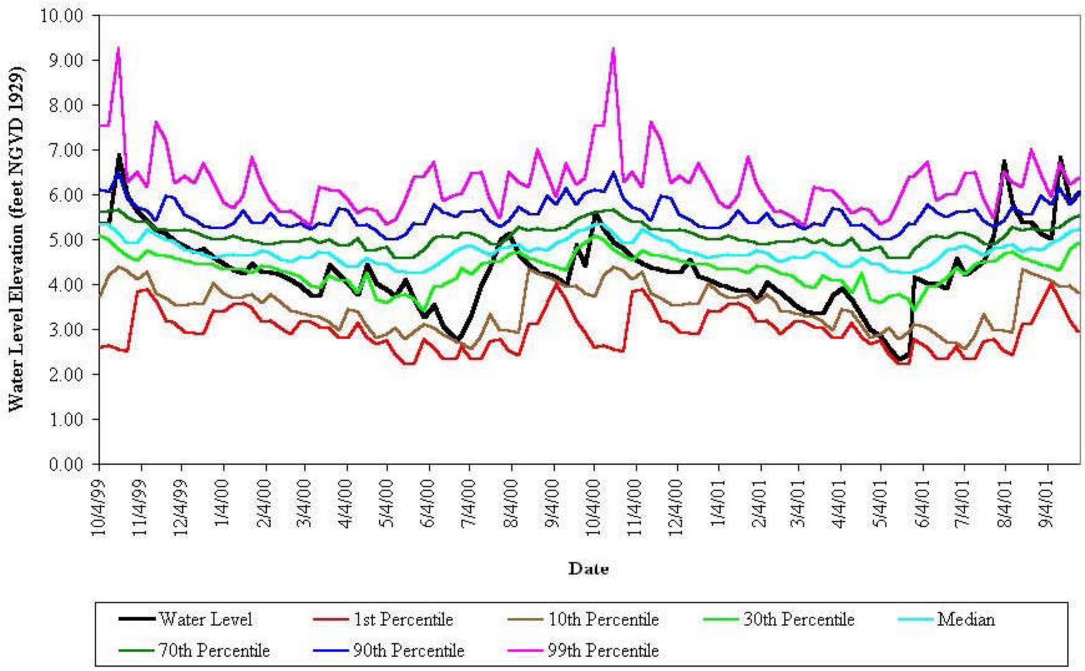

Figure 3-5. Hydrograph for M-1004 Surficial Aquifer monitoring well, October 1, 1999 to September 30, 2001

The first period of low groundwater levels began after Hurricane Irene passed over southern Florida October 14 through 16, 1999. The eastern part of the South Florida peninsula received between 10 and 20 inches of rain from Hurricane Irene. However, from mid-October 1999 to mid-April 2000, precipitation in the UEC was below normally recorded levels. As a result, the water level in the SAS dropped below its normal level from January 2000 to early April 2000 to within the lowest 10-to-30 percentile of recorded water level values (**figures 3-4** and **3-5**). A brief period of rainfall in April 2000 recharged the SAS, and the water level in the aquifer remained above its normal level until early May 2000. Again, from early May 2000 until early October 2000 the UEC received minimal rainfall and the water level in the aquifer dropped to within the lowest 1-to-10 percentile of recorded values for this period. Between October 3 and 4, 2000, a tropical depression (later named Tropical Storm Leslie) passed over the Florida peninsula, dumping 12-to-18 inches of rain along Florida's East Coast. This precipitation recharged the SAS, and water levels rose above normal levels.

The second decline in groundwater levels began in late November 2000, when the water level in the aquifer again dropped below normal. This low water level period lasted from late November 2000 to August 1, 2001. However, during this second period there were three-to-four periods of rainfall after early April 2001 that helped recharge the SAS. These periods of rainfall raised the water in the aquifer to above its normal level in the northern part of the UEC and to slightly below its normal level in the southern part of the region. Rainfall from Tropical Storm

Barry (August 1 through 4, 2001) and Tropical Storm Gabrielle (September 11 through 14, 2001) ended the drought, as water levels in the SAS rose above their normally recorded levels.

LOWER EAST COAST PLANNING AREA

Surficial Aquifer in Palm Beach County

The Surficial Aquifer in Palm Beach County is a shallow, unconfined aquifer consisting of unconsolidated quartz sand, limestone, sandstone, and shells (coquina). It is the principal source of potable water in the area (Shine et al., 1989). Between October 1, 1999 and September 30, 2001, water level trends in the aquifer were gauged from three real-time monitoring wells in the area (**Figure 3-1**).

From October 1, 1999 to September 30, 2001, water levels in the aquifer remained below the normal level during two periods. One period of low groundwater levels occurred from early December 1999 through the end of October 2000. The other period of low groundwater levels occurred between early November 2000 and early August 2001. Since the Surficial Aquifer is unconfined, it is principally recharged by rainfall. These periods of low groundwater levels occurred during periods of below-normal rainfall. **Figure 3-6** shows the water level elevation trend in monitoring well PB-565 in northern Palm Beach County during the drought. This well is depicted in this report because it best represents the water level trends in the aquifer during the drought that occurred between October 1, 1999 and September 30, 2001.

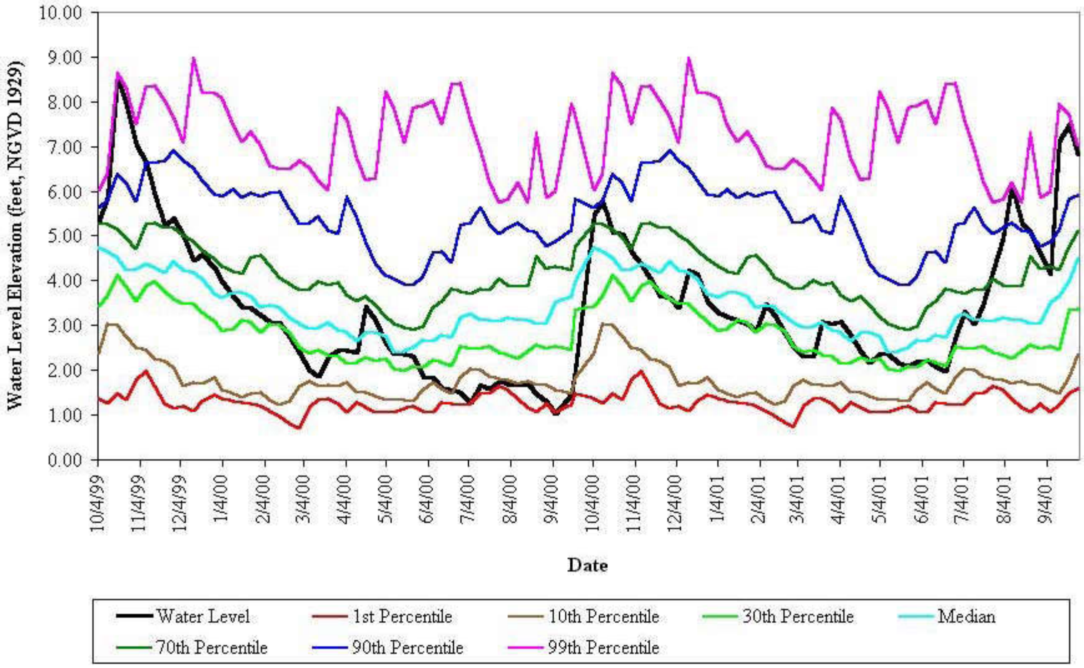

Figure 3-6. Hydrograph for PB-565 Surficial Aquifer monitoring well, October 1, 1999 to September 30, 2001

The first period of low groundwater levels began after Hurricane Irene passed over South Florida, October 14 through 16, 1999. From mid-October 1999 to mid-April 2000, precipitation in Palm Beach County was below normally recorded levels. As a result, the water level in the aquifer dropped to within the lowest 10-to-30 percentile of recorded values from January 2000 to early-April 2000 (**Figure 3-6**). A brief period of rainfall in April 2000 recharged the Surficial Aquifer, and the aquifer's water level remained above normal until early May 2000. Again, from early May 2000 until early October 2000, Palm Beach County received minimal rainfall and the water level in the aquifer dropped to within the lowest 1-to-10 percentile of recorded values for this period. Between October 3 and 4, 2000, a tropical depression (later named Tropical Storm Leslie) passed over the Florida peninsula, dropping substantial rainfall along the Southeast Coast. This precipitation recharged the Surficial Aquifer, and water levels rose above normal. The rainfall from this tropical depression effectively ended the 2000–2001drought's first phase.

The second phase of the decline began in late November 2000, when the aquifer's water level again dropped below normal. This second phase lasted from late November 2000 to August 1, 2001. However, during this second phase the decline in water levels was less precipitous, as there were three-to-four periods of rainfall between these dates that recharged the Surficial Aquifer. These periods of rainfall temporarily raised the aquifer's water level to above normal. Rainfall from Tropical Storm Barry (August 1 through 4, 2001) and Tropical Storm Gabrielle (September 11 through 14, 2001) ended the drought, as the water level in the Surficial Aquifer in Palm Beach County rose to within the highest one percentile of recorded levels.

Biscayne Aquifer, Miami-Dade, and Broward Counties

The Biscayne Aquifer is a shallow, unconfined aquifer consisting of highly permeable limestone and less-permeable sandy limestone and sand (Causaras, 1985 and 1987). The aquifer, which extends from southern Palm Beach County to Miami-Dade County, is generally more sandy to the north and east and contains more limestone and sandy limestone to the south and west. It is the principal source of potable water in the area (Shine et al., 1989). The aquifer is recharged when rainfall and water from numerous surface water bodies penetrate it. During dry periods, water stored in the Water Conservation Areas is released into District canals and used to maintain groundwater levels in the Biscayne Aquifer. The aquifer's high permeability allows rapid recharge from canal water (Randazzo and Jones, 1997) and from rainfall. Between October 1, 1999 and September 30, 2001, water level trends in the aquifer were gauged from 21 real-time monitoring wells in the area (**Figure 3-1**).

The water level in the Biscayne Aquifer exhibited different trends in different areas during the drought. In northern Broward County, the water level exhibited a similar trend as the SAS in Palm Beach County. There were two periods during which water levels dropped below normal. One period of low groundwater levels occurred from late December 1999 through the end of September 2000. The other occurred between early November 2000 and early August 2001. **Figure 3-6** is a hydrograph for monitoring well G-1260, located in northern Broward County.

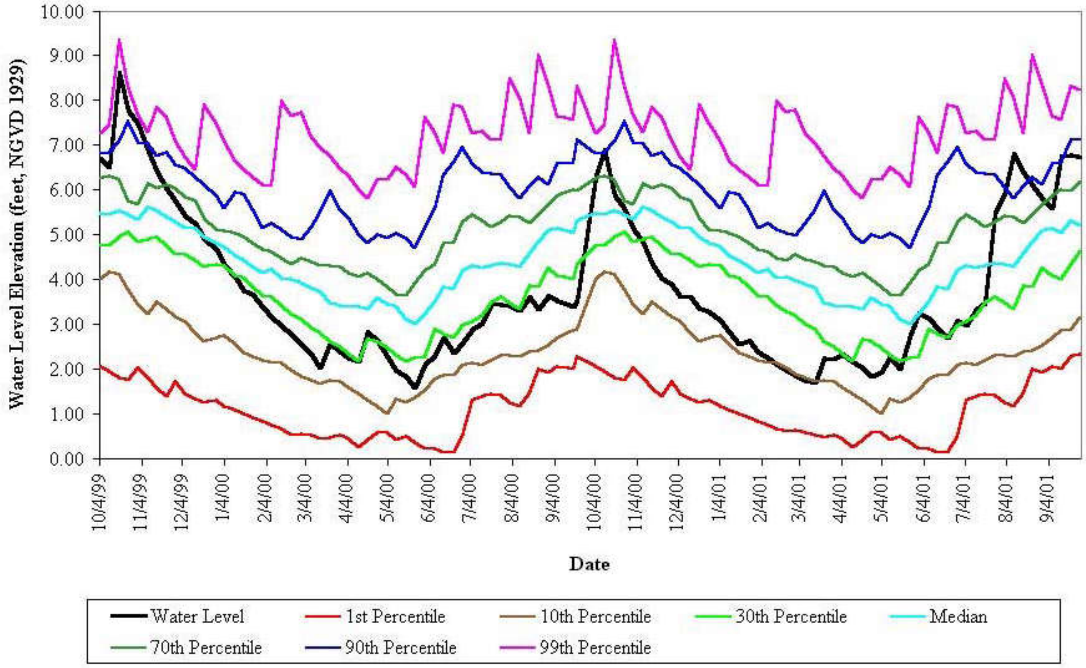

Figure 3-7. Hydrograph for the G-1260 Biscayne Aquifer monitoring well, October 1, 1999 to September 30, 2001

In northern Miami-Dade County, the water level in the Biscayne Aquifer had one extended period (mid-November 1999 to mid-March 2000) and several shorter periods when water levels were below normal. **Figure 3-8** is a hydrograph for monitoring well F-291, located in northern Miami-Dade County. There were also several peaks when the water level in the aquifer was significantly above normal. These high levels probably correspond to a recharge event due to rainfall or inflow from District canals.

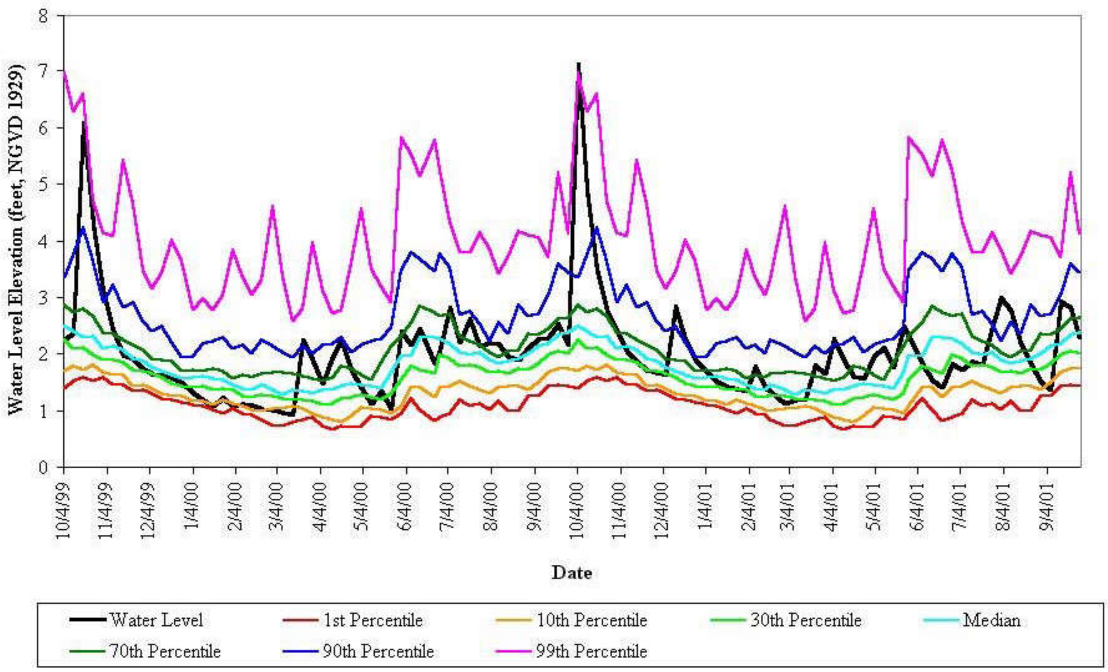

Figure 3-8. Hydrograph for F-291 Biscayne Aquifer monitoring well, October 1, 1999 to September 30, 2001

The water level in the Biscayne Aquifer, in southern Miami-Dade County near the coast, generally remained at or above the normal level through the 2000–2001 drought. **Figure 3-9** is a hydrograph for monitoring well G-1183, located in southern Miami-Dade County near a canal structure. However, inland around Homestead and Florida City, water levels were periodically at the lowest 1-to-10 percentile of historical levels, specifically during 2001. The low water levels in 2001 in south Miami-Dade County resulted from below-normal rainfall and lack of recharge from canals. When the water level in Lake Okeechobee dropped to critical levels, discharges into the District's canal system that supplies water to Miami-Dade County were reduced. The combination of below-normal rainfall and less recharge from surface water resulted in very little recharge to the Biscayne Aquifer and below-normal water levels. The hydrograph for monitoring well G-1183 (**Figure 3-9**) near a canal structure exemplifies that the water level in the aquifer remained fairly constant throughout the drought. This may indicate that the potential for saltwater intrusion was low during this time, as the head level in the canal behind the structure was near its normal level.

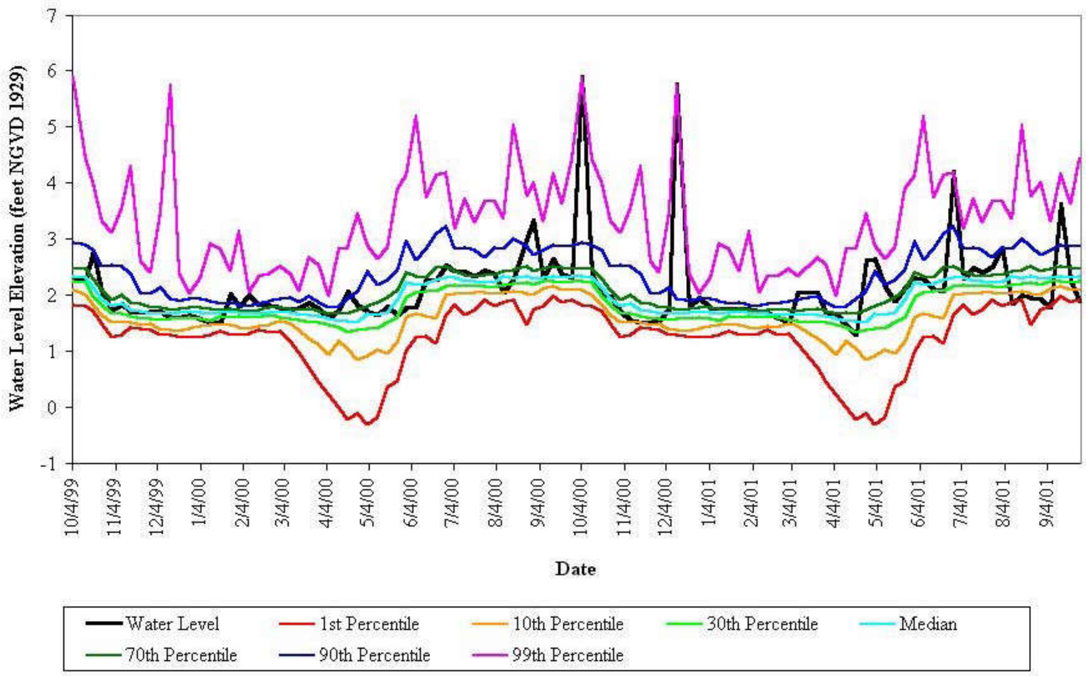

Figure 3-9. Hydrograph for G-1183 Biscayne Aquifer monitoring well, October 1, 1999 to September 30, 2001

LOWER WEST COAST PLANNING AREA

The four aquifers in the Lower West Coast (LWC) Planning Area are combined into two aquifer systems: the Surficial Aquifer System (SAS), consisting of the Surficial and Lower Tamiami aquifers; and the Intermediate Aquifer System (IAS), consisting of the Sandstone and Mid-Hawthorn aquifers. The IAS is the main source of potable water in the LWC (Randazzo and Jones, 1997). The sections below describe the water level trends in these aquifers between October 1, 1999 and September 30, 2001.

Surficial Aquifer

The Surficial Aquifer is the upper-most aquifer of the SAS. It is a shallow, unconfined aquifer consisting of undifferentiated deposits. The primary use of groundwater from this aquifer is agricultural irrigation.

During the drought, there were two distinct periods of low water levels in the Surficial Aquifer. One period occurred from early January 2000 through early August 2000. The other occurred between mid-October 2000 and early-August 2001. Since the Surficial Aquifer is unconfined, it is principally recharged by rainfall. These periods of low groundwater levels occurred during periods of below-normal rainfall. **Figure 3-10** shows the water level elevation trend in monitoring well C-492 (Collier County) during the drought. This well is shown in this report because it best represents the water level trends in the aquifer between October 1, 1999 and September 30, 2001.

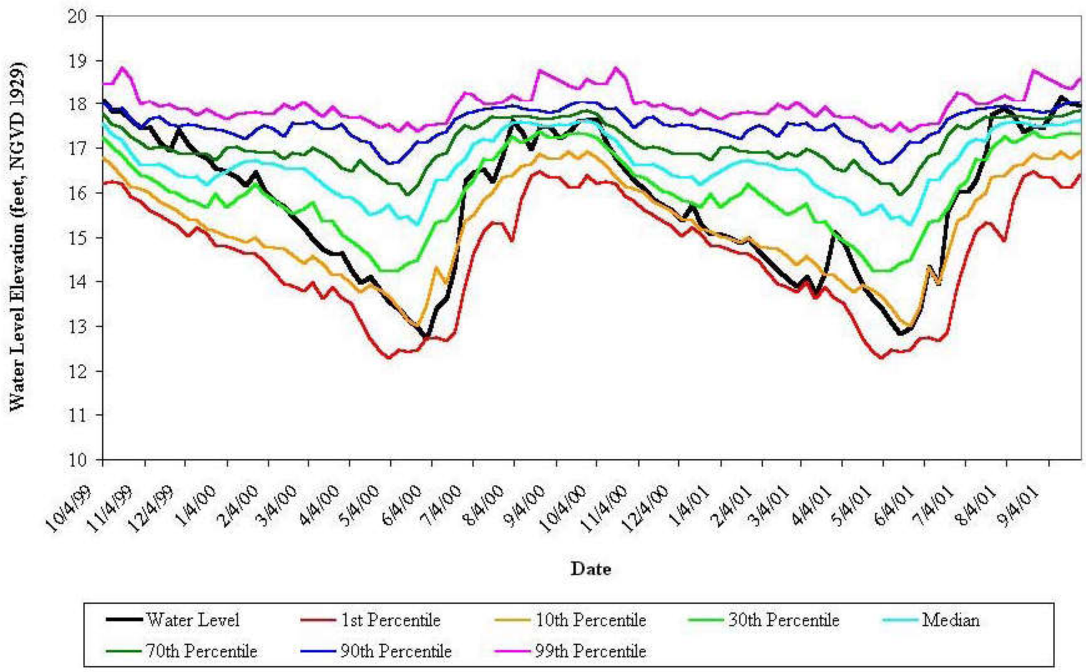

Figure 3-10. Hydrograph for C-492 Surficial Aquifer monitoring well, October 1, 1999 to September 30, 2001

The first period of low groundwater levels began after Hurricane Irene passed over South Florida, October 14 through 16, 1999. However, from mid-October 1999 to mid-April 2000, precipitation in the LWC was below normally recorded levels. As a result, the water level in the Surficial Aquifer dropped below normal to within the lowest 10th percentile of recorded water levels. From mid-July 2000 until early October 2000, the LWC received rainfall and the water level in the aquifer rose to near its normal level. Rainfall between October 3 and 4, 2000 from a tropical depression (later named Tropical Storm Leslie) recharged the Surficial Aquifer, and its water level rose to normal.

The second period of the decline began in mid-October 2000, when the water level in the aquifer again dropped below normal. This period lasted until August 1, 2001, when precipitation from Tropical Storm Barry recharged the aquifer and brought the water level above normal. Rainfall from Tropical Storm Barry (August 1 through 4, 2001), and later from Tropical Storm Gabrielle (September 11 through 14, 2001), ended the drought, as the water level in the Surficial Aquifer rose above its normally recorded level.

Lower Tamiami Aquifer

The Lower Tamiami Aquifer is the lower-most aquifer of the SAS. It is semi-confined to confined and consists of sandy, shelly limestone, and calcareous sandstone (Wedderburn et al., 1982). This aquifer supplies water to municipalities, domestic self-suppliers, and is also used for agricultural irrigation.

Between October 1, 1999 and September 30, 2001 there were two distinct periods of declining water levels in the Lower Tamiami Aquifer. However, the only extended period of time when the water level in the aquifer was below normal was between mid-November 1999 and mid-April 2000. There were other, shorter periods during the drought when water levels were below the normal level for the aquifer. However, these periods lasted no more than two months. Since the Lower Tamiami Aquifer is semi-confined, it is principally recharged from the overlying Surficial Aquifer. Low groundwater levels in the aquifer occurred during periods of below-normal rainfall. The below-normal rainfall meant that the overlying Surficial Aquifer was not being recharged and therefore could not recharge the Lower Tamiami Aquifer. **Figure 3-11** depicts the water level elevation trend in monitoring well L-738 (Lee County). This well is depicted because it best represents the water level trends in the aquifer during the drought that occurred between October 1, 1999 and September 30, 2001.

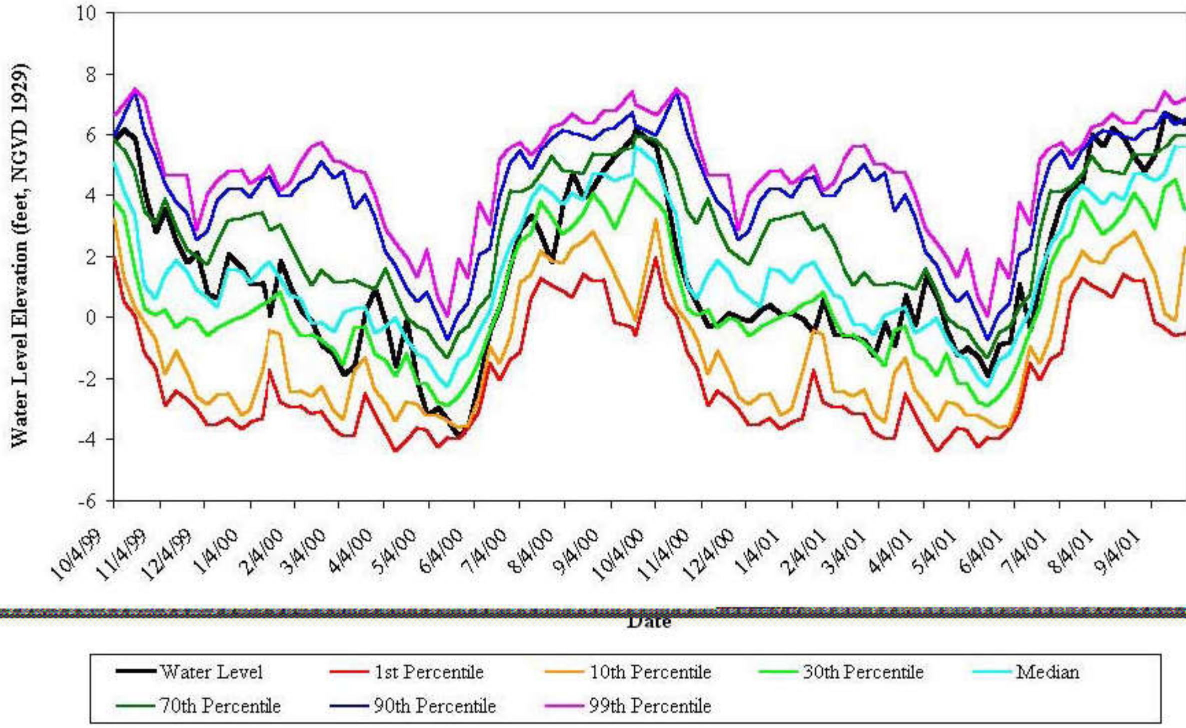

Figure 3-11. Hydrograph for L-738 Lower Tamiami Aquifer monitoring well, October 1, 1999 to September 30, 2001

After Hurricane Irene passed over South Florida, the water level in the Lower Tamiami Aquifer began to decline. The water level in the aquifer periodically dropped below normal for a brief period of time in both February and March 2000. Several peaks on the hydrograph for monitoring well L-738 (**Figure 3-11**) during this time indicate recharge to the aquifer. These recharge events raised the water level in the Lower Tamiami above normal levels. From early May to early July 2000, the water level in the Lower Tamiami Aquifer dropped to within the lowest 1-to-10 percentile of recorded water levels for the aquifer. The aquifer's water level began to rise in early July and was at its normal level by early August 2000. There was another brief period in mid-to-late August 2000, when the water level in the aquifer dipped below normal. Wet-season rainfall and precipitation from a tropical depression (later named Tropical Storm Leslie) in early October recharged the Lower Tamiami Aquifer, and the water level rose above normal.

In late October 2000, the water level in the Lower Tamiami Aquifer underwent a precipitous drop to within the lowest 10-to-30 percentile of recorded water levels by mid-November 2000. This period of below-normal water levels lasted until mid-April 2001, when, after several rainfall events, the water level in the aquifer returned to normal. It remained at normal levels until rainfall from Tropical Storm Barry (August 1 through 4, 2001) and Tropical Storm Gabrielle (September 11 through 14, 2001) ended the drought and raised the water level in the Lower Tamiami Aquifer significantly above normal.

Sandstone Aquifer

The Sandstone Aquifer is the upper-most aquifer of the IAS. It is a confined aquifer and is separated from the overlying SAS by a confining layer of green/gray clay. The Sandstone Aquifer is composed of sandy limestones, sandstones, sandy dolomites, and calcareous sands (Wedderburn et al., 1982). The aquifer's productivity is highly variable. Nonetheless, it manages to supply groundwater to utilities and for irrigation (Wedderburn et al., 1982).

From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the Sandstone Aquifer. One period occurred from early January through mid-August 2000. The other occurred between early November 2000 and mid-June 2001. Since the Sandstone Aquifer is confined, it is recharged by the overlying aquifers. The low groundwater levels in the aquifer occurred during periods of below-normal rainfall, when the overlying aquifers were not being recharged and, therefore, could not recharge the Sandstone. **Figure 3-12** is a hydrograph for monitoring well HE-556 in Hendry County. This well is presented in this report because it best represents the drought's effect on the Sandstone Aquifer's water level.

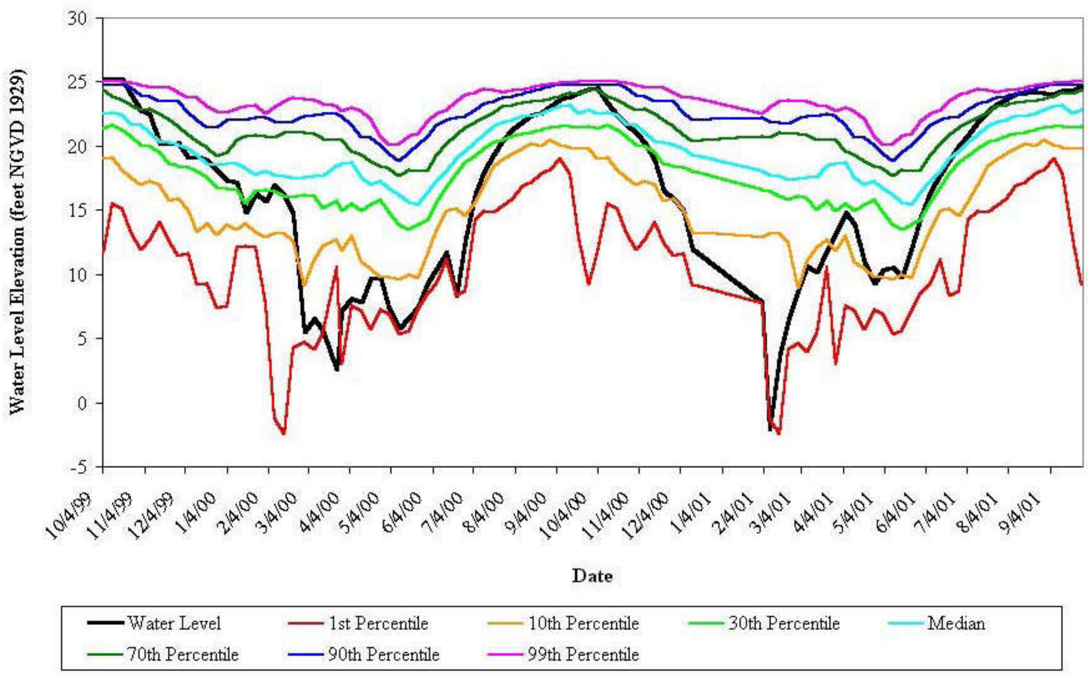

Figure 3-12. Hydrograph for HE-556 Sandstone Aquifer monitoring well, October 1, 1999 to September 30, 2001

After receiving significant recharge from Hurricane Irene, the water level in the Sandstone Aquifer began to drop as the District entered a period of below-normal rainfall in late October 1999. By early January 2000 the water level in the Sandstone Aquifer had dropped below normal, and it underwent a precipitous drop in late February/early March 2000 to within 1-to-10 percentile of its lowest level. It remained there until early July, when it began to rise. By early August the aquifer's water level was back above normal. Rainfall from a tropical depression (later named Tropical Storm Leslie) in early October 2000 helped to significantly raise the aquifer's water level to above normal.

By mid October 2000 the water level in the Sandstone Aquifer again fell below normal as it underwent another precipitous drop. By early February 2001, the water level in the aquifer was at its lowest 1 percentile of recorded levels. When water restrictions went into effect, the water level in the aquifer rose to within its lowest 10-to-30 percentile of recorded values by mid-March 2001, showing the positive effects of the water restrictions. By mid-May 2001 the water level in the Sandstone Aquifer again rose due to recharge of the overlying aquifers from wet-season rainfall. In mid-June 2001 the water level in the aquifer was back above normal. Rainfall from tropical storms Barry and Gabrielle further recharged the overlying aquifers and raised the water level in the Sandstone Aquifer significantly above normal, effectively ending the drought.

Mid-Hawthorn Aquifer

The Mid-Hawthorn Aquifer is confined and is the lowermost aquifer of the IAS. It is separated from the overlying Sandstone Aquifer by a confining layer of clay. The Mid-Hawthorn Aquifer consists of limestone, dolomite, and sandstone and derives its permeability from intergranular and moldic porosity and fractures/solution openings (Wedderburn et al., 1982). The aquifer is not always productive and is also relatively thin (it rarely exceeds 80 feet in thickness), compared to other aquifers within the District (SFWMD, 2000). The aquifer extends to the south and east, where it terminates near the Lee-Hendry counties' line. The water quality in the aquifer is poor, as it yields mostly saline water in much of the LWC (SFWMD, 2000). Groundwater from the aquifer is used by private wells in areas where city water is not provided. It is also occasionally used for agricultural irrigation.

From October 1, 1999 to September 30, 2001, there were two distinct periods of low water levels in the Mid-Hawthorn Aquifer. The first period occurred from mid-February through mid-June 2000. The second occurred between early November 2000 and mid-July 2001. The periods of low groundwater levels in the aquifer occurred during periods of below-normal rainfall, meaning that the overlying aquifers were not being recharged and, therefore, could not recharge the Mid-Hawthorn Aquifer. **Figure 3-13** is a hydrograph for monitoring well L-2644 in Lee County. This well is presented in this report because it best represents the 2000-2001 drought's effects on the water level in the Mid-Hawthorn Aquifer.

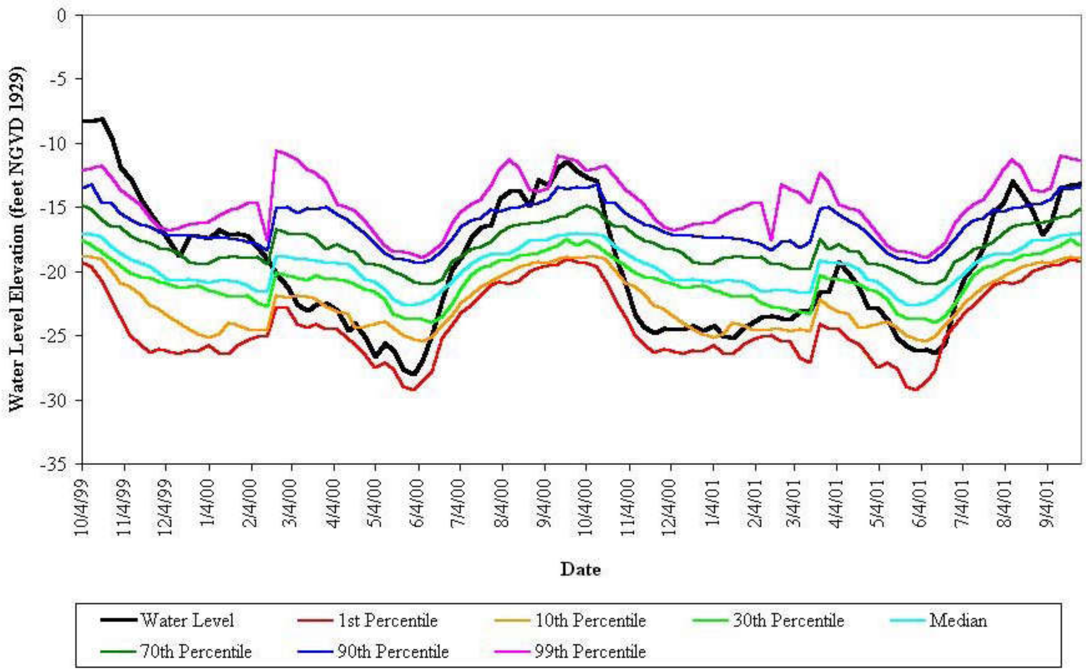

Figure 3-13. Hydrograph for L-2644 Mid-Hawthorn Aquifer monitoring well, October 1, 1999 to September 30, 2001

After receiving significant recharge from Hurricane Irene, the water level in the Mid-Hawthorn Aquifer started to drop in late October 1999, as the District entered a period of below-normal rainfall. By mid-February 2000 the aquifer's water level dropped to below normal and then steadily declined. By mid-March 2000 the water level had dropped to within 1-to-10 percentile of its lowest level, where it remained until early June 2000, when it began to rise. By late June, the water level in the aquifer was back above normal. Rainfall from a tropical depression (later named Tropical Storm Leslie) in early October 2000 significantly helped to raise the water level in the aquifer to above normal.

By late October 2000 the water level in the Mid-Hawthorn Aquifer was back below normal, as it underwent a precipitous drop. By early November 2000 it was at the lowest 1-to-10 percentile of its recorded levels. It remained there until early February 2001, when water restrictions went into effect. After the District imposed water restrictions, the water level in the aquifer rose and briefly returned to normal in early April 2001. However, by mid-June 2001 the water level in the Mid-Hawthorn Aquifer had declined to within the lowest 1 percentile of its recorded values. By early July 2001 the water level in the aquifer was back above normal, as wet-season rainfall recharged the overlying aquifers. Rainfall from tropical storms Barry and Gabrielle further recharged the overlying aquifers and raised the water level in the Mid-Hawthorn Aquifer significantly above its normal level, effectively ending the drought.

MONTHLY VOLUME OF PUMPED GROUNDWATER

From December 1999 to September 2001, nine counties reported the quantities of water withdrawn for water supply purposes from the aquifers described in the last section of this report. The average daily amount of water withdrawn per month in each county during this period is presented in **Table 3-2**.

Table 3-2. Average daily groundwater withdrawals, by county

County	Average Daily MGD Dec '99	Average Daily MGD Jan '00	Average Daily MGD Feb '00	Average Daily MGD Mar '00	Average Daily MGD Apr '00
Broward	135.63	142.38	151.94	150.10	144.34
Collier	53.23	55.80	59.12	58.33	55.82
Hendry	4.63	4.16	4.26	4.31	4.15
Lee	64.75	62.32	70.13	70.67	76.09
Miami-Dade	363.45	374.14	383.39	380.42	378.93
Monroe	16.02	17.19	18.07	18.78	18.09
Okeechobee	1.86	2.21	2.46	2.40	2.21
Orange	141.80	142.34	156.10	170.32	178.71
Palm Beach	199.08	203.53	216.66	223.52	218.12
Total	**980.45**	**1,004.06**	**1,062.13**	**1,078.86**	**1,076.46**

County	Average Daily MGD May '00	Average Daily MGD June '00	Average Daily MGD July '00	Average Daily MGD Aug '00	Average Daily MGD Sep '00
Broward	154.40	143.58	135.82	139.28	132.54
Collier	55.78	45.84	45.39	39.39	37.89
Hendry	3.44	3.67	3.44	3.79	3.67
Lee	77.16	52.19	44.07	46.27	46.37
Miami-Dade	396.52	376.32	371.04	375.38	373.65
Monroe	18.90	16.56	17.98	16.66	15.15
Okeechobee	2.47	2.07	1.97	1.97	2.02
Orange	207.59	199.12	168.21	163.27	155.93
Palm Beach	244.78	225.66	208.35	210.55	203.23
Total	**1,161.04**	**1,065.00**	**996.28**	**996.55**	**970.46**

County	Average Daily MGD Nov '00*	Average Daily MGD Jan '01	Average Daily MGD Feb '01	Average Daily MGD Mar '01	Average Daily MGD Apr '01
Broward	149.54	130.58	132.62	124.40	123.97
Collier	55.99	51.51	51.09	49.34	48.69
Hendry	3.59	3.34	3.61	3.54	3.41
Lee	74.96	65.14	66.97	61.21	59.99
Miami-Dade	387.11	343.14	351.59	341.85	350.68
Monroe	16.69	16.28	16.89	16.95	15.85
Okeechobee	2.38	2.30	2.29	2.22	2.08
Orange	170.33	139.57	137.70	137.94	154.97
Palm Beach	222.57	201.12	198.92	193.44	193.52
Total	**1,083.18**	**952.99**	**961.68**	**930.90**	**953.18**

*No data available for October 2000

County	Average Daily MGD May '01	Average Daily MGD June '01	Average Daily MGD Jul '01	Average Daily MGD Aug '01	Average Daily MGD Sep '01
Broward	119.93	116.23	115.01	125.93	114.13
Collier	49.38	45.18	38.41	41.96	39.78
Hendry	3.04	2.83	2.78	3.24	3.13
Lee	65.94	53.96	41.24	45.78	39.71
Miami Dade	346.04	353.45	348.00	355.02	340.10
Monroe	14.94	15.68	15.25	15.17	13.54
Okeechobee	2.00	1.83	2.03	1.86	1.86
Orange	158.40	143.08	140.68	139.91	132.25
Palm Beach	186.34	170.63	167.84	186.11	110.64
Total	**946.02**	**902.87**	**871.24**	**914.99**	**795.14**

The data in **Table 3-2** indicate that water restrictions imposed in 2001 were more effective in controlling groundwater withdrawals than those imposed in 2000. Generally, in 2000, the quantity of groundwater withdrawn during the drought was cyclical, i.e., it would decrease one month and increase the next. Throughout 2001, average daily groundwater withdrawals in each county decreased each month. The effects of the decrease are noticeable in the semi-confined to confined aquifers in the LWC. The hydrographs presented in the previous section for the Sandstone and Mid-Hawthorn aquifers show a slight increase in the water level in each aquifer after water restrictions went into effect and groundwater withdrawals were reduced.

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Chapter 4: Conclusions and Recommendations

Wossenu Abtew, R. Scott Huebner, and Simon Sunderland

CONCLUSIONS AND RECOMMENDATIONS

Droughts and water shortages have the potential to increase in severity and frequency as the demand for water increases in South Florida. A minimum of one severe drought every decade can be expected. Water management decision making should incorporate drought monitoring and recurrence probability. Rainfall deficit, Palmer Drought Severity Index, climatological forecasts, surface water and groundwater levels, and water demand parameters are essential to monitor. A system-wide approach is necessary to effectively deal with wildfire mitigation, drought, and water management.

Further, it is important to not only develop a drought monitoring system that will alert the public and others to the imminence of drought, but also to incorporate drought management as part of water supply planning and operational decision making. At the onset of a drought, the impact can be reduced by implementation of drought mitigation measures, specifically, increasing water supply, reducing water demand, and minimizing the drought’s impact (Rossi, 2000). Suggestions for increasing the water supply include relaxing minimum lake levels, developing new, or less-used, sources, and reusing water. Recommendations for reducing water demand include implementation of water use restrictions and education regarding water conservation methods and application. Suggestions for minimizing the impact of a drought include temporary re-allocation of water resources and the use of subsidies.

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APPENDIX 2A-1

Wossenu Abtew and R. Scott Huebner

SUMMARY

This appendix contains illustrations of historical annual rainfall, lake flows and water levels, and Water Conservation Areas' water levels.

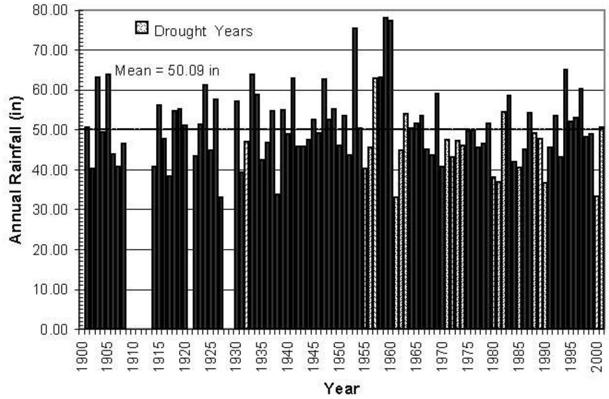

Figure 2A-1-1. Historical annual rainfall for Upper Kissimmee Rain Area and regional drought years

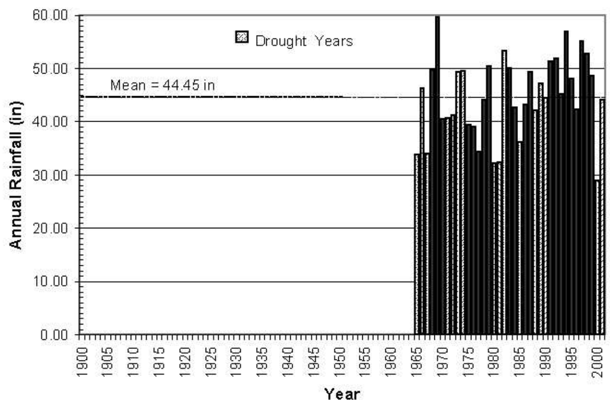

Figure 2A-1-2. Historical annual rainfall for Lower Kissimmee Rain Area and regional drought years

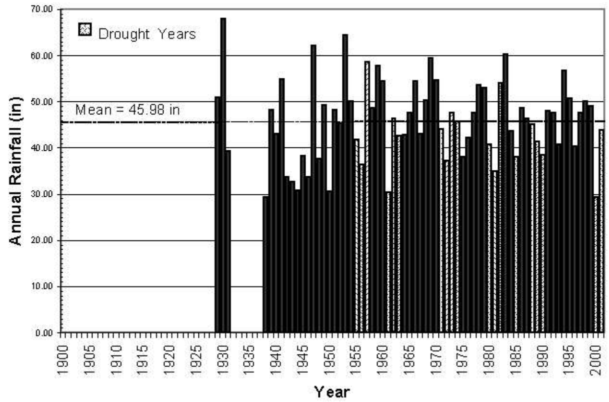

Figure 2A-1-3. Historical annual rainfall for Lake Okeechobee Rain Area and regional drought years

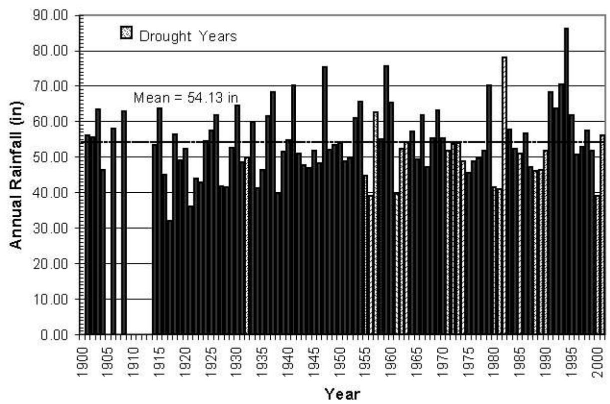

Figure 2A-1-4. Historical annual rainfall for Martin/St. Lucie Rain Area and regional drought years

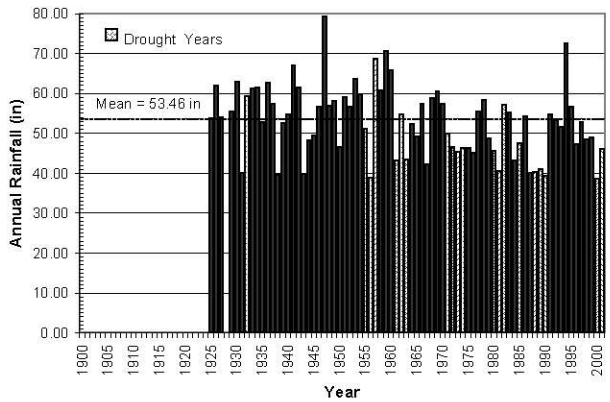

Figure 2A-1-5. Historical annual rainfall for East EAA Rain Area and regional drought years

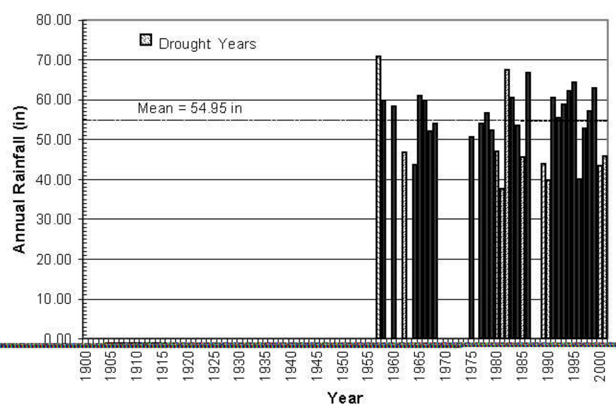

Figure 2A-1-6. Historical annual rainfall for West Ag. Rain Area and regional drought years

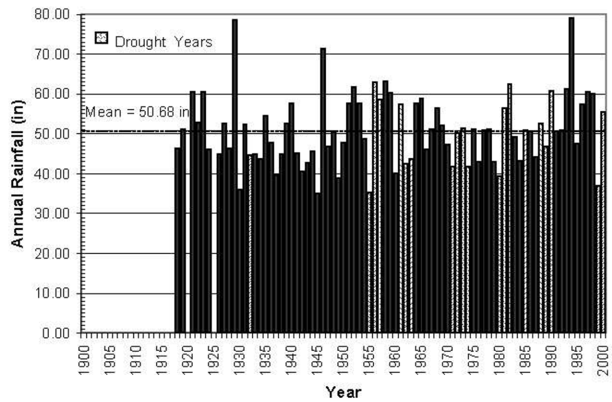

Figure 2A-1-7. Historical annual rainfall for East Caloosahatchee Rain Area and regional drought years

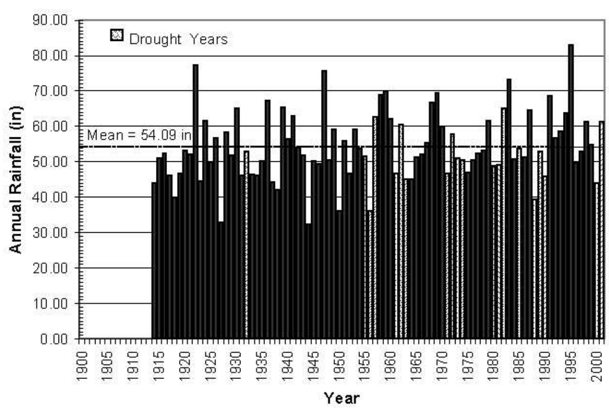

Figure 2A-1-8. Historical annual rainfall for Southwest Coast Rain Area and regional drought years

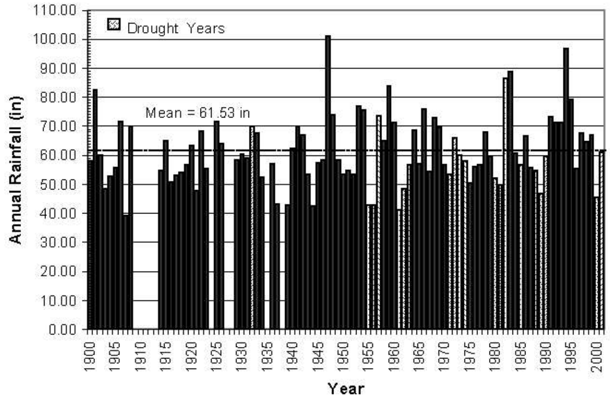

Figure 2A-1-9. Historical annual rainfall for Palm Beach Rain Area and regional drought years

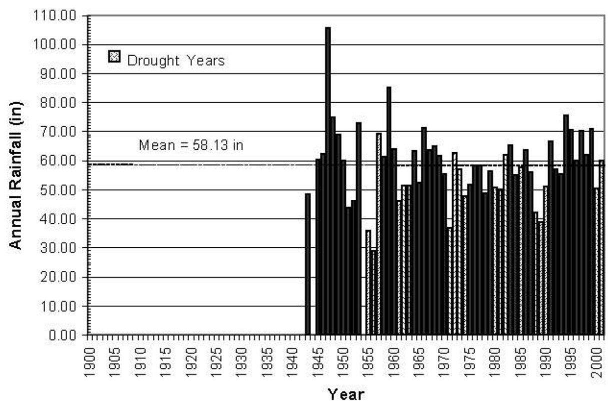

Figure 2A-1-10. Historical annual rainfall for Broward Rain Area and regional drought years

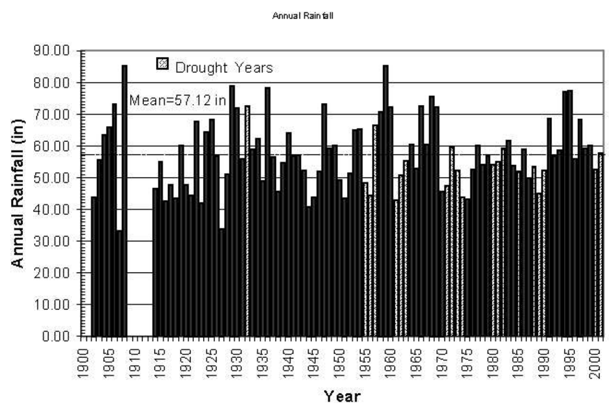

Figure 2A-1-11. Historical annual rainfall for Miami-Dade Rain Area and regional drought years

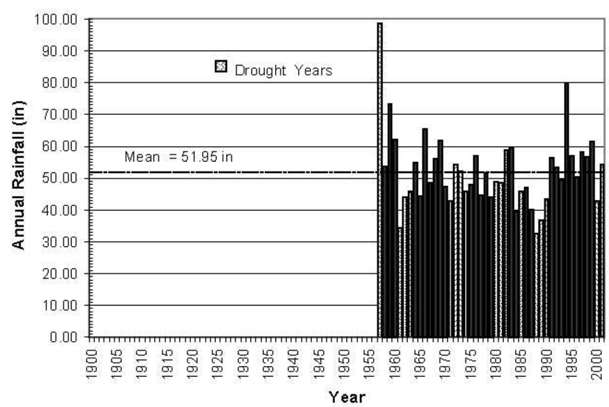

Figure 2A-1-12. Historical annual rainfall for WCA-1 and 2 Rain Area and regional drought years

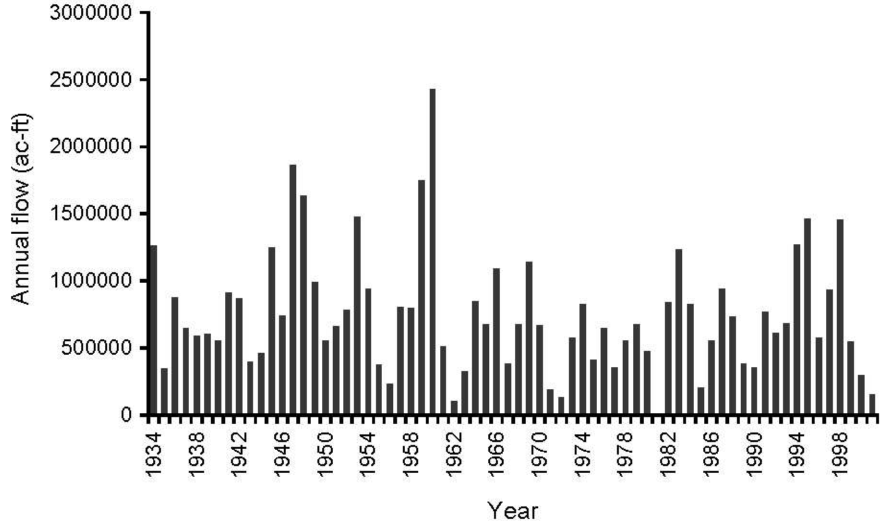

Figure 2A-1-13. Historical outflows from Lake Kissimmee through S-65 structure

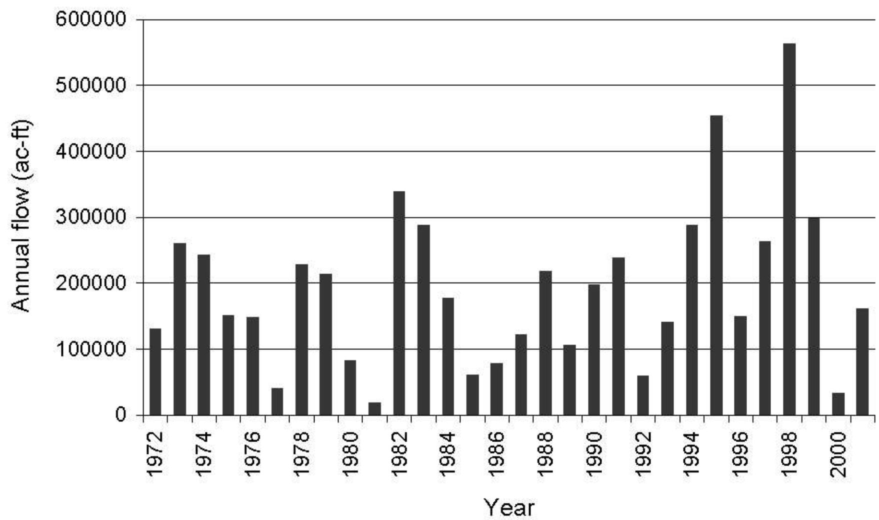

Figure 2A-1-14. Historical outflows from Lake Istokpoga through S-68 structure

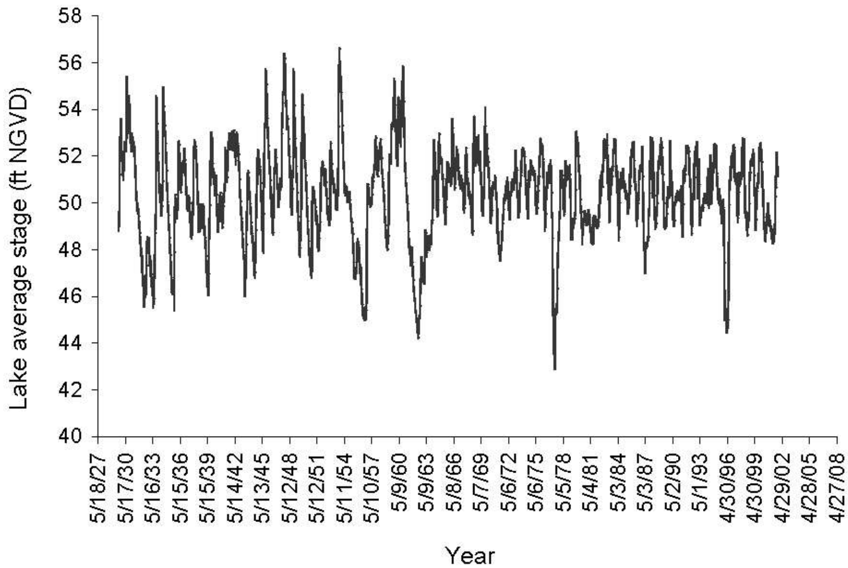

Figure 2A-1-15. Historical daily water level for Lake Kissimmee

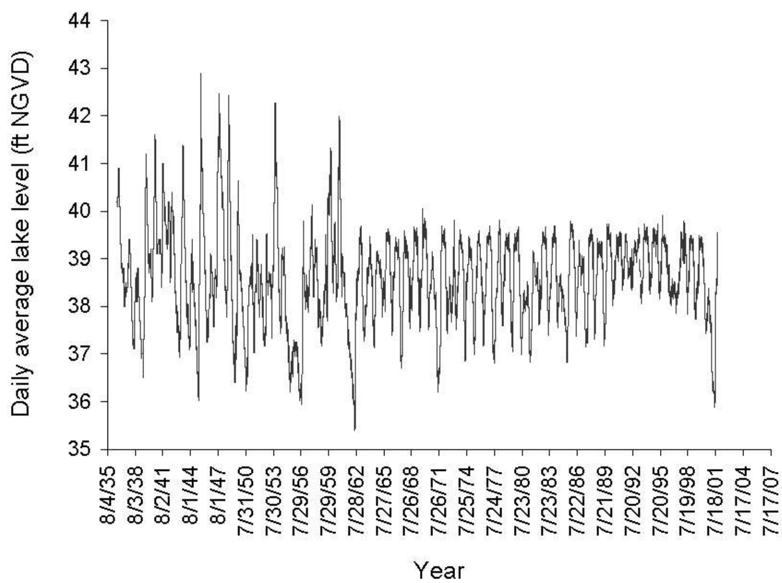

Figure 2A-1-16. Historical daily water level for Lake Istokpoga

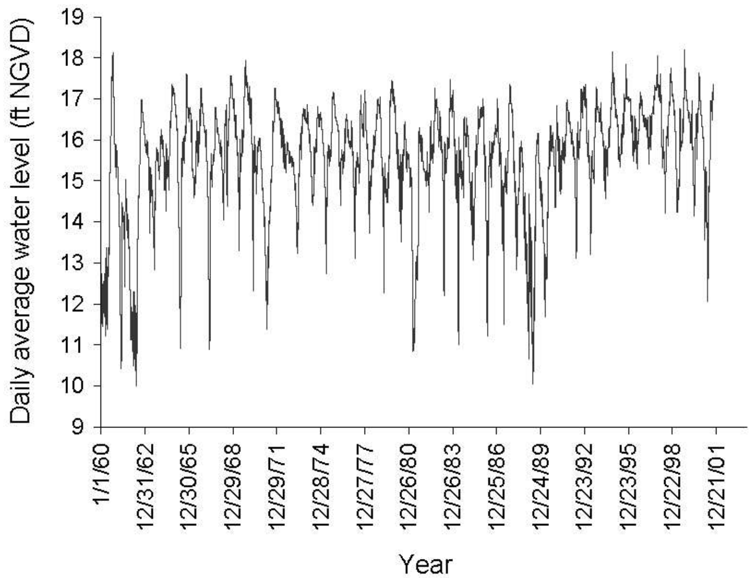

Figure 2A-1-17. Historical daily water level for Water Conservation Area 1-A

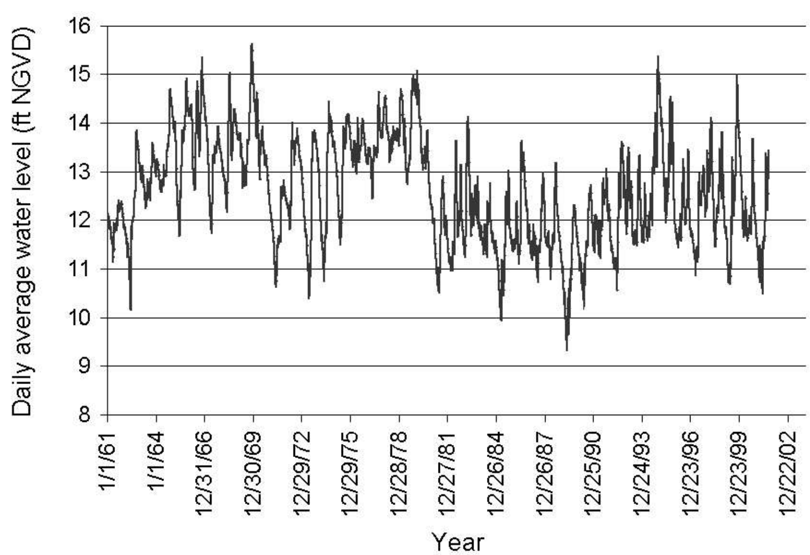

Figure 2A-1-18. Historical daily water level for Water Conservation Area 2-A

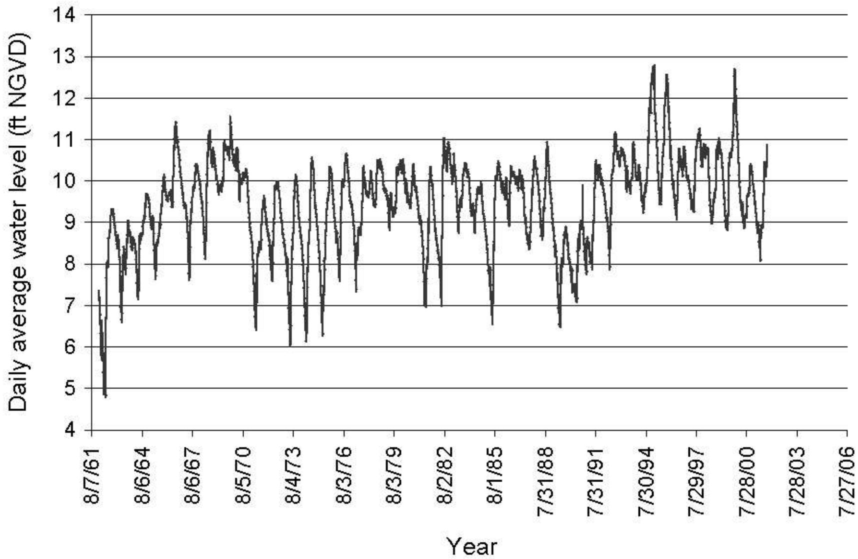

Figure 2A-1-19. Historical daily water level for Water Conservation Area 3-A

APPENDIX 2A-2

Wossenu Abtew and R. Scott Huebner

SUMMARY

This appendix contains illustrations of Stormwater Treatment Areas, Water Conservation Areas, Everglades National Park, and coastal flows during the drought period.

Table 2A-2-1. STA-1W inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	G302_S	STA-1W Inflow	G251_P	G310_P	STA-1W Outflow
1999	October	16,359	16,359	18,829	0	18,829
1999	November	9,682	9,682	10,701	0	10,701
1999	December	13,020	13,020	12,480	0	12,480
2000	January	17,787	17,787	12,763	0	12,763
2000	February	3,418	3,418	8,316	0	8,316
2000	March	14,260	14,260	9,693	0	9,693
2000	April	11,238	11,238	10,986	0	10,986
2000	May	8,412	8,412	11,400	0	11,400
2000	June	4,823	4,823	1,557	0	1,557
2000	July	15,587	15,587	14,396	3,667	18,063
2000	August	16,613	16,613	10,592	5,378	15,970
2000	September	17,497	17,497	8,191	7,339	15,531
2000	October	12,337	12,337	8,692	13,804	22,496
2000	November	0	0	1	1,178	1,179
2000	December	508	508	0	500	500
2001	January	0	0	0	106	106
2001	February	0	0	0	0	0
2001	March	4,702	4,702	534	1,038	1,572
2001	April	719	719	1,065	1,078	2,143
2001	May	917	917	0	0	0
2001	June	5,171	5,171	0	232	232
2001	July	40,219	40,219	0	40,721	40,721
2001	August	33,957	33,957	0	49,004	49,004
2001	September	47,936	47,936	1,085	56,018	57,103
Total		**295,162**	**295,162**	**141,281**	**180,063**	**321,344**

Table 2A-2-2. STA-5 inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	G342A	G342B	G342C	G342D	G349B_P	G350B_P	STA5_TMP	STA 5 Inflow	G344A	G344B	G344C	G344D	STA 5 Outflow
1999	October	2,894	1,876	1,319	1,334	0	0	0	7,422	4,159	4,645	4,382	4,082	17,267
1999	November	5	10	8	4	0	0	0	27	4	6	4	1	15
1999	December	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	January	-3	-1	-1	-2	0	0	0	-7	0	0	15	0	15
2000	February	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	March	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	April	3	10	168	441	0	0	0	622	0	0	0	0	0
2000	May	0	0	0	-1	855	839	0	1,692	0	0	0	0	0
2000	June	0	0	0	129	485	919	0	1,533	0	0	0	0	0
2000	July	2	3	2,716	3,149	0	0	0	5,871	3	0	3,391	2,390	5,784
2000	August	908	2,060	4,432	4,052	70	69	0	11,591	1,595	1,647	3,023	2,948	9,213
2000	September	2,621	5,468	5,563	3,190	2	1	0	16,845	4,744	5,145	2,529	2,988	15,406
2000	October	2,549	6,095	3,836	4,898	2	2	0	17,383	6,749	8,991	5,923	4,840	26,503
2000	November	3	3	225	271	0	0	0	502	0	7	60	58	125
2000	December	3	5	3	2	0	0	0	13	13	10	6	6	35
2001	January	2	0	0	0	0	0	0	2	11	7	6	0	24
2001	February	4	4	0	1	442	0	449	900	4	1	1	-3	4
2001	March	154	272	873	851	338	477	1,323	4,288	0	0	0	0	0
2001	April	0	1	220	240	0	0	0	460	0	0	0	0	0
2001	May	0	0	0	0	0	0	1,255	1,255	0	0	0	0	0
2001	June	2,822	3,422	3,646	2,955	0	0	134	12,980	0	0	0	0	0
2001	July	4,932	6,095	5,788	4,983	0	4	0	21,802	6,617	5,863	4,017	624	17,121
2001	August	6,464	8,142	7,073	6,104	0	8	0	27,790	10,629	7,650	8,999	-1,996	25,282
2001	September	8,188	9,993	8,414	7,133	0	0	0	33,727	13,831	11,494	10,999	5,574	41,897
Total		**31,550**	**43,458**	**44,284**	**39,733**	**2,194**	**2,320**	**3,161**	**166,701**	**48,360**	**45,465**	**43,354**	**21,514**	**158,693**

Table 2A-2-3. STA-6 inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	G600_P	STA-6 Inflow	STA6_OUT	G354_C	G393_C	STA-6 Outflow
1999	October	14,734	14,734	18,847			18,847
1999	November	5,822	5,822	5,232			5,232
1999	December	1,931	1,931	1,136			1,136
2000	January	1,044	1,044	0			0
2000	February	965	965	0			0
2000	March	283	283	0			0
2000	April	1,573	1,573	41			41
2000	May	0	0	0			0
2000	June	1,461	1,461	0			0
2000	July	5,338	5,338	3,724			3,724
2000	August	3,568	3,568	3,054			3,054
2000	September	6,667	6,667	5,415			5,415
2000	October	12,690	12,690	11,693			11,693
2000	November	2,300	2,300	343			343
2000	December	894	894	0			0
2001	January	0	0	0			0
2001	February	886	886	0			0
2001	March	4,928	4,928		1,138	870	2,008
2001	April	662	662		253	227	480
2001	May	294	294		0	0	0
2001	June	6,211	6,211		1,622	1,152	2,775
2001	July	4,762	4,762		1,488	1,100	2,588
2001	August	3,169	3,169		996	692	1,689
2001	September	8,895	8,895		3,617	2,234	5,852
Total		**89,079**	**89,079**	**49,486**	**9,115**	**6,276**	**64,877**

Table 2A-2-4. LNWR inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	G300	G301	S6	G251	G310	ACME	LNWR Inflow	S10A	S10C	S10D	S10E	S39	G94ABC	LNWR Outflow
1999	October	0	42,883	74,356	18,829	0	10,096	146,165	0	83,599	84,432	73,559	0	17,421	259,012
1999	November	9,546	-6,233	16,487	10,701	0	2,708	39,441	0	0	19,063	17,250	0	36,325	81,964
2000	December	913	2,599	19,501	12,480	0	366	35,859	0	0	0	0	0	47,235	51,510
2000	January	124	2,345	18,512	12,763	0	254	33,998	0	0	0	0	0	23,459	30,864
2000	February	-204	774	3,783	8,316	0	37	12,910	0	0	0	0	0	2,116	10,205
2000	March	5,111	2,800	13,962	9,693	0	522	32,088	0	0	0	0	0	10,323	18,848
2000	April	7,672	9,920	22,691	10,986	0	1,796	53,065	0	17,750	16,998	21,576	0	20,241	83,289
2000	May	-2,109	3,909	6,875	11,400	0	24	22,207	0	424	438	462	6	30,667	44,799
2000	June	-2,308	-1,444	6,996	1,557	0	13	8,566	0	0	0	0	0	3,530	14,695
2000	July	3,022	9,218	22,104	14,396	3,667	2,235	54,642	0	0	0	0	0	108	1,643
2000	August	-2,743	-8,138	24,048	10,592	5,378	2,151	42,169	0	2,606	1,402	1,339	0	473	20,843
2000	September	4,727	2,014	35,296	8,191	7,339	1,436	59,004	0	0	0	0	0	21	6,263
2000	October	-4,832	23,870	52,354	8,692	13,804	4,141	102,860	0	15,749	13,779	11,968	0	0	48,102
2000	November	-14,707	0	0	1	1,178	382	1,562	0	0	0	0	0	1,956	31,197
2001	December	7,388	0	0	0	500	456	8,344	0	0	0	0	0	2,846	5,547
2001	January	4,273	0	0	0	106	5	4,384	0	0	0	0	0	1,624	2,980
2001	February	-1,098	-1,386	0	0	0	0	0	0	0	0	0	0	5,746	19,107
2001	March	-112	412	6,938	534	1,038	728	9,650	0	0	0	0	0	1,553	4,988
2001	April	-1,108	0	0	1,065	1,078	10	2,153	0	0	0	0	0	86	5,473
2001	May	-688	0		0	0	12	12	0	0	0	0	0	21	3,750
2001	June	-656	33		0	232	4,068	4,333	0	0	0	0	0	204	861
2001	July	360	-962		0	40,721	9,374	50,455	0	9,328	6,500	14,235	0	0	31,025
2001	August	-6,091	114		0	49,004	4,089	53,206	0	10,689	24,762	30,373	0	360	72,332
2001	September	-3,075	-338		1,085	56,018	7,401	64,504	0	11,435	11,006	10,790	0	0	36,644
	Inflow	43,137	100,890	323,902	141,281	180,063	52,303	Outflow	0	151,581	178,381	181,553	6	206,314	
	Outflow	-39,731	-18,501	0	0	0	0	Inflow	0	0	0	0	0	0	
Total								**841,576**							**885,941**

Note: Negative inflow values counted as outflow in sums; negative ouflow values counted as inflows in sums.

Table 2A-2-5. WCA-2 inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	S7	S10A	S10C	S10D	S10E	G335	NorthSpr	WCA2 Inflow	S11A	S11B	S11C	S34	S38	S141	S143	WCA2 Outflow
1999	October	63,709	83,599	84,432	73,559	0	0	3,268	308,568	0	65,732	63,705	50,436	4,903	7,333	0	192,110
1999	November	6,525	0	19,063	17,250	0	0	175	43,013	0	28,487	27,493	20,519	12,895	13,184	0	102,577
2000	December	985	0	0	0	0	0	0	1,937	0	-952	0	0	14,831	14,484	0	29,315
2000	January	2,656	0	0	0	0	0	0	2,656	0	0	0	0	14,675	14,028	0	28,703
2000	February	2,460	0	0	0	0	0	0	2,460	0	1,359	0	0	13,187	12,610	0	27,155
2000	March	2,352	0	0	0	0	0	276	2,628	0	13,966	0	0	8,061	10,828	0	43,707
2000	April	24,900	17,750	16,998	21,576	0	0	258	81,483	0	0	0	0	10,613	10,487	0	32,293
2000	May	19,803	424	438	462	6	0	0	21,134	0	17,504	0	0	20,150	14,900	0	74,164
2000	June	1,724	0	0	0	0	0	0	1,724	0	0	0	0	0	5,162	0	5,162
2000	July	8,952	0	0	0	0	0	212	9,168	0	20,791	0	0	0	0	-4	20,791
2000	August	10,106	2,606	1,402	1,339	0	0	166	15,624	0	19,785	0	0	0	456	-5	20,241
2000	September	20,713	0	0	0	0	0	718	21,431	0	0	0	0	0	195	0	195
2000	October	49,716	15,749	13,779	11,968	0	0	1,270	93,513	0	48,563	0	0	0	1,024	-1,031	49,587
2000	November	20,888	0	0	0	0	0	0	20,888	0	12,827	0	0	0	6,936	22	19,785
2001	December	8,452	0	0	0	0	0	0	8,452	0	0	0	0	0	4,761	0	4,761
2001	January	-6,113	0	0	0	0	0	0	0	0	0	0	0	0	6,146	0	12,259
2001	February	0	0	0	0	0	0	0	0	0	0	0	0	0	3,781	0	3,781
2001	March	5,297	0	0	0	0	0	0	5,297	0	0	0	0	0	0	0	0
2001	April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	May	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
2001	June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	July	6,236	9,328	6,500	14,235	0	42,059	0	78,359	0	8,428	10,612	22,733	0	0	0	41,772
2001	August	-8,850	10,689	24,762	30,373	0	33,914	755	101,950	0	42,970	42,091	53,823	0	0	-1,458	147,735
1900	September	9,627	11,435	11,006	10,790	0	49,288	1,307	94,912	0	7,585	12,196	8,928	0	0	-1,458	28,709
	Inflow	265,100	151,581	178,381	181,553	6	125,262	8,405	Outflow	0	287,996	156,097	156,438	99,315	126,316	22	
	Outflow	-14,963	0	0	0	0	0	0	Inflow	0	-952	0	0	0	0	-3,956	
Total									**915,197**								**884,803**

Note: Negative inflow values counted as outflow in sums; negative ouflow values counted as inflows in sums.

Table 2A-2-6. WCA-3 inflow and outflow during the 2000-2001 drought (ac-ft)

Year	Month	S140_TOT	S150_C	S8	S9_P	L4 cut	WCA3 Inflow	G69_C	S12_T	S142_C	S30_C	S31_C	S333	S343A_C	S343B_C	S344_C	WCA3 Outflow
1999	October	57,885	0	135,412	67,960		261,257	0	0	261,540	12,969	0	0	248	5,213	5,966	289,688
1999	November	20,109	0	11,621	25,430		57,160	0	0	339,134	15,873	662	206	690	6,053	6,495	373,317
2000	December	3,687	0	0	3,186		6,873	0	0	193,626	12,265	12,154	25,438	0	3,275	3,456	252,546
2000	January	0	34	246	79		359	0	0	90,307	0	11,244	34,877	34,318	0	0	170,747
2000	February	40	392	185	514		1,130	0	0	24,831	1,731	10,720	30,160	66,851	0	0	134,293
2000	March	-448	8,745	682	6,190		16,051	0	0	0	-434	4,912	2,337	22,534	0	0	30,231
2000	April	2,831	18,703	21,676	9,278		52,560	0	0	0	-71	0	6,973	31,074	0	0	38,047
2000	May	44	0	15,041	1,154		16,239	0	0	0	0	0	10,917	21,631	0	0	32,548
2000	June	5	1,731	14,886	14,091		30,712	0	0	0	0	0	0	11,776	0	0	11,776
2000	July	2,366	29,371	30,246	44,897		108,125	0	0	1,131	-1,245	0	0	8,509	0	0	9,640
2000	August	5,359	4,990	15,698	25,771	-236	51,839	0	-21	20,243	926	0	0	4,402	0	0	25,808
2000	September	15,572	803	38,703	22,183	10,648	92,689	0	-385	5,260	-4,396	0	0	7,158	0	0	12,419
2000	October	36,863	1,529	51,892	41,175	24,488	162,276	0	99	13,416	-6,329	0	0	1,386	0	0	14,902
2000	November	2,698	0	430	3,466	6,020	12,719	0	-106	4,108	992	0	0	19,841	0	0	24,941
2001	December	0	0	0	8,497	7,974	17,859	0	-128	0	-1,260	0	19	9,162	0	0	9,181
2001	January	18	0	278	3,617	9,882	15,158	0	-98	3,027	-1,263	0	71	3,709	0	0	6,807
2001	February	0	0	82	0	8,879	11,784	0	-59	413	-2,765	0	0	490	0	0	903
2001	March	1	859	1,133	7,191	9,460	20,738	0	-151	0	-1,942	0	0	0	0	0	0
2001	April	0	0	561	125	8,049	13,500	0	-180	0	-4,585	0	0	1,704	0	0	1,704
2001	May	0	0	0	24,132	5,322	36,511	0	-136	0	-6,920	0	0	0	1	104	105
2001	June	6,401	0	0	24,686	11,177	50,122	0	-160	666	-7,698	0	0	1,135	0	0	1,802
2001	July	14,755	3,139	2,986	34,101	9,962	72,787	0	191	1,250	-7,843	0	0	270	0	0	1,710
2001	August	15,074	104	7,518	43,746	10,778	79,495	0	-303	62,771	-1,973	0	0	73,043	2,839	3,096	143,381
1900	September	21,393	1,007	34,337	40,046	38,074	135,915	0	48	94,816	-1,057	0	0	14,095	3,945	4,223	120,442
	Inflow	205,100	71,407	383,612	451,516	160,712	Outflow	0	337	1,116,540	44,756	39,691	111,000	334,026	21,326	23,340	
	Outflow	-448	0	0	0	-236	Inflow	0	-1,727	0	-49,781	0	0	0	0	0	
Total							**1,323,856**										**1,706,935**

Note: Negative inflow values counted as outflow in sums; negative ouflow values counted as inflows in sums.

Table 2A-2-7. Coastal outflow during the 2000-2001 drought (ac-ft)

Year	Month	S99_S	S49_S	S97_S	S80_S	S46_S	S44_S	S155_S	S40_S	S41_S	G56_S	G57_S
1999	October	76,704	74,303	73,739	116,471	40,035	23,057	127,653	38,951	55,592	49,116	2,462
1999	November	3,530	8,082	2,743	104,682	8,991	8,239	69,877	8,137	10,258	42,587	680
2000	December	5	32	0	46,195	386	4,605	51,578	728	1,071	43,998	288
2000	January	5	2	13	22,316	1	3,639	28,713	1,125	1,683	20,211	116
2000	February	4	16	0	2,013	0	3,335	4,604	0	221	1,425	21
2000	March	2	0	0	4,899	0	3,148	4,984	3,498	4,440	13,883	96
2000	April	7	7	1,433	39,769	195	4,812	19,359	6,711	10,863	22,502	157
2000	May	0	0	0	87,759	0	1,973	4,330	520	1,029	20,666	81
2000	June	542	368	3	2,083	0	1,051	1,738	662	1,187	1,085	455
2000	July	13,874	12,558	8,008	2,152	0	5,069	19,462	296	1,220	8,205	478
2000	August	8,017	11,857	10,742	2,152	0	3,838	14,656	1,581	4,793	7,285	346
2000	September	4,197	8,351	5,281	2,083	1	4,807	8,048	5,045	13,420	6,006	284
2000	October	10,986	17,099	10,236	2,152	9,086	11,810	38,380	16,369	26,804	20,199	1,453
2000	November	0	0	0	2,083	35	7,458	8,319	5,615	10,385	3,135	125
2001	December	0	0	0	2,152	2	5,247	11,729	269	2,656	2,300	62
2001	January	0	0	0	2,152	0	3,842	377	5	474	1,499	3
2001	February	0	0	0	1,944	0	3,235	0	7	0	1,324	0
2001	March	0	0	0	2,152	0	5,744	7,724	591	3,713	1,294	281
2001	April	0	0	0	2,083	0	4,241	267	71	318	0	43
2001	May	0	0	0	2,152	0	2,243	0	1	344	0	264
2001	June	9,175	9,141	2,513	2,083	408	4,803	20,976	2,988	11,707	1,114	340
2001	July	62,454	53,687	19,244	2,152	8,845	9,243	63,805	5,397	23,752	12,595	540
2001	August	46,919	43,255	19,503	2,152	26,563	16,527	60,283	17,078	25,156	21,499	1,082
2001	September	38,920	40,628	42,100	2,083	21,811	22,628	76,135	24,606	39,030	22,351	1,465
Total		**275,340**	**279,383**	**195,558**	**457,912**	**116,360**	**164,595**	**642,998**	**140,251**	**250,114**	**324,280**	**11,122**

Table 2A-2-7. Coastal outflow during the 2000-2001 drought, continued

Year	Month	S37A_S	S36_S	S33_S	G54_S	S13_P	S13_S	S29_S	G58_C	S28_S	S27_S	S26_S
1999	October	43,370	13,295	3,136	10,262	13,641	10,983	192,692	39,222	1,141	32,208	8,004
1999	November	17,940	6,297	220	16,721	1,581	12,937	111,822	22,490	32	5,868	11,868
1999	December	11,075	4,708	0	13,483	0	20,294	98,874	16,476	0	0	15,305
2000	January	9,601	2,764	0	11,405	27	15,751	78,673	11,225	0	304	20,686
2000	February	7,840	1,970	0	8,646	0	12,252	60,951	9,184	0	2,299	15,611
2000	March	11,154	3,560	70	8,244	0	13,137	71,925	10,099	4	5,982	1,180
2000	April	6,645	2,544	215	9,809	0	12,663	63,536	19,609	132	9,341	7,244
2000	May	6,256	746	0	12,024	0	4,146	46,122	2,074	31	1,723	8,391
2000	June	1,772	1,547	0	2,405	0	8,248	28,615	29,255	153	11,618	3,053
2000	July	4,413	6,742	254	12,481	0	8,538	65,267	22,291	88	14,219	5,136
2000	August	2,414	3,584	0	6,716	0	5,777	37,363	27,892	39	9,953	6,614
2000	September	4,494	3,506	0	1,469	587	6,779	33,953	20,626	63	10,481	5,703
2000	October	14,049	6,766	996	3,064	10,180	6,249	84,807	58,871	-1,679	33,990	11,212
2000	November	0	0	0	0	585	2,613	6,592	2,802	0	1,468	1,797
2000	December	612	870	15	325	0	5,246	14,143	12,472	-14	5,030	2,369
2001	January	0	1	5	0	0	2,560	5,094	0	0	0	19
2001	February	0	0	0	0	1	684	1,360	0	0	0	0
2001	March	212	0	153	188	0	3,092	7,787	1,331	16	976	23
2001	April	0	0	0	0	0	1,534	3,128	5,141	11	1,940	67
2001	May	186	116	49	905	0	4,923	12,781	11,860	229	9,846	306
2001	June	3,312	1	23	0	0	4,290	15,801	18,714	128	6,330	2,076
2001	July	7,267	4,243	498	2,022	2	6,676	42,146	29,711	143	11,611	4,741
2001	August	13,557	5,751	1,080	7,657	5,370	3,208	74,787	40,401	193	10,930	9,900
2001	September	23,441	8,634	2,007	5,586	5,575	5,542	103,636	43,684	-868	19,894	8,829
Total		**189,611**	**77,646**	**8,721**	**133,412**	**37,550**	**178,122**	**1,261,854**	**455,431**	**-157**	**206,011**	**150,133**

Table 2A-2-7. Coastal outflow during the 2000-2001 drought (ac-ft), continued

Year	Month	S25_C	S25B_S	G93	S22_S	S123_S	S21_S	S21A_S	S20G_S	S20F_S	S197_C	East Coast To Tide	West Coast To Tide S79_S
1999	October	37,896	391	40,161	7,919	40,504	32,013	-12,246	31,200	4,098	43,242	1,271,215	287,437
1999	November	14,088	121	24,424	1,414	16,495	1,883	10,995	8,132	1,694	12,960	567,788	239,173
1999	December	9,180	16	25,367	0	4,985	1,603	2,248	7,900	63	10,922	391,386	110,116
2000	January	4,856	0	3,083	0	420	925	1,399	5,982	0	8,444	253,367	51,090
2000	February	5,348	160	12,039	0	452	677	2,154	4,651	2	5,933	161,809	1,075
2000	March	1,647	48	7,118	1	32	7	1,487	3,501	16	6,053	180,215	22,383
2000	April	5,066	36	11,230	529	7,179	9	4,238	3,757	90	5,579	275,265	80,497
2000	May	3,349	49	711	18	196	0	1,166	1,074	0	694	205,129	174,020
2000	June	15,990	330	9,650	0	78	8	3,581	4,013	239	7,685	137,412	29,263
2000	July	16,732	557	6,665	1	3,286	130	12,002	6,663	1,173	11,368	269,328	49,908
2000	August	14,369	107	17,842	255	6,072	1,221	17,450	8,076	1,323	18,830	251,164	29,470
2000	September	17,066	642	26,118	1,967	8,400	2,586	11,553	8,214	1,195	14,752	237,676	106,380
2000	October	33,875	2,700	38,517	6,915	26,504	25,338	19,912	29,166	5,042	42,236	623,282	49,218
2000	November	12,556	234	16,655	0	210	6	2,938	4,703	503	8,854	99,669	9,160
2000	December	16,132	790	16,316	1,278	12,625	3,242	11,705	13,728	2,844	20,246	164,391	0
2001	January	9,282	0	4,382	0	0	0	1,296	3,432	0	5,186	39,608	9,449
2001	February	5,008	0	0	0	0	0	0	921	0	144	14,628	0
2001	March	3,245	41	0	0	0	0	145	2,128	0	101	40,938	1,888
2001	April	8,328	3	0	0	0	0	717	1,500	102	0	29,495	1,966
2001	May	15,968	868	3,309	0	834	595	5,250	2,352	419	1,993	77,795	8,102
2001	June	15,551	540	10,399	-13	2,533	613	4,765	4,910	1,205	10,061	166,486	29,419
2001	July	18,078	386	22,726	31	13,744	2,369	17,859	9,700	1,902	17,585	475,155	130,772
2001	August	19,290	385	24,364	435	13,341	2,173	32,492	10,404	1,301	23,169	580,203	179,570
2001	September	24,988	2,276	23,504	1,847	25,413	13,825	18,584	19,120	3,516	32,460	723,247	324,468
Total		**327,888**	**10,678**	**344,578**	**22,597**	**183,302**	**89,223**	**171,691**	**195,228**	**26,726**	**308,494**	**7,236,651**	**1,924,825**

Table 2A-2-8. ENP inflow during the 2000-2001 drought (ac-ft)

Year	Month	S18C	S197_C	S18C_net	S12_T	S332_P	S332B_P	S332D_P	S333	ENP Inflow
1999	October	52,955	37,410	15,545	261,540	32,804	0	12,538	248	413,040
1999	November	15,451	0	15,451	339,134	31,644	0	6,285	690	408,655
2000	December	11,883	0	11,883	193,626	32,837	0	0	0	250,229
2000	January	15,612	0	15,612	90,307	33,000	0	24,796	34,318	213,646
2000	February	9,848	0	9,848	24,831	19,735	0	16,595	66,851	147,707
2000	March	5,691	0	5,691	0	1,565	0	0	22,534	35,481
2000	April	5,820	0	5,820	0	1,927	0	0	31,074	44,640
2000	May	612	0	612	0	1,024	0	229	21,631	24,108
2000	June	8,995	0	8,995	0	304	0	762	11,776	30,831
2000	July	21,128	0	21,128	1,131	46	0	18,158	8,509	70,099
2000	August	31,267	0	31,267	20,243	1	0	21,729	4,402	108,910
2000	September	31,910	1,273	30,637	5,260	0	0	24,615	7,158	100,854
2000	October	46,380	24,220	22,160	13,416	0	0	25,433	1,386	132,994
2000	November	4,285	0	4,285	4,108	1	0	8,425	19,841	40,944
2001	December	6,958	0	6,958	0	1	1,726	0	9,162	24,804
2001	January	157	0	157	3,027	0	0	0	3,709	7,050
2001	February	2	0	2	413	0	0	0	490	907
2001	March	0	0	0	0	0	0	0	0	0
2001	April	212	0	212	0	0	0	0	1,704	2,128
2001	May	1,089	0	1,089	0	0	0	0	0	2,178
2001	June	4,012	0	4,012	666	0	0	740	1,135	10,565
2001	July	19,689	0	19,689	1,250	0	3,967	13,435	270	58,299
2001	August	30,155	4,936	25,219	62,771	0	6,933	16,970	73,043	220,026
2001	September	29,371	2,410	26,962	94,816	0	14,364	25,084	14,095	207,101
Total										**2,555,198**

The 2000-2001 DROUGHT in South Florida

Part II: Water Management

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PART II: Water Management During the 2000–2001 Drought in South Florida

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PREFACE

The 2000–2001 drought in Central and South Florida was a significant hydrologic and water management event. During this period, a critical water supply shortage was experienced by all sectors of water users. The continual monthly rainfall deficit compounded the decline in storage volume, forcing the South Florida Water Management District to declare a drought emergency and implement water use restrictions. Water quality and biological monitoring were expanded, and daily, weekly and monthly reports were generated to assist water management decision making and inform the public about the status of the hydrologic system. The South Florida Water Management District took the lead in facilitating a multi-agency response to this event, coordinating a series of decisions and actions to protect the public interest to the maximum extent possible.

Documentation of such an event is necessary to preserve the experience for the benefit of future managers of such events. Thus, the District is producing the *2000–2001 Drought Report*. The report is divided into three parts. *Part I: Hydrologic Analysis of the 2000–2001 Drought in South Florida* summarizes the hydrologic and water resources conditions from October 1, 1999 through September 30, 2001. Historical hydrologic analysis is also provided for a comparative understanding of the magnitude of the drought. *Part II: Water Management During the 2000–2001 Drought in South Florida* addresses water management during this period of record-low rainfall and highly restricted water supply. It provides a record and overview of the drought management process, including valuable information for future drought monitoring and drought management. Finally, the Executive Summary contains a synopsis of the major findings.

Many staff members worked to make the Drought Report a reality. Special thanks go to the editorial team, chapter authors and support staff. Their assistance was invaluable.

Sincerely,

Linda Lindstrom, P.G.
Director
Environmental Resource Assessment Department

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Chapter 1: Introduction and Overview

Garth Redfield, Wossenu Abtew, Beth Ross, Naomi Duerr
and Dean Powell

INTRODUCTION TO THE WATER MANAGEMENT REPORT

Part II of the report on the 2000–2001 drought in South Florida addresses water management during this period of record low rainfall and highly restricted water supply. The South Florida Water Management District took the lead in facilitating a multi-agency response to this event, coordinating a series of decisions and actions to protect the public interest to the maximum extent possible. This water management report chronicles and evaluates these responses as an after-action assessment of the drought event.

The fundamental purpose of *Part II: Water Management During the 2000–2001 Drought in South Florida* is to provide a permanent record and a synoptic view of management actions and their context during the drought, as well as a vehicle for communicating lessons learned for use during future droughts. The report begins with a brief summary of Part I, the essential hydrology of the event, and then presents general management philosophies applied across the many activities associated with the period. The chronicle continues with a summary of system operations and District-wide efforts to manage water demand and supply. The second half of Part II provides a synthesis of data and findings on issues of water demand and supply at the regional level, and then records the many impacts resulting from the drought. The report also includes a detailed account of the far-reaching actions taken in outreach and communications.

HYDROLOGIC BACKGROUND OF THE 2000–2001 DROUGHT

The 2000–2001 drought was a significant hydrologic and water management event in Central and South Florida. A detailed evaluation of hydrological data and findings is presented in *Part I: Hydrological Analysis of the 2000–2001 Drought in South Florida*. This section of Chapter 1 highlights key aspects of Part II to provide context for the management analysis being done in the chapters of the water management report.

According to the Palmer Drought Severity Index, the 2000–2001 drought was one of the few extreme drought events in the Upper Kissimmee, Lower Kissimmee and Lake Okeechobee areas of the District (**Figure 1-1**).

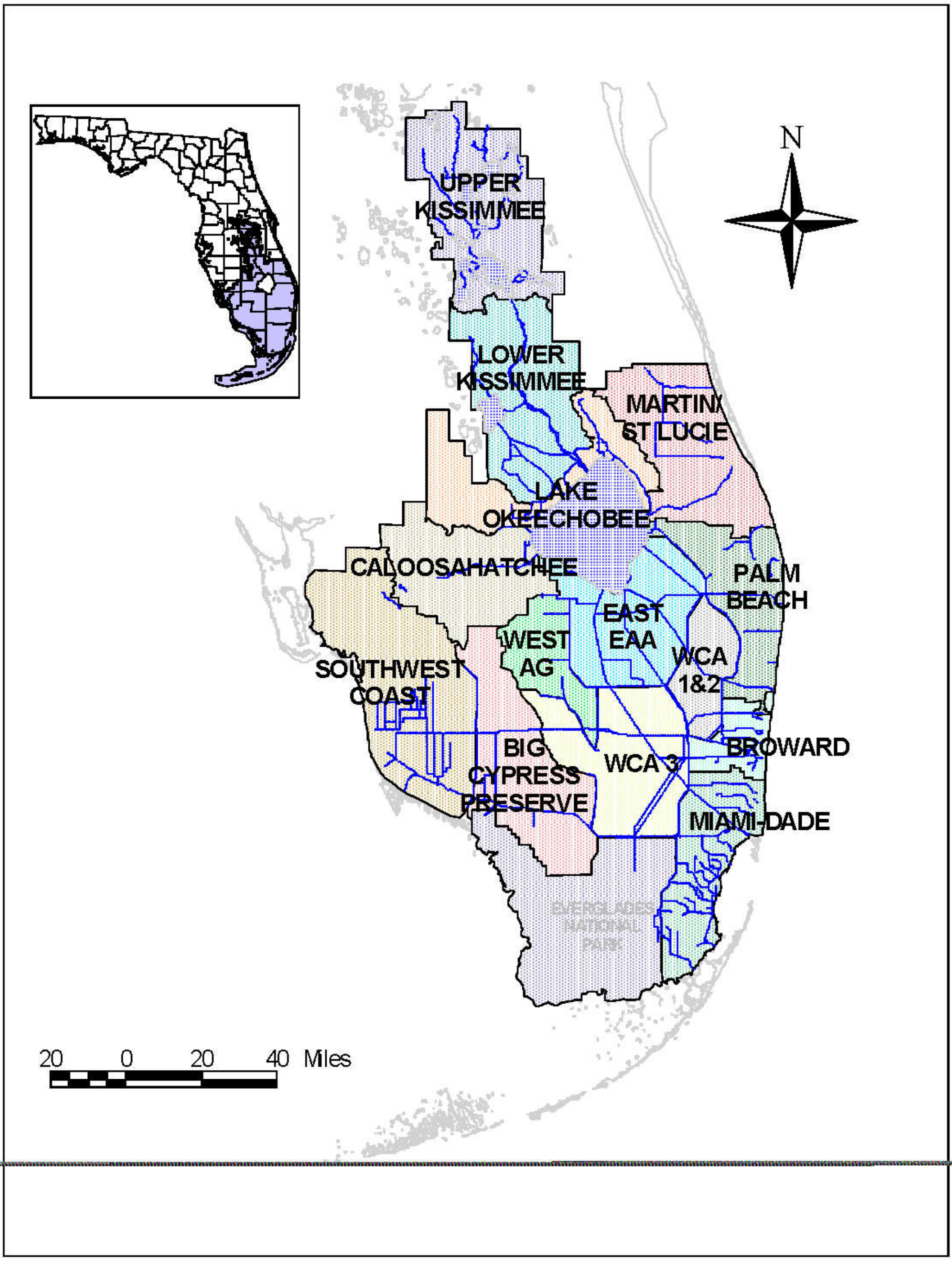


Figure 1-1. South Florida Water Management District rain areas

These are the watersheds that contribute most of the inflows to Lake Okeechobee. The 2000 annual rainfall for the three areas had a dry frequency of 1-in-100 years. Annual rainfall deficit for the three areas was 35 percent. The 2000 District-wide annual rainfall deficit was 25 percent of the historical mean. The drought persisted in most areas through August 2001. Hurricane Gabrielle passed through Central Florida in the middle of September 2001 and resulted in significant rainfall over a large area, contributing to drought relief.

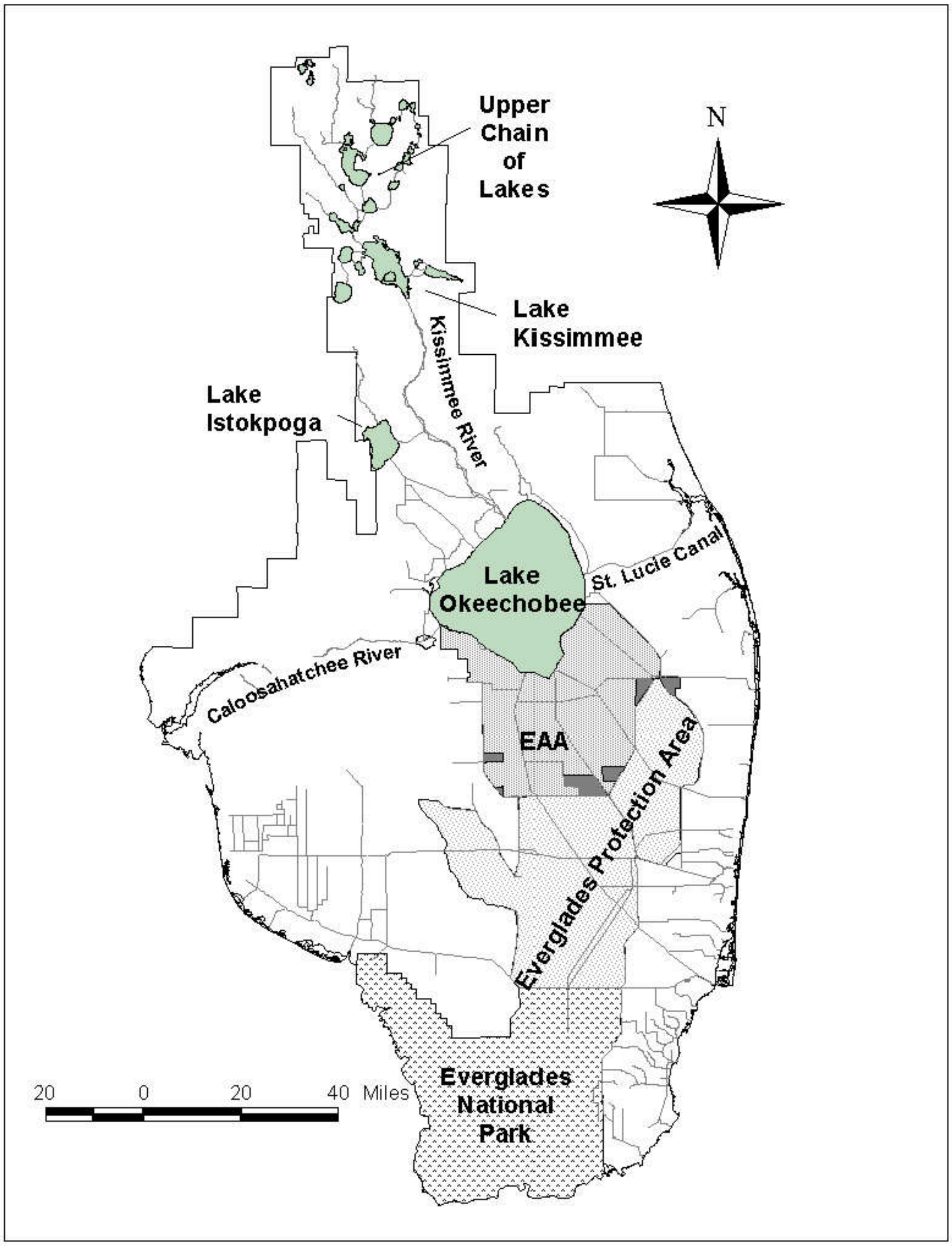
The cascading effects of the drought were demonstrated by significant reductions in inflow and outflow to the major lakes in the District (**Figure 1-2**). There was no outflow from Lake Kissimmee for eight consecutive months (November 2000 to June 2001). Lake Istokpoga was similarly affected, recording the second-lowest annual discharge during the 2000–2001 drought.

The drought's effect on Lake Okeechobee inflows and outflows was significant. From December 1999 to June 2001 there were 19 consecutive monthly inflows below the historical average. The significant increase in lake inflow from July to September 2001 corresponds with an increase in rainfall and a decrease in drought effect. During the same period, backflow into the lake through pumping and gravity was 32 percent of the total. The remaining inflow of 68 percent was from the north. The maximum annual backflow occurred in nine months of 2001 (679,157 ac-ft). The total backflow to the lake for the period of October 1999 to September 2001 was 1,017,224 ac-ft, of which 420,701 ac-ft were back pumped through the S-2 and S-3 pump stations. Based on flow data from January 1, 1972 to September 30, 2001, major surface inflows to Lake Okeechobee showed an annual average volume of 1,999,000 ac-ft with an annual minimum of 675,000 ac-ft occurring during the 2000 drought.

Outflows from the lake are mainly through the south, southeast, and southwest structures. The average historical (1972 to 2001) annual outflow was 1,282,000 ac-ft. For the period of October 1999 to September 2001, 16 months of outflows from the lake were below the historical average. A significant portion of the discharge during the lake recession occurred in May 2000. When the lake stage reached 10.1 ft referenced to the National Geodetic Vertical Datum (NGVD), temporary forward pumps were activated at the S-351, S-352, and S-354 structures to discharge water to the south. The pumps were operated irregularly from March 28, 2001 to July 3, 2001 for a total discharge of 92,904 ac-ft.

The effects of the drought were also felt south of the lake in the Stormwater Treatment Areas (STAs) and Water Conservation Areas (WCAs). Many of the inflows and outflows to the STAs were reduced by the drought. STA 6 and a portion of STA 5 dried out during the most severe period of the drought. All the STAs began to receive significant inflow beginning in June and July 2001, aiding their recovery from the drought. Inflow and outflow volumes for WCAs showed significant drought related reductions from November 2000 through June 2001. The ability to release water from the WCAs for water supply purposes was severely restricted during 2001. Inflow and outflow volumes increased progressively from July through September 2001 and led to a recovery of water levels by the end of September 2001. The same overall pattern was observed in outflow volumes from coastal structures. Total outflows through coastal structures to tide were negligible during the height of the drought in the first several months of 2001. Further south, inflow volumes to Everglades National Park (ENP) from October 1999 to September 2001 showed the drought effects dramatically. Park inflows were minimal from January 2001 through June 2001 and increased starting in August 2001.

Figure 1-2. Major hydrologic components of the South Florida Water Management District



Water levels in lakes and reservoirs are gages for drought and water shortage conditions. Water level data for Lake Okeechobee are available beginning in 1931. The minimum lake level for the period of record, 8.97 ft NGVD, occurred on May 24, 2001. Lake water level was at or below 11 ft NGVD for only 3 percent of the period since 1931, with the longest consecutive period, 194 days, occurring in 2001. In fact, Lake Okeechobee's water level declined 7.56 ft. NGVD, from 16.53 NGVD on October 1, 1999 to 8.97 ft NGVD on May 24, 2001. Decreased inflow and rainfall, with increased discharge and evaporation, corresponded to the lake water level decline, while increased inflow from the north, backflow to the lake, and reduced discharge from the lake corresponded to gain in water level.

Lake Kissimmee, with an area of 35,520 acres, has been regulated by the S-65 structure since 1964, with slightly more than a three-foot fluctuation. The mean historical lake level is 50.38 ft NGVD. For the period of October 1, 1999 to September 30, 2001, Lake Kissimmee fluctuated between 52.57 and 48.28 ft NGVD, with the minimum level occurring on April 29, 2001. Lake Istokpoga, with an area of 28,160 acres, has been regulated by the S-68 structure since the early 1960s within a three-foot fluctuation. The average historical lake level is 38.59 ft NGVD. Lake Istokpoga fluctuated between 39.55 and 35.88 ft NGVD, with the minimum occurring on June 19, 2001.

The Water Conservation Areas are shallow impoundments, with a total area of about 736,640 acres. WCA-1 (Loxahatchee National Wildlife Refuge) is 140,800 acres in area, with a daily average water level of 15.55 ft NGVD. WCA-2A is 105,408 acres in area, with an average water level of 12.59 ft NGVD. WCA-3A is 491,072 acres in area, with an average water level of 9.46 ft NGVD. Daily water level fluctuations for the three WCAs during the most recent drought period reached minimum water levels of 12.06, 10.49, and 8.07 ft NGVD at WCA-1, WCA-2A, and WCA-3A, respectively, in May 2001.

During the 2000–2001 drought, groundwater levels declined and there were periods when below-average levels were reached in most regions of the District in the various aquifers. The Upper Floridan Aquifer in the Upper Kissimmee region dropped below its average level for more than a year. At one point, it was approximately 4.0 ft below normal level at the Boggy Creek well. The Surficial Aquifer System in the Upper East Coast planning area exhibited low groundwater levels for two extended periods, as did the Surficial Aquifer in Palm Beach County. Groundwater levels approached the 100-year low water level (lower values occur less than 1 percent of the time in the historical record) in summer 2000 and spring 2001. The water level in the Biscayne Aquifer exhibited different trends in different areas during the drought period. Excluding well water levels in Southern Miami-Dade County, northern and interior wells showed declines during various periods. Water levels in the Surficial Aquifer, the Lower Tamiami aquifer and the Sandstone aquifer in the Lower West Coast planning area declined with decreased rainfall and increased pumping and demonstrated a recovery after water use restrictions were imposed and with increased rainfall and recharge. All of the aquifers in the Lower West Coast planning area approached the 100-yr (1 percent) low groundwater level in summer 2000 and spring 2001.

DROUGHT MANAGEMENT PHILOSOPHY

To understand the water management responses to the extreme drought conditions described in section B, the fundamental legal and administrative framework for agency activities must be explained. This section summarizes Florida's system for equitable distribution of available water resources during the 2000–2001 drought event. The review will summarize theoretical underpinnings, associated laws, implementation of rules concerning water shortages, and linkages to the certainty concept.

CERTAINTY CONCEPT

Water users seek certainty, a reduction in risk of the water supply being interrupted for any reason, including drought. Water law systems attempt to resolve the issues of legal, tenure, and physical certainty (Maloney et al., *A Model Water Code 158,*1972). The latter is relevant to water shortages. Physical certainty concepts in water law address the status of water rights in changing weather conditions, particularly droughts. Common law rights in western prior-appropriation states reduced uncertainties associated with drought events by granting priority to the "first in time" user. The senior user's full water rights were preserved, while those of subsequent users were eliminated (*A Model Water Code 158*, and *Waters and Water Rights, Volume 2*, s. 12.03(e) 118). Conversely, Florida's system of addressing water shortages is based on equitable distribution of available supplies among all users. This equitable distribution of water in light of drought events begins in the permitting scheme and is further implemented in water shortage plans.

In the permitting realm, water is allocated to users based on its physical availability in a specified level of drought. The permitting system makes assumptions about the severity of rainfall deficit to allocate sufficient "make-up" water to satisfy demands. For example, a drought that has a rainfall deficit so extreme that, statistically, it can be expected to occur only once every 100 years is more severe than a drought whose rainfall deficit would occur once every 10 years. Supplemental water allocations to meet demands in extreme, 100-year drought events would involve huge quantities. If permitted, these quantities of water would become the protected water right of existing legal users. If users acquired rights to such large quantities of water to insulate themselves from the impacts of extreme drought events, their physical certainty of supply would be assured. However, few users would be able to access water, since Florida law prohibits unmitigated impacts to legally existing users (F.S. 373.223(1)(b)). A balance between user desire for certainty of supply, risk of impacts from drought events, and the number of water users who can acquire water rights is achieved via the assumptions relating to drought contemplated in the permitting scheme. Once a significant drought event occurs, Florida's Water Shortage Plan provisions may be triggered.

THEORIES BEHIND FLORIDA'S EQUITABLE SCHEME OF WATER SHORTAGE ALLOCATION

In 1972, during a severe drought, the Florida Legislature adopted F.S. Chapter 373, creating a unique and innovative means of allocating water resources. Water resource planning is a key theme of this landmark statute, by which the legislature requires the state's water management districts to adopt water shortage plans as an integral part of Florida's water allocation scheme (F.S. 373.246). A companion statute, F.S. 373.175, was also adopted.

User Knowledge: First, F.S. 373.246 requires the water management districts to adopt Water Shortage Plans, found in Chapters 40-A, C, D, and E of the Florida Administrative Code; the districts generally use consistent numbering for the rules contained within the various plans. Users are able to refer to the Water Shortage Plan provisions that will apply to their use class to determine the level of restriction in a given drought condition. Knowledge of potential restrictions enables users to prepare themselves for such circumstances, thereby increasing their physical certainty. For example, citrus growers who refer to the restrictions might notice that highly efficient irrigation systems are not restricted (e.g., FL Admin. Code Rule 40E-21.551). Thus, a grower may opt for installation of a highly efficient irrigation system to avoid or minimize drought restrictions.

Equitable Distribution of Available Water: Implementation of water shortage plans enables the districts to equitably apportion available supplies among all legal users, while also protecting the water resources. Equal treatment of all users also mediates the economic implications of use restrictions.

Minimizing Economic Impact: The Water Shortage Plans identify use classes (e.g., FL Admin. Code Rule 40D-21.511) so each permitted user is classified with similar users. Restriction of an entire class of users is anticipated. Individual projects are generally not singled out. A given project may be restricted, particularly via the emergency water shortage order provision found at F.S. 373.246(7). The restrictions of the Water Shortage Plans impact all use classes: domestic self-supply, irrigation, golf course, public water supply, agricultural, dewatering, etc. Even users who are exempt from permitting (domestic self-supply) are subject to water shortage restrictions. Specific restrictions consider the unique needs of each use class in an attempt to equitably minimize the economic, social, and health-related impacts of drought cutbacks.

FLORIDA'S WATER SHORTAGE PLANS

Classification System: As noted above, each user is classified according to use type. Further, each user's source and method of withdrawal are classified. Source classes are divided into surface and groundwater. District rules identify the location of surface water use basins and groundwater sources. Method of withdrawal classes is also established by rule (e.g., FL Admin. Code Rule 40D-21.531, .541, and .571). For example, surface water users are classified by identification of pump usage or gravity inflow. In this manner, like users are grouped for equitable implementation of restrictions.

Evaluating Water Conditions: The water management districts monitor and evaluate water conditions. Comparisons between current and historical data help judge whether estimated present and anticipated available water supply within a source class will be sufficient to meet users' estimated present and anticipated demands from the source and whether serious harm to the water resource may occur. A series of technical factors help evaluate both the supply and demand components (e.g., FL Admin. Code Rule 40C-21.221).

Water Shortage Declaration and Restrictions: If a district governing board expects that sufficient water is not or will not be available to meet demands it may declare a water shortage for the affected source class. Estimates of the percent reduction in demand required to match available supply are used to identify which phase of drought restriction is implemented (e.g., FL Admin. Code Rule 40C-21.251). For example, phase one restrictions require golf course managers to restrict irrigation of fairways and roughs on the first nine holes of the course to the hours of 12:01 a.m. to 8:00 a.m. on Mondays, Wednesdays, and Saturdays. Phase two restrictions cut back the available irrigation days to Wednesdays and Saturdays (e.g., FL Admin. Code Rules 40E-21.521(3)(e) 2 and .531(3)(e)2). Thus, a gradual progression in severity of restriction is implemented through increasing phases. Once declared, the districts must both notify permitted users by mail of the restrictions and publish them in area newspapers (e.g., FL Admin. Code Rule 40E-21.291).

Monitoring of Conditions and Enforcement of Water Shortage Restrictions: Continuous assessment of supply, demand, and resource impacts is to occur through assessment of resource data. Restrictions may be modified or lifted as conditions warrant (e.g., Fla. Admin. Code Rule 40C-21.291(4)).

Generally, the water management districts seek the cooperation and assistance of state and local government resources in the enforcement of water shortage restrictions. Law enforcement officers are asked to ticket violators. (F.S. 373.609). Some districts, in an effort to enhance coordination, have encouraged local government adoption of water shortage ordinances that parallel district restrictions. Many local governments have implemented such ordinances.

Variances: The water shortage plans universally provide an opportunity for particular users to make a request to the district executive director and governing board for a variance. Application contents and conditions for issuance of a variance from water shortage restrictions are stated in water management district rules. Procedures for review of variance applications are expedited. Generally, the rules provide for a 10-day review period, after which staff must make their recommended agency action. If the application requires immediate action, staff may present the application to the Executive Director for temporary action, with governing board concurrence to follow. Otherwise, the variance applications are presented at the District monthly meetings. (e.g., FL Admin. Code Rules 28-104 and 40E-21.275).

CHRONOLOGY OF THE DROUGHT AND ASSOCIATED DECISIONS

The combination of drought hydrology and the legal framework described in previous sections of this chapter resulted in a series of water management actions and other drought-related activities. The remaining chapters of Part II will detail this management. The chronology and summary of management actions shown in **Figure 1-3** will help guide the reader through drought management and represents an organizational tool for this water management report.

Conditions During 2000

In April 2000, it appeared that a normal wet season weather pattern was beginning. In response to six years of high water levels, a managed recession was planned and implemented for Lake Okeechobee, primarily during May and June of 2000. However, May 2000 was the driest month statewide in more than 100 years and the summer of 2000 saw the development and implementation of a water supply contingency plan, highlighted in the next section of the chapter. Drought conditions during 2000 got progressively more severe as the rainfall deficit continued throughout the South Florida Water Management District area. Many other signs of the emerging drought appeared in the fall of 2000, including high salinity levels in the Caloosahatchee River, increased navigational problems in Lake Okeechobee, construction of temporary forward pumping facilities to move water from the lake at low stages, and imposed water restrictions in 11 of 16 counties in the District. By the close of 2000, lake levels were causing widespread concern as water restrictions were being implemented by the District's governing board.

Conditions During 2001

The first half of 2001 produced the worst drought conditions seen in many decades, and phases I and II water restrictions were imposed over most of the District early in 2001. Levels in Lake Okeechobee continued to fall, and the lowest level since record keeping began was recorded in May 2001. Nevertheless, early in 2001 the lake began to display a number of positive impacts from the low water levels, including growth of submerged plant beds, expansion of bulrush stands, very clear water with low phosphorus concentrations, and oxidation and consolidation of lake sediments. The Lower West Coast was being impacted by falling groundwater levels, and there was an increasing risk of saltwater intrusion. As the summer wet season approached, pumping was stopped on lake canals, and backpumping into the lake began for water supply purposes. Deviations from Water Conservation Area floor elevations were implemented in late spring affecting the amount of water available to the Lower East Coast, as modified phase II water restrictions were imposed on the Lower East and West Coast service areas.

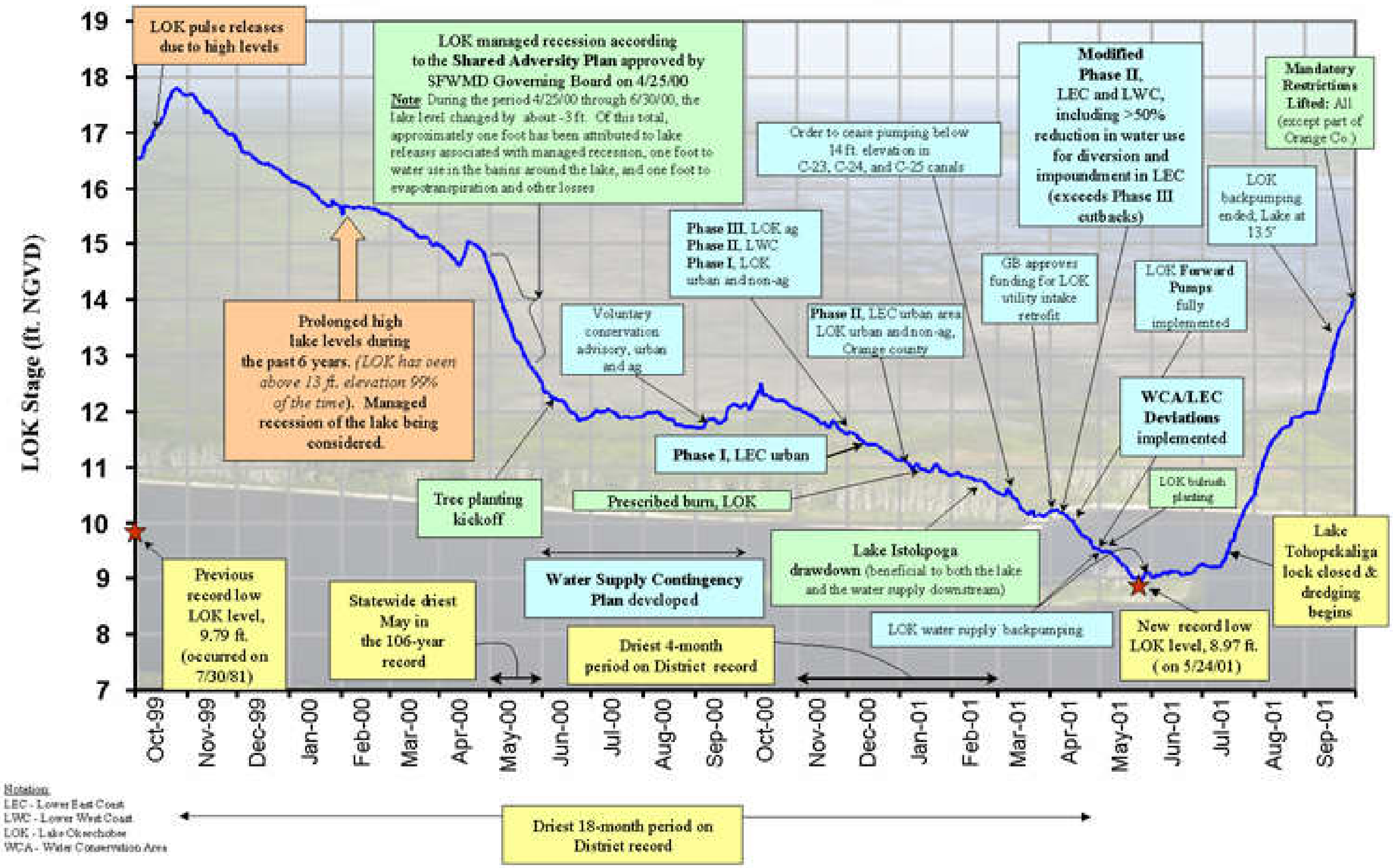


Figure 1-3. Chronology of the 2000-2001 drought

The wet season began in June and brought gradual relief from drought conditions. During the summer of 2001, water levels increased in District lakes and Water Conservation Areas. Both coastal discharges and releases into Everglades National Park increased sharply in August and September, accompanied by renewed inflows and outflows to the Stormwater Treatment Areas. Most specific responses to drought conditions were not necessary after September 2001 and the District resumed routine, seasonal water management activities.

WATER SUPPLY CONTINGENCY PLAN

During the summer of 2000 the District developed a Water Supply Contingency Plan that described measures that could be taken in response to the emerging drought. The plan was a compilation of short-term water management options that could be implemented at the advent of emergency water shortage conditions. This plan was implemented during the 2000–2001 dry season.

During the summer of 2001 the District began updating the Water Supply Contingency Plan for implementation during the 2001-2002 dry season. The list of water shortage management options was updated based on lessons learned over the previous year. Each option was then described and analyzed with respect to implementation factors, costs, and benefits. Before the plan could be finalized, normal rainfall returned and the water supply situation improved significantly. The second iteration of the Water Supply Contingency Plan was never finalized, and remains in draft form. It is available to serve as a starting point for future water shortage situations. Some of the major features of the draft plan are described below.

Option Implementation Matrix

The matrix (**Table 1-1**) was developed to show relationships among factors that are considered during the water shortage management decision process. The matrix contains information on the water shortage severity that should exist, the appropriate time of year, costs and benefits, and other considerations associated with each option. Each option was evaluated on this basis and placed into one or more of four categories, based on whether the option could be appropriately implemented during moderate, severe, extreme, or critical water shortage conditions. The implementation process reflected in this matrix was based on existing policies adopted by the South Florida Water Management District governing board over the course of the drought.

Severity: The severity of water shortage, as incorporated within the Option Implementation Matrix, is defined based on consideration of the following factors:

Lake Okeechobee stage/storage

Water Conservation Areas stage/storage

Local groundwater and surface water conditions

Timing: The appropriate time to implement the option, for maximum effectiveness, was also determined. Some options can be implemented year-round, while others can only be effective when water levels are above or below certain levels.

Costs and Benefits: Relative benefits and costs of options vary widely. Costs are defined to include environmental effects, as well as monetary expenses. The amount of water supply benefit that can be realized from any given option also varies and, in some cases, cannot be quantified in advance.

Table 1-1. Water supply contingency options implementation matrix

Option	Water Shortage Severity[2]			Season to Implement[1]		Costs	Benefits	Other Considerations
	Lake Okeechobee	Water Conservation Areas	Local GW/SW Conditions	wet	dry			
1. Lake Okeechobee Backpump & Augmentation	M, S, E, C	N/A	N/A	x		$855K	371K ac-ft	WQ impacts
2. Water Conservation Area Schedule Deviations	S, E, C	S, E, C	S, E, C		x	Staff time	(34-38% less demand on LO)	MFL violation environ. impacts
3. Upper Chain of Lakes Operational Flexibility	M, S, E, C.	M, S, E, C	N/A	x	x	Staff time	Environ., WQ improve.	Recreation loss environ. benefits
4. Cloud Seeding	C	C	C	o	x	Yr 1: $950K Yr 2: $750K	30-60% rain-fall increase	Ancillary WQ, environ. + flooding
5. Modified Supply Side Man-agement (yellow book)	M, S, E, C	N/A	N/A	o	x	Staff time	More equitable restrictions	MFL violation
6. Revise BMP Makeup Water Deliveries	M, S, E, C	M, S, E, C	M, S, E, C		x	Staff time	160K ac-ft	STA, WQ impacts
7. Water Shortage Triggers	M, S, E, C	M, S, E, C	M, S, E, C	x	x	$80K admin	Resource-based trigger	Changes in value of water; user impacts
8. Minimize Deliveries to Maintain LEC Canal Levels	S, E, C	S, E, C	M	o	x	Lower op. cost; High poss. impact	40K ac-ft + environ. benefits	MFL violation SW intrusion
9. Diversion and Impoundment Operations	S, E, C	S, E, C	S, E, C	o	x	Poss. local ag impacts	12K ac-ft/day + environ. benefits	
10. Southern Istokpoga Basin Operations	M, S, E, C	N/A	M, S, E, C	o	x	$48K pump costs	4K ac-ft	
11. STA Operations	M, S, E, C	M, S, E, C	M, S, E, C	o	x	(saves money)	35K ac-ft	STA vegetation, WQ impacts
12. Water Conservation BMPs For Water Shortage	M, S, E, C	M, S, E, C	M, S, E, C	x	x	varies	Up to 50% of demand	
13. Water Shortage Restrictions	M, S, E, C	M, S, E, C	M, S, E, C	x	x	$300-15000 per ac-ft	10-50 % reduction	Local Government responsibility
14. Forward Pumping	S, E, C	S, E, C	S, E, C	o	x	$2.5M+op and maintenance	266K ac-ft	Lower lake levels
15. Compr. Water Shortage Public Education Program	M, S, E, C	M, S, E, C	M, S, E, C	o	x	$1M	10-50% of PWS demand	
16. C-23, C-24, & C-25 Water Shortage Operations	N/A	N/A	E, C	o	x	Varies	.5 to .8K ac ft	Time to Implement
17. Caloosahatchee River At-Risk Utilities	S, E, C	N/A	M, S, E, C	o	x	$ 32 M to local utilities	Less frequent restrictions	Caloosahatchee WQ, MFL violation
18. Lake Okeechobee At-Risk Utilities	E, C	N/A	N/A	o	x	$2M	Reliability to 6 ft	
19. Ground Water At-Risk Utilities	M, S, E, C	M, S, E, C	S, E, C	o	x	Admin, monitor and report costs	Minimize local SW intrus. risk	
20. Water Supply Improvements for C-40 and C-41 Canals	S, E	N/A	N/A	o	x	$450K	34K acre-ft	
21. Local Government Enforcement	M, S, E, C	M, S, E, C	M, S, E, C	x	x	Staff time	Reduced water use	Local Government responsibility
22. District Enforcement	M, S, E, C	M, S, E, C	M, S, E, C	x	x	Staff time	$ collected; red. In water use	

[1] x= preferred; o =optional; [2] Severity is classified s follows: C = critical, E = extreme, S = severe, M = moderate

Other Considerations: Other conditions, issues, or events may play a role in the decision process, such as water quality or environmental effects, economic considerations, violations of Minimum Flow and Level (MFL) criteria, local government or other agency actions or participation, etc.

How Options are Implemented

Depending on the extent and nature of a drought, actions may be taken either regionally or locally. Regional actions involve operation of the canals, structures, and reservoirs of the primary water management system. Local options involve area-specific water use restrictions, or changes to local drainage, district, or utility operations.

An example of how the process of balancing timing, cost/benefit, and drought severity considerations worked during the period from October 1999 to June 2001 is presented in this report. The initial Water Supply Contingency Plan was developed beginning in June 2000. Due to conditions in Lake Okeechobee, implementation of features of this plan began immediately, even before the final document was completed.

Recommendations for implementation of available options are based on monthly Lake Okeechobee position analyses, which are computer simulations of projected lake levels under various rainfall scenarios, and projections of other relevant water conditions. The entire range of options is continually evaluated for implementation in an iterative fashion, based on existing water conditions, projected water conditions, current severity of water shortage and demand characteristics, option cost, environmental impact, and water supply benefit.

Water Shortage Team

The District established a water shortage team under the auspices of the Emergency Operations Center (EOC) to develop and implement the plan. As emergency situations threatened or occurred, Emergency Management activated the EOC to facilitate evaluation and incident planning, as well as implementation of emergency functions and resources.

FUNDING

Many of the options identified in the 2000 contingency plan were costly to implement and were also unbudgeted. The District governing board authorized $10,134,026 in emergency drought expenditures through August 2001. Since these expenditures were unbudgeted, a number of funding options was identified to support water shortage operations. The next iteration of the Water Supply Contingency Plan identified additional expenditures of $6,159,014, which were incorporated into the FY02 budget.

Chapter 2: Emergency Management

Olivia McClean

The South Florida Water Management District's (District's) Comprehensive Emergency Management Plan establishes the policies and procedures the District will use to prepare for, respond to, and recover from any and all emergencies. The plan is developed from an "all hazards" approach and is designed to address the management of District resources assigned to an emergency event, such as the water shortage. A nationally recognized management system known as the Incident Command System is used to organize the District's Emergency Operations Center (EOC) whenever it is activated.

In September 2000, the water shortage was becoming a threat to agricultural, environmental, and utilities' needs. Based on their concerns and on the precipitation forecast, the District's Executive Director activated the EOC under the direction of the deputy Executive Director for Water Resource Operations. The director of emergency management was charged with securing the appropriate District resources to effectively respond to the emergency situations. The Water Shortage Team, consisting of directors from impacted departments, was organized under the Incident Command System. Key staff members from various departments and with diverse expertise were organized under the EOC sections of water operations, response, logistics, finance, legal, and public information. Assignments to the water shortage emergency were made from the director of emergency management to the department directors for a specific length of time, depending on the assignment. Many duties required full-time dedication to the water shortage situation, and regular duties were re-assigned within the impacted department.

The EOC was activated at level 2 (partial activation). It operated approximately 12 hours a day and remained activated until July 2001.

The District's EOC served as the information clearinghouse, event coordination center, records management area, and central working area for the management team. This allowed for quick decision making and the necessary coordination among the various groups involved in the operation.

The EOC conducted daily briefings, at which time each section reported on its areas of responsibility. A weekly briefing was held for the executive management group. Weekly situation reports summarizing key actions taken by the District were distributed to the governing board, the state EOC, the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), and the Florida governor.

A weekly action plan for the upcoming operational period was developed during a planning meeting that outlined specific assignments for each section.

COORDINATION WITH THE STATE EOC

The District's EOC remained in constant contact with the state EOC during the water shortage emergency. The state EOC continued to monitor the situation and prepared contingency plans for delivery of emergency water supplies in case a utility become inoperable. Statewide conference calls were held weekly with water management districts, the FDEP, the Florida

Department of Emergency Management (FDEM), FDACS, and Federal Emergency Management Agency (FEMA). In addition, the District's EOC provided both a weekly and a biweekly situation report to the state EOC.

Chapter 3: System Operations

Susan Gray, Paul McGinnes, Gary Goforth and Tom Kosier

SUMMARY

Management of the Water Conservation Areas (WCA) and the South Dade Conveyance System (SDCS) during the drought involved operating according to approved schedules. Temporary deviations from approved schedules were sought and obtained to maximize operational flexibility while protecting environmental resources. To a large extent, the successes in obtaining temporary deviations to the minimum water level regulation schedule relied on the timely hydrodynamic predictive modeling and ecological assessment reports prepared by District staff. This information was provided to the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS). These reports revealed no significant ecological impacts due to the temporary deviations. Water levels in the Loxahatchee National Wildlife Refuge (WCA-1) fell below the normal minimum water level regulation schedule for approximately four weeks (May 2001). During this time the WCA was operated in accordance with the approved temporary minimum water level regulation schedule, thereby avoiding the need to bring water into the WCA from Lake Okeechobee or other sources while making water supply releases to the Lower East Coast Services Area – 1 (LECSA-1). Rains that began in mid-May returned the WCA to non-critical water levels by mid-June 2001. Water levels within WCA-2 were already below both the normal and approved lower minimum water level when a temporary deviation was approved in late April 2001. With the May rains, water levels returned to normal in WCA-2 by mid-June 2001.

LAKE OKEECHOBEE MANAGEMENT

Lake Okeechobee water levels fell to historic lows because of the drought. Initially the 2001 rainy season generated only average rainfall, hampering the lake's recovery and raising the possibility of even more severe water shortages during the approaching dry season.

In anticipation of these historic lows the South Florida Water Management District secured a pump vendor and several contractors to manufacture and install a temporary pumping system at structures S-351, S-352, and S-354. The system was designed so all components could be installed, operated, and removed at each structure without modifications. In March 2001, as the lake levels approached 10 feet, a total of 14 100-cfs pumps and system components were installed at a cost of $2.3 million. The pumps were operated an average of three days a week and provided needed irrigation to the surrounding farm communities. The pumps delivered 92,904 ac-ft during this period, as the lake reached an all-time low of 8.97 feet. They were removed in August 2001. Several of these pumps have been designated for permanent installation in new District structures.

The water intakes for the City of Fort Myers and Lee County potable water supply plants are located on the C-43 canal at Olga, approximately one mile upstream of the W.P. Franklin Lock and Dam (S-79). During periods of negligible discharge at S-79, saltwater intrudes up the estuary to the lock and dam and eventually upstream of S-79 and into C-43. As a result, chloride concentrations at the water plant intakes can reach unacceptable levels (>200 ppm). In response, water supply releases are made from Lake Okeechobee to flush chlorides from the system. Two such releases occurred during the drought. The first occurred as a pulsed release over a five-day period in November 2000 (November 22 through 26) and peaked at 1,563 cfs on November 23,

2000. The release totaled about 9,100 ac-ft. The second release occurred as a pulsed release over a six-day period in January 2001 (January 4 through 9) and peaked at 1,968 cfs on January 7, 2001. The release totaled about 9,100 ac-ft. Both releases successfully flushed chlorides from the top five meters of the seven meter water column. Use of bubble curtains at the lock, as well as limited lockage, helped retard further saltwater intrusion. A minor rain event in early April resulted in 1,900 ac-ft of discharge at S-79, which helped keep chloride levels low at the plant intakes. Rains began in late May, and high chloride ceased to be a problem.

As a result of these and other effects of the drought, the District's Executive Director declared a water emergency on March 27, 2001. The District governing board subsequently concurred with the decision in an emergency board meeting that same day. In response to the declared water emergency, the Florida Department of Environmental Protection (FDEP) issued the first Emergency Final Order (OGC no. 01-0715) on April 27, 2001. This order authorized the District to initiate water supply backpumping into the lake through the existing structures at S-2 and S-3 at the south end of Lake Okeechobee. In the ensuing months, as the drought continued and concerns escalated regarding the impending dry season, the FDEP issued a second Emergency Final Order (OGC no. 01-1202) on August 3, 2001. This order authorized the District to continue water supply backpumping and also allowed augmentation of the pumping and gravity flows of water into the lake through the structures at S-4, S-77, S-308, S-352, and culvert 10-A. In addition, the District was authorized to install temporary pumps to backpump supplemental water as necessary. Operation of the temporary pumps did not occur, however, because increased rainfall during the latter part of the rainy season, as well as gravity inflow through key structures, sufficiently raised lake water levels before the pumps became operational.

During the backpumping and recession period from June 1 through September 21, 2001, augmentation activities contributed 575,726 ac-ft, or approximately 39 percent of the total inflow, to Lake Okeechobee (**Table 3-1**). From June 1 to September 21, 2001, the lake's contributing basins received 26 to 37 inches of rainfall as the lake's stage rose from 9.0 to 13.5 feet, with the largest increase occurring in September (**Table 3-2**). Flow augmentation and backpumping operations, coupled with the increased rainfall during the latter part of August and early September, sufficiently raised Lake Okeechobee water levels to allow the discontinuation of the activities authorized by the Emergency Final Orders on September 21, 2001. The full report detailing the Lake Okeechobee backpumping and augmentation activities is included as **Appendix 3A-1.**

Table 3-1. Summary of inflows for June 1, 2001 through September 21, 2001, water supply backpumping and water supply augmentation sites and total inflow for all lakewide sites

STATION	Total Inflow		% of lake-wide inflow total
	Cfs-days	Acre-feet	
S-2	98,882	196,129	13%
S-3	65,324	129,569	9%
CULV10A (L-8)	37,753	74,881	5%
S-77	34,916	69,255	5%
S-308	45,860	90,962	6%
S-4	6,072	12,044	1%
S-352	1,455	2,886	<1%
Total for above sites	**290,262**	**575,726**	**39%**
% lake-wide of all inflow	**39%**	**39%**	**39%**
Lake-wide inflow total	**741,275**	**1,470,298**	**100%**

Table 3-2. Lake stage and rainfall for Lake Okeechobee and vicinity

Month/Date	USACE STAGE Data. Daily Lake Average in ft (NGVD)		Monthly total of SFWMD provisional 24-hour rainfall (inches), starting on the first of each month and ending at 7:00 a.m. EST on the indicated date							
	Beginning	Ending	EAA West	EAA East	Lake Okee-chobee	Upper Kissimmee	Lower Kissimmee	East Caloos.	Martin, St. Lucie County	Palm Beach County
June / 30	9.01	9.27	6.51	6.12	5.69	8.04	6.58	6.56	7.44	6.56
July / 31	9.26	10.53	7.14	8.24	9.07	8.44	8.89	13.44	11.71	9.41
August / 31	10.61	11.98	4.53	5.78	6.19	6.67	4.53	8.48	8.18	7.95
September / 21	11.96	13.56	8.21	6.24	7.80	9.87	8.47	9.04	7.31	9.86
Total	**9.01**	**13.56**	**26.39**	**26.38**	**28.75**	**33.02**	**28.47**	**37.52**	**34.64**	**33.78**

STORMWATER TREATMENT AREA MANAGEMENT

BACKGROUND

The Stormwater Treatment Areas (STAs) are large constructed wetlands designed to reduce the levels of phosphorus entering the Everglades Protection Area. Four of the six STAs that comprise the Everglades Construction Project (ECP) are fully operational and total over 18,000 acres. The remaining two are under construction and should be completed by October 2003. A schematic of the STAs is presented in **Figure 3-1**. The STAs will reduce phosphorus levels from stormwater originating from the Everglades Agricultural Area (EAA), the C-139 and C-51 West basins, and Lake Okeechobee releases prior to discharging into the Water Conservation Areas. The long-term phosphorus removal mechanism for the STAs is the growth and subsequent deposition of organic matter as new sediment, or accumulation of peat.

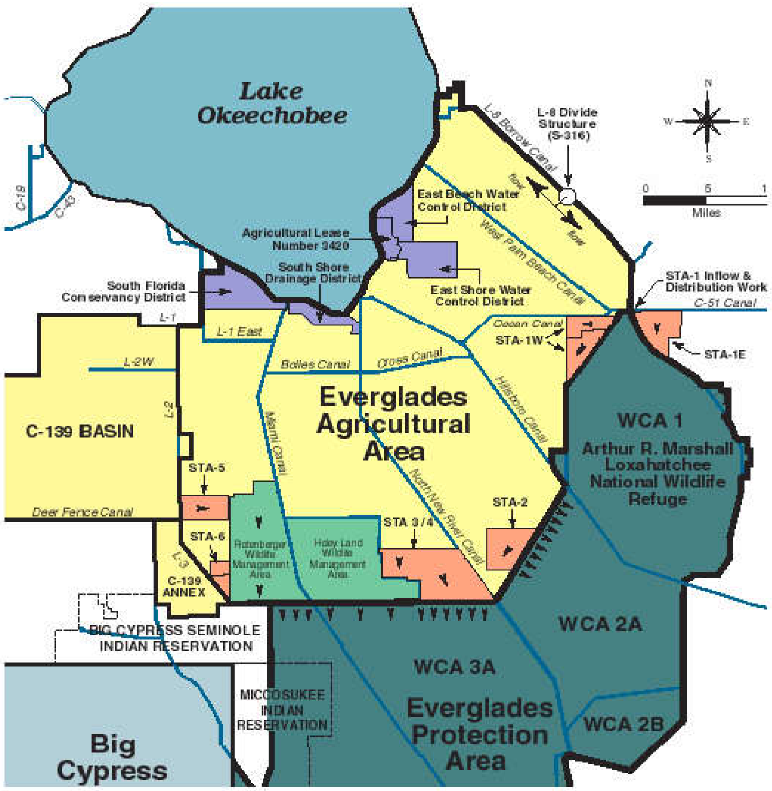


Figure 3-1. Overview of the Everglades Construction Project

The success of the STAs in removing phosphorus is directly linked to the health and viability of the vegetated communities within the STAs and the soil's ability to retain phosphorus. Even during dry weather (including drought conditions) it is important that these vegetated communities receive enough water to ensure they can effectively remove phosphorus during future storm events. Three critical water depth thresholds are used in operating the STAs for vegetative health:

1. Optimal performance. Three general types of vegetated communities are used in the STAs: cattail; sawgrass and other mixed-marsh species; and submerged aquatic vegetation (SAV).

For optimal phosphorus removal performance it is necessary to maintain normal operating depths of 18 to 24 inches above average ground level.

2. Net improvement. To ensure that the organic sediment within the STAs does not release phosphorus when exposed to the air, the operational target for the STAs is to maintain a minimum depth of six inches above average ground level.
3. Vegetation viability. Based on the best available scientific information, the three vegetation communities have unique minimum-depth requirements for keeping the vegetation alive and healthy. For cattail, the stress threshold is approximately six inches below the ground. For sawgrass and other mixed-marsh species, there apparently is no mortality threshold. For SAV, the mortality threshold is approximately six inches above the ground.

The potential impacts of dryout within the STAs will vary depending on site-specific soil, vegetation, and hydrology.

Death of wetland vegetation due to dehydration is a major factor in STA operation related to drought conditions. The growth of undesirable vegetation (exotics, dog fennel, and other terrestrial species) as the organic soil is exposed to the air is another STA issue. Following a low-water period, resuspension and release of phosphorus from the soil into surface waters upon re-wetting can impair the wetland's ability to retain phosphorus. Once the area is re-flooded, there may be a period of a year or more during which phosphorus reduction may be greatly decreased, depending on the severity of the drought and the health of the vegetation upon re-wetting. It may be necessary to take individual treatment cells offline as the STA vegetation re-grows before the cell produces a net reduction in phosphorus, as required by permit.

Finally, there is evidence that dryout and subsequent re-wetting of these systems may stimulate the mercury methylation process, which may result in potential risks to wildlife both at the site and downstream in the Everglades.

In addition to the biological basis for maintaining minimum depths within the STAs, there are also relevant legal and regulatory concerns. The District is party to a federal Everglades Settlement Agreement that establishes STA performance targets. To the extent that drydowns adversely affect the STAs' ability to achieve performance targets, there may be legal consequences. The STAs are subject to state and federal operation permits that establish minimum performance targets and operational requirements to ensure that performance targets are met. Non-compliance could potentially result in enforcement action against the District.

STA Operations

STA operations during the 2000–2001 drought were based on the philosophy of "shared adversity" with other water users. Due to extreme drought conditions, water levels dropped below the optimal water levels for phosphorus reduction within the STAs. In addition, the drought's severity resulted in water levels dropping below the minimum operational target of six inches in all the cells, a level typically associated with maintaining a net reduction of phosphorus. The shared adversity philosophy was manifested in an operations strategy designed to supply just enough water to keep the vegetation alive. In STA-5, during the drought cattail cells fell below the assumed stress threshold of six inches below ground for a period that did not exceed 90 days. STA-6 is predominantly mixed marsh and sawgrass. It was believed that both community species could remain viable during and following dryout, so no supplemental water was delivered.

STA-1 WEST

STA-1 West contains five treatment cells and more than 6,670 acres of wetland vegetation. Treatment cells 5A, 1, 2, and 3 are comprised predominantly of cattail and other emergent vegetation, with significant quantities of SAV. Treatment cells 4 and 5B are dominated primarily by SAV. During the 2000–2001 drought approximately 830 ac-ft of water were delivered to STA-1W to maintain viability of the vegetation. Water deliveries also were made to cells 4 and 5 to ensure SAV viability.

STA-2

STA-2 contains three treatment cells and more than 6,430 acres of wetland vegetation. Treatment cells 1 and 2 are comprised predominantly of sawgrass and other emergent vegetation. Treatment cell 3 is dominated by SAV. During the 2000–2001 drought approximately 400 ac-ft of water were delivered to STA-2 to maintain the viability of vegetation in cell 3.

STA-5

STA-5 contains four treatment cells and more than 4,100 acres of wetland vegetation. Treatment cells 1A, 2A, and 2B are comprised predominantly of cattail and other emergent vegetation. Treatment cell 1B is dominated by SAV. During the 2000–2001 drought approximately 3,027 ac-ft of water were delivered to STA-5 to maintain viability of the SAV in the downstream cells. Initially the operations relied on the existing water supply and seepage return pumps that delivered water to the STA's upstream (cattail vegetation) portion. However, after observing the small amount of water that traversed the cattail community from the upstream to the downstream cells, future water supply deliveries were made via a leased, portable pump installed on the levee directly into cell 1B. During the drought the cattail cells fell below the assumed stress threshold of six inches below ground for a period that did not exceed 90 days. Water quality and limited biological data collected subsequent to the drought were evaluated to determine the 2000–2001 drought's impact on the STA's performance.

STA-6

STA-6 contains two treatment cells and approximately 870 acres of wetland vegetation. Both treatment cells are comprised predominantly of grasses and other emergent vegetation. During the 2000–2001 drought, no supplemental water was delivered to STA-6. Water quality and limited biological data collected subsequent to the drought were evaluated to determine the drought's influence on the STA's performance.

WATER CONSERVATION AREA MANAGEMENT

INTRODUCTION

The five Water Conservation Areas (see **Figure 3-1**) were constructed as part of the Central and South Florida Project (C&SF Project). Collectively, these areas provide a detention reservoir for excess water from the Everglades Agricultural Area, parts of the Lower East Coast (LEC) planning area, and flood discharge from Lake Okeechobee. The WCA levees prevent Everglades floodwaters from inundating East Coast urban areas and retain water that can later be supplied to East Coast areas and Everglades National Park. In addition, these levees help maintain higher water levels that provide recharge to surficial aquifers, ameliorate saltwater intrusion in coastal basins, reduce seepage, and benefit Everglades fish and wildlife.

In general the WCAs provide water during the dry season to three Lower East Coast service areas. Lower East Coast Service Area 1 (LECSA-1) includes that part of Palm Beach County east of WCA-1 and a small part of Broward County. Lower East Coast Service Area 2 (LECSA-2) includes that part of Broward County east of the WCAs and south of the Hillsboro Canal basin and the C-9 Canal basin in northern Miami-Dade County. Lower East Coast Service Area 3 (LECSA-3) includes that portion of Miami-Dade County east of WCA-3B and Everglades National Park, as well as the Florida Keys. All three service areas are heavily urbanized and have experienced rapid growth for several decades.

Water levels within the WCAs are managed according to schedules established by the U.S. Army Corps of Engineers (USACE). The WCA regulation schedules represent seasonal and monthly limits of storage. This seasonal range permits the storage of runoff during the wet season for use by the Lower East Coast service areas and Everglades National Park during the dry season. In addition, the regulation schedules help maintain and preserve native plant communities, which are essential to fish and wildlife.

The regulation schedules establish minimum water levels below which water releases are not permitted due to anticipated adverse environmental impacts. However, the schedules permit water to be "passed through" the WCAs. This can be accomplished by sending water to the WCAs from another source (Lake Okeechobee, for example), and then releasing it to the service areas on an equal-volume-in/equal-volume-out basis.

REQUEST FOR TEMPORARY DEVIATION

In December 2000 the District determined that, because of then-current water levels within the WCAs and Lake Okeechobee, and in anticipation of the coming dry season, water levels within the WCAs had the potential to fall below the regulation schedules' minimum water levels. In addition, the District recognized that the ability to "pass through" water from the lake to the Lower East Coast service areas could be compromised due to an inability to move water from Lake Okeechobee to the WCAs. As Lake Okeechobee levels decreased to stages of 10.0 ft-NGVD and lower, it was virtually impossible to move water south from Lake Okeechobee into the WCAs. One option the District considered was that of seeking "temporary deviations."

On March 29, 2001, as lake levels continued to decline toward record lows, the District formally requested a temporary deviation from the minimum water level schedule for WCA-1 from the USACE. The request to lower the schedule for the minimum water level from 14.0 ft-NGVD to 11.0 ft-NGVD was made to "protect the public water supply wellfields in Service Area 1 from saltwater intrusion." The temporary deviation allowed releases to be made to the LECSA-1 from the WCA without the need to "pass through" water from Lake Okeechobee or other sources. The releases from WCA-1 to the LECSA-1 occurred until the temporary minimum water level schedule was reached.

On April 4, 2001 the District made a similar, formal request to the USACE for a temporary deviation to the minimum water level regulation schedule for WCA-2. The request temporarily lowered the minimum water level from 11.0 ft-NGVD to 10.0 ft-NGVD and limited water releases to the South Dade Conveyance System (SDCS) through SFWMD structure G-211. This allowed water supply releases to be made from WCA-2 to the LECSA-2 until the temporary minimum water level schedule was reached without the need to "pass through" water from Lake Okeechobee or other sources. Restricting the releases to the SDCS through the G-211 structure would conserve water in WCA-3.

On April 9, 2001, District staff members were invited to attend an "informal consultation" with the USACE and the USFWS. Under section 7 of the Endangered Species Act of 1973, the USACE was required to consult with the USFWS on the two formal requests for temporary deviations, described above, that the USACE had received from the SFWMD. In essence, the USFWS was charged with determining whether the requested deviations would have a "significant impact" on any endangered species living in or near WCA-1 and WCA-2. At this informal consultation, SFWMD staff presented hydrodynamic modeling information and the draft of a report on then-current ecological conditions (*Ecological Impacts of Drought in the Water Conservation Areas*) to assist the USFWS in making its determination.

As a result of this meeting, the District modified its requests for the two temporary deviations. The original requests were for lowering the minimum water level schedule abruptly from the normal level to the lower level. However, at the meeting it was agreed that lowering the levels gradually over a period of several weeks would be more environmentally sound and would provide nearly the same water conservation benefits as the originally requested deviations.

On April 25, 2001 the District hosted a USACE-sponsored "public meeting" describing the District's modified requests. The USACE gathered additional comments and suggestions from the public to assist in reaching a decision on the two District requests.

On April 26 the District made a similar, formal request to the USACE for a temporary deviation to the minimum water level regulation schedule for WCA-3. The request sought to temporarily lower the minimum water level schedule to 6.5 ft-NGVD from the normal 7.5 ft-NGVD. Although not granted, the temporary deviation would have allowed water supply releases to be made from WCA-3 to the LECSA-3 until the temporary minimum water level schedule was reached without the need to "pass through" water from Lake Okeechobee or other sources.

Additionally, on April 26 the District received a copy of a letter from the USFWS to the USACE. In summary the USFWS found "no significant impacts" from the modified requests for temporary deviations to the schedules for WCA-1 and WCA-2.

On April 30, 2001 the District received approval from the USACE for the modified requested temporary deviations to the minimum water level schedules for WCA-1 and WCA-2.

On May 4, 2001 the District received a letter from the USACE clarifying its position on the operation of structure G-211 referenced in the District's request dated April 4 (described above). In summary, the USACE concluded that "termination of the water supply deliveries to the SDCS is in accordance with approved water control plans and, therefore, does not require a deviation."

On May 10, 2001 the District received a copy of a letter to the USACE from the USFWS concerning the District's request for a temporary deviation to the minimum water schedule for WCA-3 (described above in the April 26 letter). In this letter, the USFWS was concerned that approving the requested deviation to the minimum water level schedule would "lead to adverse impacts." This finding led the USACE to begin discussions with the District on the USACE's responsibility to conduct a full "Environmental Impact Statement" (EIS) on the potential effects of the deviation request. The two agencies informally agreed that in the time it would have taken to complete an EIS (six months), the wet season would by that time already have begun and the need for a temporary deviation would have passed. For this reason, an EIS in support of the requested deviation was not initiated.

Chapter 4: Water Demand Management

Bruce Adams, Kurt Leckler, Joel Van Arman,
Robert M. Brown and Patricia Walker

SUMMARY

The South Florida Water Management District (District) has a long history of promoting voluntary water conservation under normal rainfall conditions and routine water management activities. During times of drought, the District may declare mandatory water use restrictions to prevent serious harm to the region's water resources. During the 2000–2001 drought, the District imposed phase II and phase III mandatory water use restrictions over a large portion of the area under its jurisdiction. Local governments enforced the restrictions on small-volume water users that were not required to obtain a water use permit from the District. The District enforced restrictions on larger-volume water users that were required to obtain a water use permit from the District. The District also processed variance requests from water users seeking relief from the provisions of the mandatory water use restrictions.

INTRODUCTION

This section describes the menu of options that the District may use to reduce water demand. These options range from routine water conservation to mandatory water use restrictions imposed during time of serious water shortage. The District's Water Shortage Plan describes four phases (I-IV) of mandatory water use restrictions designed to obtain 15 percent, 30 percent, 45 percent, and 60 percent reductions in water use. The plan also provides provisions for obtaining a variance from the restrictions under certain circumstances.

WATER CONSERVATION

The District has a long history of promoting voluntary water conservation. The water conservation program is aimed at educating the public to reduce water usage for each type of use to the lowest level economically feasible. This program is geared to normal rainfall years and routine hydrologic circumstances. When deficit rainfall periods occur, the techniques involved in wise water use often become the components of mandatory water use restrictions. Those behaviors practiced voluntarily during non-drought periods become required behaviors during a water shortage crisis. All wise water use practices within the District's water conservation program can be applied during a drought, thereby reducing the need to impose mandatory water use behavior. Water users who practice a true water conservation ethic rarely feel the impacts of drought and should not be overly impacted in their water use by the imposition of mandatory water shortage restrictions. Mandatory restrictions are aimed at bringing water users who waste the resource to a level of use similar to that of those who practice water conservation as a way of life.

MANDATORY WATER USE RESTRICTIONS

The South Florida Water Management District governing board issues water shortage declarations requiring mandatory water use restrictions only when the physical impacts of drought threaten serious harm to the region's water resources. In contrast to the routine water conservation efforts discussed above, mandatory restrictions are imposed as emergency water management actions in response to extreme hydrologic conditions. In November 2000, after a general call for water conservation, District staff and the governing board determined a need to impose mandatory water use restrictions on South Florida residents because of a pending threat of serious harm to the region's water resources. To lessen the drought's impact and corresponding disruption to the regional economy and residents' lifestyles, the District decided to ease South Florida into water use restrictions by first declaring a phase I, or moderate, water shortage in most of the District.

On November 29, 2000, the District's executive director declared a water shortage emergency for non-agricultural uses from Lake Okeechobee and connected surface waters within the Everglades Agricultural Area water use basin, the lakeshore perimeter water use basin, the Caloosahatchee River water use basin, portions of the Indian Prairie water use basin, and the St. Lucie River water use basin and imposed phase I water use restrictions in these areas. A water shortage emergency was also declared for agricultural uses in these same water use basins and phase III water use restrictions were imposed. A water shortage emergency and phase II water use restrictions were imposed within the Caloosahatchee River water use basin, the Caloosahatchee River Watershed North, the Caloosahatchee River Watershed South, the western-most portion of the South Hendry County/L-28 Gap water use basins, the Fakahatchee North water use basin, the Fakahatchee South water use basin, the Big Cypress water use basin and the coastal Collier County water use basin on November 29, 2000. On December 8, 2000, phase I water use restrictions were imposed for the South Dade Water Conservation Area/Everglades National Park, Water Conservation Area 3, Water Conservation Area 2, Water Conservation Area 1/C-51, the M Canal, C-18, the Loxahatchee River, the North Palm Beach County and the interior Palm Beach County water use basins. These water emergency declarations were approved by the District's governing board at its meeting on December 14, 2000.

After about a month of phase I restrictions, it became apparent that to protect the region's water resource from the potential impact of saltwater intrusion into public water supply aquifers, a phase II, or severe, water shortage declaration was necessary. Lake Okeechobee is the reserve water supply for most of the Lower East Coast and parts of the Lower West Coast and Upper East Coast. Because of record-low water levels in the lake, this potential recharge source was in jeopardy. Reducing water demand on the coasts lessened the need to recharge coastal well fields from the lake. On January 11, 2001, the District's governing board declared a phase II water shortage for both the Lower East Coast region and water use basins in the EAA, Indian Prairie, St. Lucie River and Lake Okeechobee areas. Modified phase II restrictions were also imposed in the Orlando metropolitan area based on the threat of sinkhole formation from record-low Floridan aquifer levels. The District received a significant amount of input from the major water use industries and public water suppliers regarding the potential economic impact to the region under a prolonged phase II declaration. The District did not anticipate relief from drought conditions until June, when the South Florida rainy season typically begins.

In March 2001, with no rainfall projected, the District was faced with declaring a phase III or extreme water shortage emergency. At the March governing board meeting, the District's executive director asked the governing board to declare a phase III water shortage emergency, an action never before taken on "demand management" restrictions. Previous water shortages had included phase III "supply-side" restrictions on water users taking water directly from Lake Okeechobee. The governing board approved a motion to impose phase III restrictions at its regular meeting on March 15, 2001, but the negative response to the board's action was strong and vocal. Consequently, the governing board directed District staff to analyze the economic threat/water-saving relationship and meet with concerned industries to devise an alternative. At a public meeting with District managers on March 21, 2001, many business owners expressed concern over the potential economic impact on their businesses and clients relative to the projected water savings in implementing phase III restrictions.

Protestors showed up at the District's special board meeting on March 27, 2001, and picketers gathered outside the District auditorium. At the meeting, District staff presented an alternative plan calling for a modified phase II declaration for the Lower East Coast and Lower West Coast regions. This plan met three criteria: reduce economic impact; meet or exceed the water saving potential of the existing phase III restrictions; and make the alternative restrictions enforceable to encourage compliance. Subsequent to this action, District staff continued to meet with the industry work groups to forge proposed changes to the other three phases of water shortage restrictions that would also meet the above criteria.

In September 2001, the governing board voted to rescind restrictions for those public water suppliers using at least 20 percent alternative water supply technologies, including water re-use and aquifer storage and recovery (ASR).

At its October 10, 2001 meeting, the governing board voted to rescind all water use restrictions and orders except those in place for the Orlando area (coordinating with the St. John's River Water Management District's modified phase II restrictions, which remained in effect).

LOCAL GOVERNMENT ENFORCEMENT

The District and the local governments within its jurisdiction shared responsibility for enforcing water shortage restrictions. Local governments were responsible for enforcing water use restrictions imposed on small-volume residential and commercial water users that do not use enough water to be required to obtain a water use permit from the District. The District was responsible for enforcing water use restrictions on larger-volume water users required to obtain a water use permit from the District.

County sheriffs' offices, local police departments and municipal and county code enforcement officials are typically responsible for enforcing water shortage restrictions at the local level of government. The local government departments and agencies provided the funds for staff time to enforce water shortage restrictions. The District supplied warning tickets, water shortage violation tickets, and water shortage publications for distribution to assist in enforcement activities. When the District officially declared the water shortage in effect and subsequently imposed restrictions, members of the District's water shortage team and the District's regional service centers held a series of compliance/enforcement workshops. These workshops, or "cop shop" meetings, were held in those counties affected by water use restrictions to coordinate water shortage enforcement between cities and counties.

The District printed warning tickets (nicknamed "scarlet letters") and violation tickets and made them available to local sheriffs' offices and police and code enforcement departments. In addition, District staff worked closely with the court system and the local state attorney's office to develop a program that was enforceable and effective.

To track the effectiveness of utility water conservation programs and water supply delivery reductions during water shortages, the District's Water Supply Permitting Department produced monthly utility pumpage reports. The reports were produced each Friday before the next regularly scheduled governing board meeting to provide up-to-date information for the monthly Water Shortage Conditions Report presented to the governing board.

Complaint calls from the District's phone bank were mapped, and analyses of the calls indicated which communities had potential enforcement problems. In addition, service center staff compiled information from local governments within the county or area served by the service center. At the beginning of each week, local governments reported to the service centers regarding enforcement activities within their jurisdiction, providing details regarding the numbers of water shortage warnings, water shortage violations, and citations issued, as well as the number of fines imposed. District service centers held weekly teleconferences to monitor local governments' level of restriction enforcement. This forum made regional information available that located problem areas and assisted in the prompt identification and coordination of solutions. Local government enforcement information is provided in **Table 4-1**.

Table 4-1. Number of warnings and tickets issued, by county, during the water shortage

County	Warnings	Tickets
Broward	7985	2579
Charlotte[1]	N/R[2]	N/R[2]
Collier	778	1498
Glades	N/R[2]	N/R[2]
Hendry	N/R[2]	N/R[2]
Highlands	N/R[2]	N/R[2]
Lee	510	2345
Martin	N/R[2]	N/R[2]
Miami-Dade	358	234
Monroe	304	3
Okeechobee	27	0
Orange	393	0
Osceola	N/R[2]	N/R[2]
Palm Beach	8268	969
Polk[1]	N/R[2]	N/R[2]
St. Lucie	N/R[2]	N/R[2]
Total	18623	7628

[1] Part of county within District boundary
[2] N/R = No report

Smaller communities can quickly exhaust their staff resources when a water shortage is declared because of the additional compliance enforcement responsibilities. During the 2000–2001 drought in South Florida, the District provided funds to help these smaller communities augment their enforcement staff resources to ensure enforcement of water shortage restrictions.

Water shortage restriction enforcement occurred in every region within the South Florida Water Management District that was declared to be under a water shortage, and the water resource management benefits accrued locally and regionally.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT ENFORCEMENT

Due to the severity of the water shortage, as well as the possibility of imposing phase III water restrictions in the urban areas, the District implemented a compliance/enforcement program to address potential water shortage violations by water users that are required to have a water use permit from the District. At the March 2001 governing board meeting, District staff presented an overview of the plan for implementing water shortage enforcement in both the agricultural and urban areas (see **Appendix 4A-1**, Exhibit 1), including proposed fines. Following the presentation, the District aggressively pursued compliance in accordance with the various water shortage orders. The agriculture component was comprised of inspections conducted both by air and on the ground. Compliance of this initiative was pursuant to Water Shortage Order number 2000-172 DAO-WS. The urban component was conducted primarily on the ground. Compliance with this initiative was pursuant to Water Shortage Order numbers 2001-04 DAO-WS and 2001-048 (modified phase II). The effort involved the use of more than 50 staff members from various divisions within the District. Compliance sweeps were conducted in shifts on non-watering days, including weekends, and after hours, with a shift commencing at midnight.

Overall, the District identified 708 violations during the water shortage effort, and had collected approximately $300,000 in penalties and costs. Largely because of internal training and the dissemination of detailed guidelines for properly documenting enforcement cases, the District was able to successfully resolve the majority of the enforcement actions taken.

URBAN ENFORCEMENT

District staff from numerous departments conducted compliance inspections, also known as "sweeps." The locations of the sweeps were determined both randomly and through complaints received by the District's phone bank. Using a field report form specifically designed for the water shortage (see **Appendix 4A-1**, Exhibit 2), District staff documented unauthorized uses of water and District right-of-way. The District trained all compliance enforcement staff regarding the use of the forms, as well as how to properly document a violation (i.e., photographs, time, date, and the inspector's name). All field reports were submitted to the Water Use Division's Compliance Section and were reviewed and compared with permit files regarding unauthorized use of water. The Water Use Division maintained an updated ledger for those projects receiving variances, as well as those on reuse/mix, so that those projects were not inadvertently issued violation notices. For alleged violations in which it appeared that a structure (i.e., pump) had been placed on a District right-of-way, the District's Right-of-Way Division reviewed the field report and confirmed ownership. Once the field report was reviewed and the alleged violation was confirmed, the file was sent to the Environmental Resource Compliance Division's enforcement supervisor.

Based on the volume of water permitted for the project (extent of deviation), the number of previous offenses, and whether the water user had a valid permit, a penalty was assigned using a schedule that had been developed specifically for the water shortage (see **Appendix 4A-1**, exhibits 3 and 4). If the violation involved a District right-of-way, an additional fine was imposed for the infraction. A standardized "Notice of Violation/Short-Form consent agreement," which included the assigned penalty and any provisions the permit holder was required to implement to resolve the violation, was sent to the respondent (see **Appendix 4A-1**, exhibits 5 through 7). The permittee then had the option to either agree to the provisions of the consent agreement or refuse. If the permittee/respondent agreed to the consent agreement (by his or her signature), the District's governing board approved it at the next regular meeting. If the permittee/respondent refused to sign the consent agreement, staff referred the file to the District's Office of Counsel and requested litigation authority from the governing board to resolve the matter in court. If a permittee/respondent violated the provisions of the water shortage on more than one occasion or refused to cease, an increased penalty was imposed.

The District documented 708 alleged water shortage violations, of which 676 occurred in the urban area. Section 373.129, Florida Statutes, authorizes the District to collect civil penalties and costs associated with an enforcement action. The District deposited all civil penalties that were collected as the result of enforcement actions into the water management lands trust fund. Recovered staff costs were deposited into the District's general revenue fund. Because of significant staff time and resources involved with the water shortage, all civil penalties and costs were split on an even 50/50 basis.

AGRICULTURAL ENFORCEMENT

Immediately after implementation of phase III water restrictions in the Lake Okeechobee Service Area, Indian Prairie Basin, and the Upper East Coast, field maps were produced that contained the aerial coverage of the established sub-basins, boundaries of District-issued consumptive use permits (CUPs), and associated permit numbers. In addition, these maps contained locations of District structures, permitted pump locations and, later, the locations of those pumps that had approved variances. All maps were drawn to scale and were sized for field activities. An index referencing the permit numbers, the property name, and the general location of the permitted withdrawal point accompanied the sub-basin maps. The aerial photography base for the maps was extremely useful when pinpointing locations in the field, especially during helicopter fly-overs or when violations were discovered on properties that had no CUP.

Prior to implementing enforcement activities, public meetings were held with permittees in the sub-basins to discuss the restrictions, the variance process, and enforcement. The District encouraged each sub-basin to delegate a basin coordinator, but only the sub-basins within the Everglades Agricultural Area (EAA), and the C-44 basin did so. The EAA basin coordinator conducted meetings with stakeholders within those areas, while the District held meetings with the remaining permittees in other sub-basins. In those areas where no sub-basin coordinator was selected, the District established toll-free telephone information lines that allowed permittees to call for daily updates on water conditions in their area and inform them if pumping would be allowed that day. These information lines were updated daily by 6:00 a.m.

The District established enforcement teams to patrol the agricultural areas by land-based vehicles and helicopter. Team members were selected to enforce those areas with which they were most familiar. Normal business activities were coupled with enforcement during the week. A kickoff meeting was held with the selected team members, and the District provided information about water restrictions, the enforcement process, field documentation, scheduling, and lines of communication. Each Monday, team members were contacted to discuss the week's enforcement strategies and convey pertinent information regarding water conditions, operations, and approved variances. Weekend enforcement trips were scheduled on Wednesdays. The District's flight department was notified when flyovers were necessary.

Enforcement was typically performed in pairs, with each team possessing a hand-held Global Positioning System (GPS), a camera (film or digital), a cell phone, and appropriate maps and forms.

A separate enforcement form was prepared for the agricultural areas (see **Appendix 4A-1**, Exhibit 8). The agricultural form contained pertinent permit information, as well as space for listing the crop type and the specific violation observed. Field inspectors also obtained GPS coordinates for each violation, and this information was included on the enforcement form. In addition, several photographs depicting the violation were attached to the form, which was stamped with the time and date that the violation was observed. The location of the violation, as well as information about the inspector, was provided on the back of each form. The field enforcement forms were designed to keep violation information thorough, yet concise. The photographs and GPS coordinates proved crucial when assessed violations were challenged by water restrictions violators.

Enforcement was primarily conducted on "no pumping" days established by rule (i.e., canal stages), Supply Side Management operations, and/or water supply delivery schedules. However, overhead irrigation violations were documented throughout the week as team members were performing routine business activities in the field. Therefore, agricultural enforcement was consistently a five-day-a-week operation, with weekend trips being most frequent during February, March, and April. Weekend surveillance was conducted by land-based vehicle and by helicopter. Several weekend trips were also conducted during the evening (from 7 p.m. to 11 p.m.) by land-based vehicle, when canal stages monitored by Operations Department staff appeared to drop significantly during times when pumping was prohibited.

Enforcement teams were instructed to document violations, complete the required paperwork, and submit the information to the Environmental Resource Compliance Division (ERC) for processing and permittee/owner notification. Water shortage enforcement staff notified the property owners/operators directly only when immediate action was necessary. During the drought, two such events occurred when water supply deliveries were being made to the Water Conservation Areas, and the illegal pumping was documented. During those events it was crucial that no withdrawals occur from the canals conveying water to the target areas; therefore, immediate notification and action was necessary. All other notifications were handled through ERC staff. Of the 708 alleged water shortage violations documented by District staff, 32 occurred in the agricultural area.

VARIANCE REQUESTS

Both permitted and exempt water users are provided with the opportunity to request relief from the provisions of a water shortage declared under Chapter 40E-21, Florida Administrative Code (F.A.C.). Applicants must provide reasonable assurances that the variance will not otherwise be harmful to the District's water resources and must affirmatively demonstrate that one or more of the following circumstances exist:

4. The variance is essential to protect the public health or safety.
5. Compliance will require measures which, because of their extent or cost, cannot be accomplished within the anticipated duration of the water shortage.
6. Alternative restrictions that achieve the same level of demand reduction as the restriction from which a variance is sought are available, binding, and enforceable.
7. The applicant is a public or private utility that demonstrates that special circumstances exist that necessitate issuing a variance.
8. The applicant's water source includes an approved aquifer storage and recovery installation or a water reclamation project.

The District examines each variance petition individually to determine its applicability to one or more of the above criteria, and may issue relief for the designated restrictions within a single, specific governing board order. The variance expires simultaneously with the expiration of the board's order. The board may, at its discretion, extend a variance into another phase of a water shortage by a declaratory statement within the subsequent board order.

Variance petitions that request relief from restrictions due to the extent or cost of compliance within the anticipated duration of a water shortage (criterion 2) account for the majority of the variance petitions the District receives. These variances may be issued for the duration of a single water shortage event only and do not extend to future water shortage events. Rather, the petitioner is expected to exercise due diligence by modifying or repairing the water use system so it will meet the requirements of subsequent water shortage events.

The District may consider variance petitions from entities that hold valid water use permits or that obtain water from a public water supply (PWS) utility, and from individuals who are exempt from water use permitting (single-family homes and duplexes) pursuant to Chapter 40E-2.051, F.A.C. The District's governing board may not consider variance petitions for illegal uses of water. Variance petitions for uses that were not exempted by rule and were not supplied by a PWS, yet were withdrawing water without the benefit of a water use permit, were closed without action. Those variance petitions were returned to the senders, along with a set of permit application forms and a letter of instruction to obtain a water use permit.

During the 2000–2001 drought, District staff in West Palm Beach and at the Ft. Myers Service Center reviewed 1,052 variance petitions. The West Palm Beach Service Center received and reviewed 85 percent of the petitions, while the Fort Myers Service Center received and reviewed 15 percent of the petitions. The disposition of these reviews is shown in **Table 4-2** (also shown by percentage in **Figure 4-1**).

Four of the most common use types for which a variance was requested (community/ governmental/commercial landscape, 38 percent; single-family landscape, 29 percent; new landscape, 4 percent; and washing of vehicles and non-pervious surfaces, 11 percent) represented 82 percent of the total number of variance petitions received. Agricultural users seeking relief from the day/time Supply Side Management requirements comprised 6 percent of variance requests. Public water supply utilities (1 percent) requested enhancement of water main pressure and sought authorization to conduct water main flushing for safety purposes. Four motion picture crews working within the Lower East Coast requested permission to irrigate landscaping and to "slick down" roads for film production (< 1 percent) (**Figure 4-2**).

Table 4-2. Petition breakdown, West Palm Beach and Fort Myers

Approved	610
Denied	243
Withdrawn	71
Closed Without Action	128
Total	1052

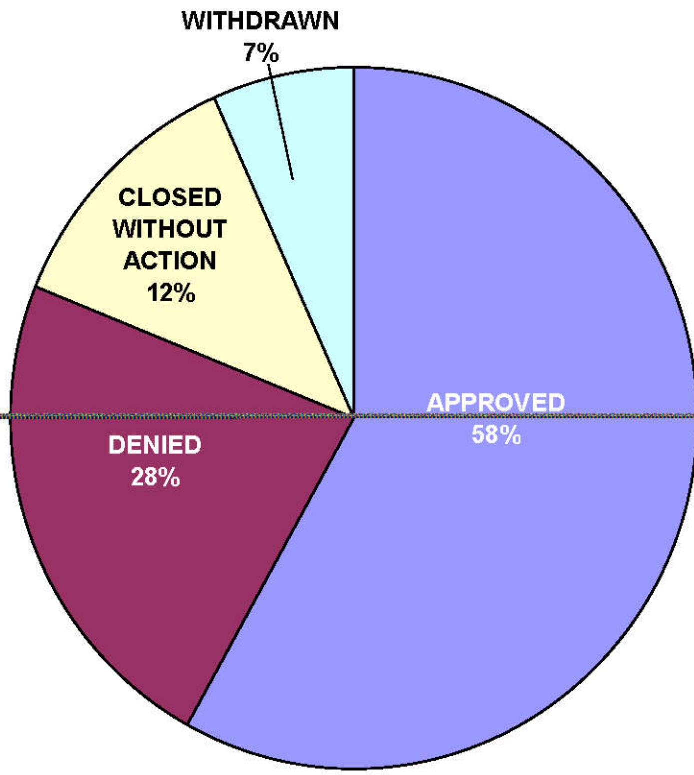


Figure 4-1. Variance requests by disposition

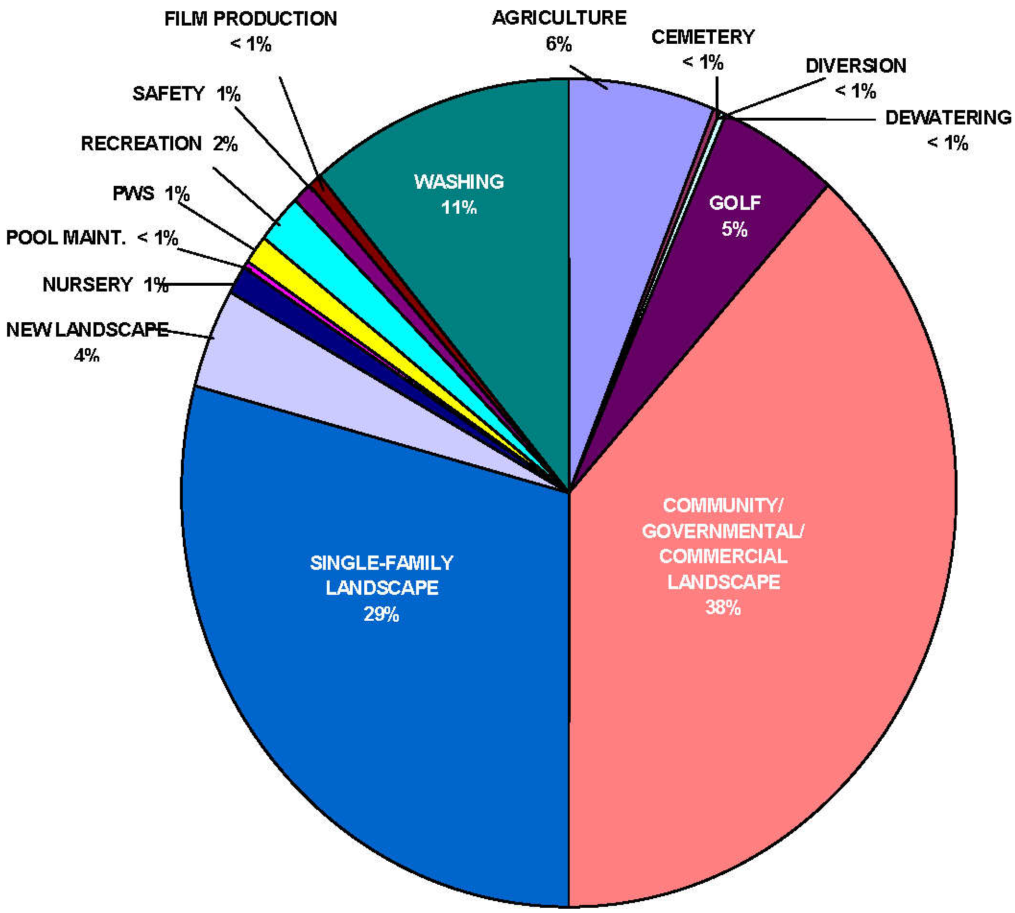


Figure 4-2. Variance requests by use type

Chapter 5: Lake Okeechobee Water Supply Management

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SUMMARY

The Supply Side Management documentation produced after the 1990–1991 drought (SSM1991) was used extensively again during the 2000–2001 drought. This chapter describes how the SSM1991 was used in the most recent drought and the modifications or variations that were required. It provides a summary of Lake Okeechobee allocation volumes, tabular histories of the allocation factors, and required changes to the reference stage. Finally, this chapter provides a brief description of the communication process between the South Florida Water Management District (District) and Lake Okeechobee water users.

INTRODUCTION

The South Florida Water Management District protocols for responding to a drought include careful management of available water supplies to extend the reasonable, beneficial use of the resource until rains return and replenish regional and local supplies. The 2000–2001 drought presented a special challenge because the low water levels extended well into the wet season. Existing drought management strategies, which addressed only dry-season shortages contained in the Supply Side Management Plan, had to be quickly modified to include wet-season conditions. This chapter details the Supply Side Management Plan and its application during the 2000–2001 drought.

SUPPLY SIDE MANAGEMENT

As part of the overall Water Shortage Plan (SFWMD, 1991) the Supply Side Management (SSM) protocol was designed as a guide for implementing water use restrictions and management alternatives associated with Lake Okeechobee during declared water shortages. Written in 1991, the Supply Side Management policy document (Hall, 1991) is commonly known as the “yellow book,” or SSM1991. The document states that at any point during the dry season “the amount of water available for use…is a function of the anticipated rainfall, lake evaporation, and water needs for the balance of the dry season in relation to the amount currently in storage. Supply Side Management was designed to complement the District Water Shortage Plan by providing a means for the prudent management of surface water storage in Lake Okeechobee.” (Hall, 1991). During the dry season (October through May), the District can declare water restrictions for Lake Okeechobee water users when the lake stage falls below a critical water level (an indicator of drought conditions), which can vary depending on the time of year. The time series of these water levels is referred to as the Supply Side Management line (SSM line). The computation procedures outlined in the SSM1991 document may be used to determine allocation volumes for agricultural users in the Lake Okeechobee Service Area (LOSA). The original SSM line (Hall, 1991) was defined in terms of normal rainfall and evapotranspiration (ET) over the lake and average lake water uses expected over the balance or remainder of the dry season. It was lowered by half a foot as a result of the recent Lower East Coast Regional Water Supply Plan development process

(SFWMD, 2000). The line was lowered, effectively increasing the amount of available lake water, for the purpose of maintaining the same level of service for the Lake Okeechobee Service Area over the next 5 to 10 years while water resource projects are under development.

The SSM1991 protocol called for implementation of supply-side management on the first day of the 2000–2001 dry season (October 1, 2000). However, water shortage restrictions were not declared until November 29, 2000. The South Florida Water Management District deemed this delay necessary to provide relief to water users dependent upon the lake, which was experiencing unusually low levels due to the ongoing severe drought and to the April-May 2000 Lake Okeechobee managed recession. Likewise, SSM1991 only addressed a single dry season implementation of supply side management. Due to the severity and prolonged nature of the drought, water restrictions remained in effect through the following wet season (June-September 2001) and into the beginning of the subsequent dry season until their suspension on October 10, 2001.

Ten LOSA sub-basins were identified during the 2000–2001 implementation of SSM (**Figure 5-1** and **Table 5-1**). Allocations for agricultural users in each of these sub-basins were calculated weekly throughout the 45-week period of SSM implementation (**Figure 5-2**).

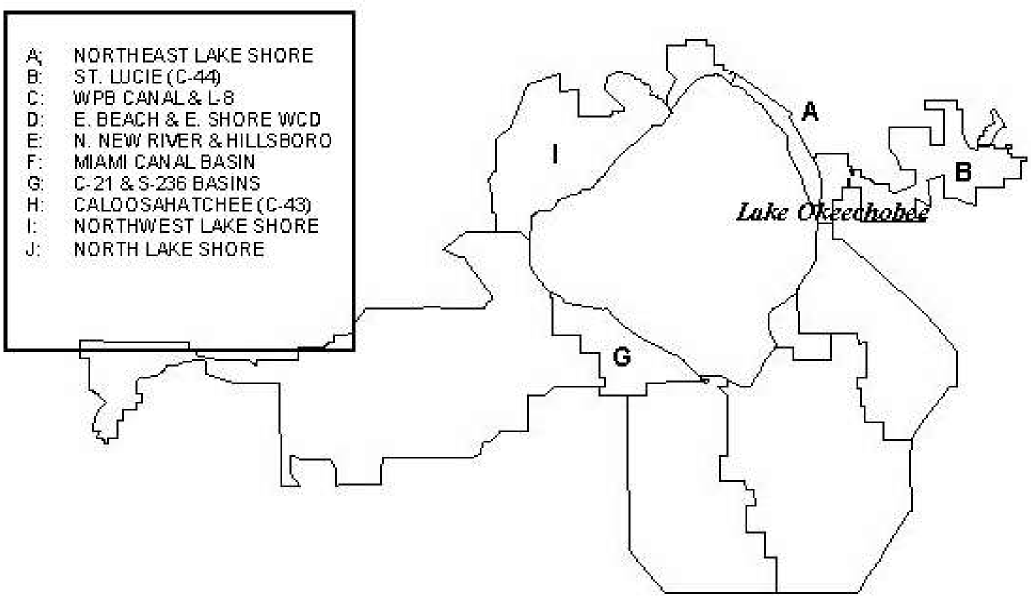

Figure 5-1. Identification of Lake Okeechobee service area sub-basin boundaries as used in supply side management

Table 5-1. Lake Okeechobee Service Area sub-basins used for SSM implementation during the 2000–2001 drought

Sub-basin Name	Controlling Structure(s)	Crop Type	Water Use Permit Irrigated Area (ac)*
Northeast Lake Shore	S-135 and G-36	Citrus	420
		Other	7,289
St. Lucie (C-44)	S-308	Citrus	47,575
		Other	8,776
WPB Canal and L-8	S-352, C-10A, C-13 and C-16	Citrus	7,590
		Other	123,537
E. Beach and E. Shore WCD	C-12 and C-10	Citrus	0
		Other	13,054
N. New River and Hillsboro	S-351 and C-4A	Citrus	234
		Other	230,146
Miami Canal Basin	S-354	Citrus	2,426
		Other	113,325
C-21 and S-236 Basins	S-310 and S-169	Citrus	0
		Other	34,122
Caloosahatchee (C-43)	S-77 and C-5A	Citrus	68,219
		Other	58,311
Northwest Lake Shore	S-131, S-129, S-127, G-207 and G-208	Citrus	4,362
		Other	2,101
North Lake Shore	S-193	Citrus	117
		Other	1,060

Total: 722,664 acres *As of October 2001

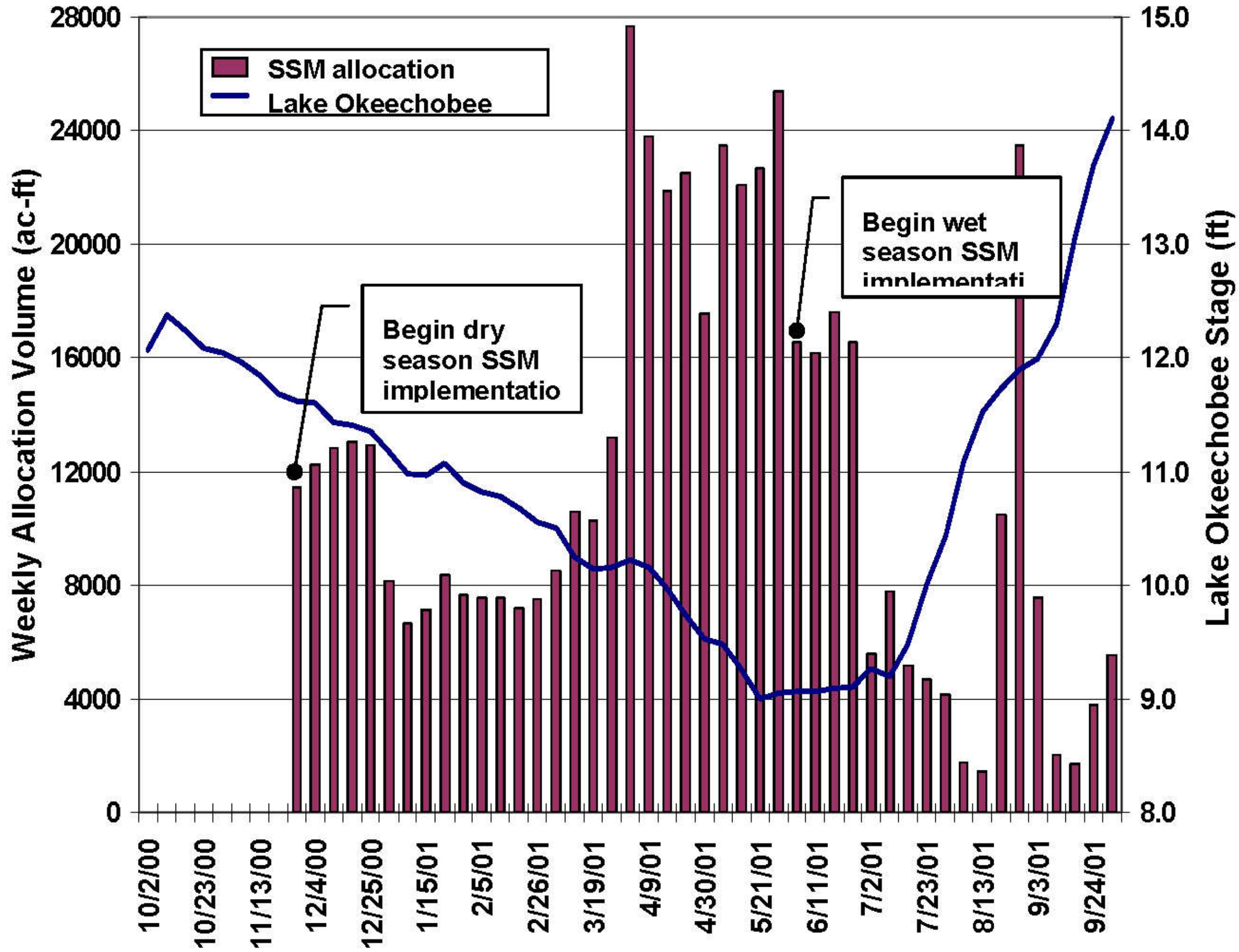

Figure 5-2. Lake Okeechobee stage and Lake Okeechobee Service Area allocation during the 2000–2001 drought

Lake Okeechobee stage and weekly allocation volumes for the period of the 2000–2001 water shortage restrictions are shown in **Figure 5-2**. Water shortage cutbacks for the Seminole Indian tribal lands are not calculated in the normal SSM procedure, but are included in the Water Rights Compact. Similarly, SSM calculations do not explicitly determine lake water allocation for non-agricultural uses, e.g., public water supply to the Lower East Coast (LEC) service areas, releases to navigational lockages, and environmental deliveries to the Stormwater Treatment Areas (STAs). However, the SSM calculations do take into consideration the amount of water consumed by these users in determining lake water allocations for agricultural users within the LOSA. No water was specifically provided from Lake Okeechobee for pasture irrigation during the drought (SFWMD, 2001).

During the 2000–2001 dry-season implementation of the SSM, a total volume of approximately 380,000 ac-ft was allocated to the Lake Okeechobee Service Area using the calculation procedure for the LOSA outlined in SSM1991. The largest weekly allocation was 27,697 ac-ft for the week of April 1, 2001; the smallest was 6,663 ac-ft for the week of January 8, 2001. On average, approximately 14,070 ac-ft were allocated weekly to the entire LOSA. **Table 5-2**, adapted from Hall (1991), shows some of the data associated with calculations of allocation during the 2000–2001 SSM implementation.

The allocation for any week during the dry season is equal to the weekly allocation factor multiplied by the allocable volume of water from the lake for that particular week. The allocation factor distributes allocable volume in time and is patterned after the historical distribution of demands (LOSA water use). For a given week the allocation factor is derived as the water use for that week divided by the projected cumulative water use for the remainder of the dry season, based on historical information. For example, the allocation factor for May 16, 2001 is equal to 30,193 (30,193 + 30,193 + 17,253) or 0.389. The allocable volume is also determined on a weekly basis. It is calculated as the storage above a lake reference stage associated with the ending date of the dry season (May 31), and adjusted for expected average net rainfall (rainfall minus evapotranspiration) on the lake for the remainder of the dry season.

Table 5-2. Data used for SSM implementation during the 2000–2001 dry season (adapted from Hall, 1991)

Week Starting	Lake Okeechobee Rainfall (ac-ft)	Lake Okeechobee ET (ac-ft)	LOSA Water Use (ac-ft)	Weekly Allocation Factor*
10/04/00	20203	28614	11833	0.017883
10/11/00	20203	28614	11833	0.018209
10/18/00	20203	28614	11833	0.018547
10/25/00	20203	28614	11833	0.018897
11/01/00	16925	27876	14737	0.023988
11/08/00	15614	27581	15898	0.026515
11/15/00	15614	27581	15898	0.027237
11/22/00	15614	27581	15898	0.028000
11/29/00	16345	25147	16202	0.029357
12/06/00	17320	21903	16608	0.031002
12/13/00	17320	21903	16608	0.031994
12/20/00	17320	21903	16608	0.033051
12/27/00	17320	21903	16608	0.034181
01/03/01	20004	23619	11994	0.025558
01/10/01	20004	23619	11994	0.026229
01/17/01	20004	23619	11994	0.026935
01/24/01	20004	23619	11994	0.027681
01/31/01	23702	27201	12962	0.030767
02/07/01	26475	29888	13688	0.033521
02/14/01	26475	29888	13688	0.034684

Table 5-2. Continued

Week Starting	Lake Okeechobee Rainfall (ac-ft)	Lake Okeechobee ET (ac-ft)	LOSA Water Use (ac-ft)	Weekly Allocation Factor*
02/21/01	26475	29888	13688	0.035930
02/28/01	26958	34962	16780	0.045689
03/07/01	27321	38768	19099	0.054493
03/14/01	27321	38768	19099	0.057633
03/21/01	27321	38768	19099	0.061158
03/28/01	26681	40138	21141	0.072106
04/04/01	22843	48360	33392	0.122742
04/11/01	22843	48360	33392	0.139916
04/18/01	22843	48360	33392	0.162677
04/25/01	22843	48360	33392	0.194282
05/02/01	48220	52615	30650	0.221328
05/09/01	52450	53324	30193	0.280000
05/16/01	52450	53324	30193	0.388889
05/23/01	52450	53324	30193	0.636364
05/30/01	29971	30471	17253	1.000000

*Allocation factor is derived as the water use for the week, divided by the projected cumulative water use for the remainder of the dry season. It is used to distribute the total allocation among the remaining weeks of the dry season.

The reference stage used on the first week of SSM implementation during the 2000–2001 dry season was 9.80 ft-NGVD. This was lower than the 10.50 ft-NGVD recommended in the LEC plan (SFWMD, 2000), resulting in an increased allocable volume. Data supporting the SSM1991 calculations (Lake Okeechobee rainfall and ET, and LOSA water use) were based on average dry season conditions. However, the 2000–2001 drought conditions were more severe than what was assumed in SSM1991. In fact, it was necessary for the reference stage to be altered on several occasions during the entire 2000–2001 drought to:

1. Account for the difference between actual rainfall during the 2000–2001 drought and what was assumed in SSM1991; and
2. Maintain a minimum level of supply to all users of lake water (i.e., public water supply in LOSA, water supply deliveries to the LEC service areas, provide minimum levels for stormwater treatment areas, and/or maintenance of navigational depths in the C-43 and C-44 canals). This guideline was approximated by meeting 40 to 50 percent of the 1-in-10 LOSA supplemental irrigation demand on Lake Okeechobee as estimated by the South Florida Water Management Model or SFWMM (SFWMD, 1999).

A summary of adjustments to the reference stage during the 2000–2001 drought is listed in **Table 5-3**. The SSM1991 methodology defines a dry season reference stage on June 1, 2001 only. An extension of the methodology into the following wet season required a July 1, 2001 reference stage.

To distribute the total allocation volume as calculated by the SSM1991 procedure to each of the ten individual LOSA sub-basins during the dry season, a separate methodology was developed that uses evapotranspiration models. The method estimates the relative demand for a particular LOSA sub-basin compared to the total demand for all ten sub-basins. This spatial distribution method was dependent on the characteristics of each sub-basin, including its predominant crop and soil type, and was conducted weekly.

SSM1991 did not include a procedure for SSM implementation during the wet season. However, the persistence of low Lake Okeechobee stages beyond May 2001 resulted in the extension of SSM implementation and water restrictions from June through October 2001. Since drought conditions in June were expected to be similar to those experienced in May, the methodology associated with dry season Supply Side Management was extended to include the month of June 2001. Beginning on June 6, weekly allocations were computed using a July 1 reference stage. Rainfall and ET data used in the SSM implementation for June 2001 came from the SFWMM. Sub-basin distribution of allocation was also accomplished in a manner similar to the procedure used during the dry season. The corresponding data for computing allocation factors, extracted from the SFWMM, is presented in **Table 5-4**. Definitions for the data in **Table 5-4** are identical to the definitions in **Table 5-2**.

Table 5-3. Summary of reference stage changes

Reference Stage #	Date of Change	New Reference Stage	Comments
Dry Season Adjustments (June 1 Reference Stage)			
1	11/29/00	9.80	SSM Implementation Begins
2	12/13/00	9.60	Drought Management Decision (based on below-normal rainfall relative to SSM1991)
3	01/17/01	9.57	Adjust for release to control saltwater intrusion in Caloosahatchee River (9449 ac-ft)
4	02/21/01	9.53	All non-LOSA releases prior to 2/13 including releases to the STAs, except the previously accounted (9449 ac-ft)
5	03/07/01	9.52	Non-LOSA releases 2/14 to 2/27 including releases to the STAs, and data revisions back to 11/29
6	03/14/01	9.20	Drought Management Decision (based on below-normal rainfall relative to SSM1991)
7	03/21/01	9.17	Non-LOSA releases 2/28 to 3/13
8	04/04/01	9.15	Non-LOSA release 3/14 to 3/27 including releases to the STAs, and data revisions back to 2/28
9	04/11/01	9.35	Maintain minimum level of supply: 40% to 50% of the 1-in-10 LOSA demand estimated from the SFWMM.
10	04/25/01	9.25	
11	05/09/01	9.20	
12	05/16/01	9.07	
13	05/23/01	8.87	
14	05/30/01	9.00	
Wet Season Adjustments (July 1 Reference Stage)			
15	06/06/01	8.89	Maintain minimum level of supply: 40% to 50% of the 1-in-10 LOSA demand estimated from the SFWMM.
16	06/13/01	8.94	
17	06/20/01	9.00	
18	06/27/01	9.07	

Table 5-4. Data used for SSM implementation during June 2001 (based on SFWMM)

Week Starting	Lake Okeechobee Rainfall (ac-ft)	Lake Okeechobee ET (ac-ft)	LOSA Water Use (ac-ft)	Weekly Allocation Factor*
06/06/01	58528	55990	35904	0.259259
06/13/01	58528	55990	35904	0.350000
06/20/01	58528	55990	35904	0.538462
06/27/01	50167	47992	30775	1.000000

*Allocation factor is derived as the water use for the week divided by the cumulative water use for the remainder of the dry season.

During the wet-season months of July through September 2001, and continuing until the suspension of SSM on October 10, 2001, a methodology was used for allocation of water to the LOSA that represented a departure from the traditional "reference stage"-type calculations, as outlined for the dry season in SSM1991. During this period the supplemental irrigation demands on Lake Okeechobee were relatively small due to rainfall in the service area. The changes in supply due to rainfall and other sources were inestimable. As a result, the implementation of an allocation procedure based on the concept of reference stage would have been difficult. Instead, the methodology allocated a predetermined quantity for each week computed using the results from the SFWMM. The predetermined volume was chosen to represent approximately 40 to 50 percent of the 1-in-10 LOSA supplemental irrigation demand volume on Lake Okeechobee as simulated in the SFWMM. The selection of this level of service is consistent with the procedures used in previous months. This methodology was adequate for the majority of the period. There were, however, several consecutive weeks of dry conditions in late August and early September that resulted in higher-than-expected demand in the LOSA. As a result, temporary deviations were made from the predetermined volumes to provide increased allocations for the weeks of August 20 to September 9, 2001 and maintain the minimum level of service. The District's drought management team deemed these measures appropriate, considering that lake stages had already begun to recover and revised allocation volumes were still small relative to typical late dry season demand volumes. A total of approximately 152,000 ac-ft of Lake Okeechobee water was allocated to the LOSA from June through October 2001.

The previously mentioned uncertainty associated with projected rainfall during the wet season also created a challenge for sub-basin distribution. The evapotranspiration models used during the dry season were deemed unresponsive to antecedent rainfall conditions. To help determine the real-time relative spatial distribution of demand for LOSA agricultural users during this wet season period, more complete models that include antecedent conditions, soil type, crop type, soil moisture accounting, and real-time monitoring of rainfall and evapotranspiration were used to compute weekly irrigation requirements for each sub-basin. As before, the total allocation volume was distributed to each sub-basin based on its corresponding fraction of the total projected demand.

EXTERNAL COMMUNICATION

The Supply Side Management calculations were performed weekly on Mondays and were posted/communicated for users on Tuesdays for implementation on Wednesdays. Most of the users accessed the information posted on the SFWMD Website. The 298 Districts and the majority of the users in the Lake Okeechobee Service Area hired a basin coordinator to use the Website information and calculate the number of hours each farm could operate their pumps. The basin coordinator communicated this pumping information directly to clients. If questions arose regarding the SSM information posted on the SFWMD Website, the basin coordinator would contact assigned personnel in the District's Operations (OPS) and Hydrologic Systems Modeling (HSM) divisions.

The southern Lake Istokpoga-Indian Prairie basin did not have a basin coordinator; clients had to be contacted individually. Assigned personnel in the District's Operations Division informed clients via phone, e-mail, or fax regarding the SSM allocation and weekly pumpages for specific farms and the Brighton Reservation. In addition, individual farms pumped on different days than the Brighton Reservation to eliminate direct competition of water resources and to better ensure water allocations were delivered to the appropriate user.

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Chapter 6: Regional Water Supply and Demand Management Issues

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SUMMARY

The District is divided into four planning areas within which water supply planning and other activities are focused: Lower East Coast (LEC), Lower West Coast (LWC), Upper East Coast (UEC), and Kissimmee Basin. **Figure 6-1** illustrates the four planning areas.

LOWER EAST COAST PLANNING AREA

The LEC planning area includes Palm Beach, Broward, and Miami-Dade counties and portions of Monroe, Hendry, and Collier counties. The LEC planning area encompasses a sprawling, fast-growing urban complex along the coast; extensive agricultural lands, including the EAA; critical environmental resources, such as the Everglades ecosystem; and important estuaries, including Biscayne Bay and Florida Bay. The existing population is concentrated in the coastal areas of Miami-Dade, Broward, and Palm Beach counties, which are expected to remain the area's population centers.

LOWER WEST COAST PLANNING AREA

This area includes all of Lee County and parts of Charlotte, Collier, Glades, Hendry, and Monroe counties. Rapid growth in population and irrigated agricultural acreage within the LWC planning area has caused demands for water to increase significantly. The existing population is concentrated in the coastal areas of Lee and Collier counties. These areas are expected to remain the population centers for the area.

UPPER EAST COAST PLANNING AREA

The UEC planning area is comprised of St. Lucie and Martin counties and eastern Okeechobee County. The existing population is concentrated in the coastal areas of Martin and St. Lucie counties. These areas are expected to remain the population centers for the area.

KISSIMMEE BASIN PLANNING AREA

The Kissimmee Basin planning area includes parts of Orange, Osceola, Polk, Highlands, Okeechobee, and Glades counties. The majority of the basin drains to the Kissimmee River, though some areas drain into Fisheating Creek, the canal system within the Indian Prairie Basin, or a few landlocked lakes within the basin. A few fringe areas drain to either the Southwest Florida or the St. Johns River water management districts. Urban growth is anticipated to be concentrated in Orange and northern Osceola counties, while irrigated agricultural acreage is anticipated to increase to the south in Highlands, Okeechobee, and Glades counties. Most of the area is rural/agricultural, and this pattern is projected to continue through 2020.

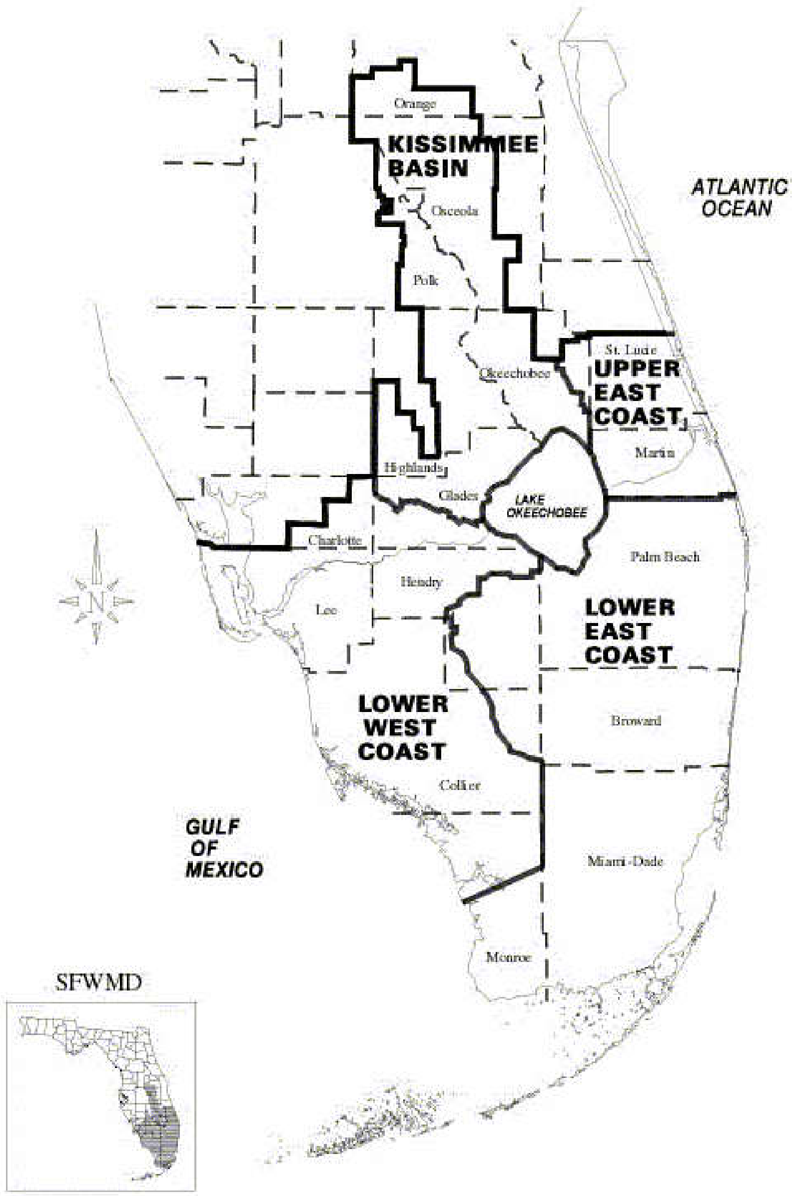

Figure 6.1 The four planning areas used by the District in managing water and related resources

KISSIMMEE BASIN

DESCRIPTION OF THE AREA AND ASSOCIATED WATER RESOURCES

The Kissimmee Basin water supply planning area (**Figure 6-2**) covers approximately 3,500 square miles and is divided at the outlet of Lake Kissimmee into upper and lower basins. These two sub-regions have distinctly different current and projected water demand and source patterns and are described separately below.

The upper Kissimmee River basin stretches into the heart of Orlando, where urban development continues to expand the boundaries of the Orlando metropolitan area. The SFWMD has jurisdiction in approximately a third of Orange County. That region includes a large portion, though less than a third, of the Orlando metro area. Also within the District's jurisdiction in Orange County are the Outstanding Florida Waters of the Windermere or Butler Chain of Lakes, the intense development in the Disney resort area, the growing urban corridor connecting Orlando to Kissimmee, and the Orlando International Airport.

Most of the population of the Orlando metro area reside in the St. Johns River Water Management District (SJRWMD), which is not significant from a groundwater perspective; the resource serves the entire region. However, the SJRWMD presence in Central Florida is significant to the discussion of how the drought was handled and how the districts worked together to develop both a consistent message to the public and nearly identical water use restrictions.

In the SFWMD, the local governments encompassing the areas under water use restrictions included the city of Orlando, Orange County, the town of Windermere, and the Reedy Creek Improvement District (the political subdivision that supports the Disney parks and resorts).

The Floridan aquifer is the region's primary groundwater resource. Concern about sinkhole development brought on by declining Floridan aquifer levels drove the decision to impose water use restrictions. Three years of drought have dropped the Floridan to historic lows. Though the region received normal levels of rainfall during 2001 to the present in 2002, the Floridan has not recovered completely. As a policy decision, the SFWMD has agreed to allow the St. Johns River WMD to determine the time span to pursue mandatory restrictions. Since the Floridan does not respond quickly to normal rainfall, the SJRWMD has concluded that the restrictions will remain in place as long as the Floridan continues to hover near record lows.

The area also supports a productive surficial aquifer that yields a sizable amount of water, but this shallow aquifer is almost entirely used for home lawn irrigation and other needs that do not require a source of consistently high-quality water. The surficial aquifer does not contribute to the sinkhole threat, and therefore was not a concern in the decision making process that led to mandatory water use restrictions.

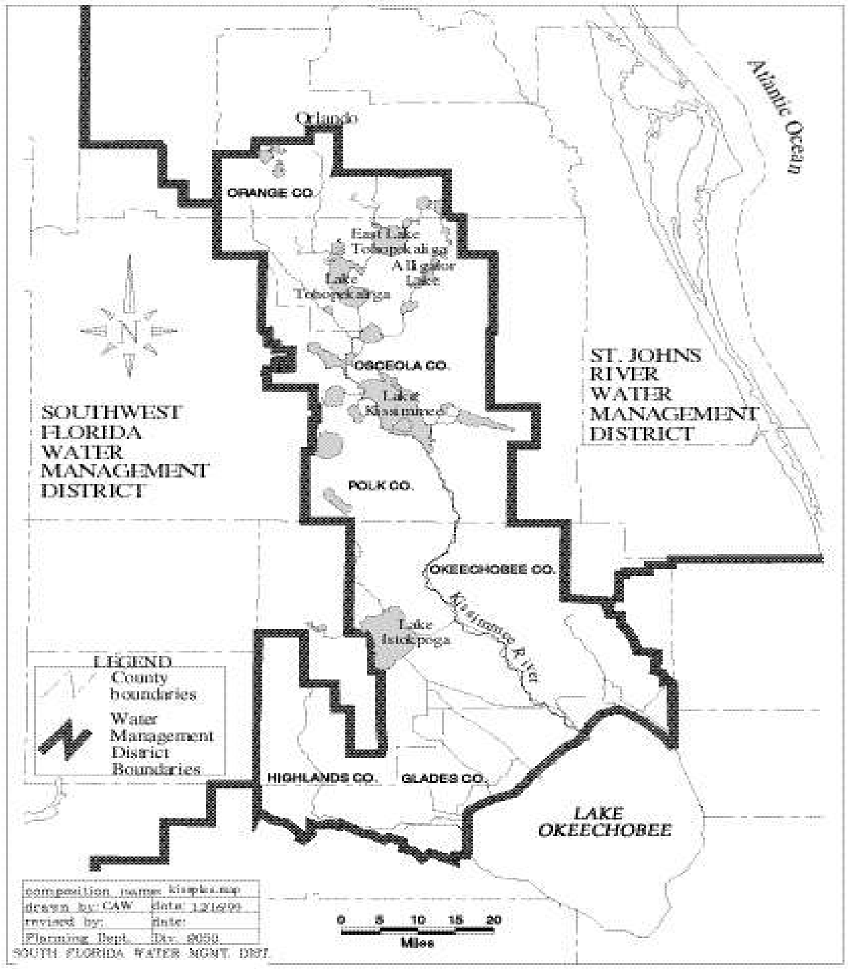

Figure 6-2. Kissimmee Basin water supply planning area

The area is dotted with hundreds of lakes and a number of springs are located to the north of the SFWMD in the SJRWMD. Sinkhole activity has also been more prevalent in the SJRWMD in the northern portion of the Orlando Metro Area. A relatively small area of the SFWMD in Central Florida is prone to sinkhole development, primarily in and around the Butler Chain of Lakes in west Orange County.

The Lake Istokpoga-Indian Prairie Basin, further south in the Kissimmee Basin planning area, encompasses 575 square miles of Polk and Highlands counties. The Brighton Seminole Reservation is located in the southern portion of this basin. Lake Istokpoga is a shallow lake with an average bottom elevation of 33.5 ft-NGVD and a surface area of 43 square miles. It is the fifth-largest lake in Florida.

Control structure S-68 discharges water from Lake Istokpoga into associated downstream canals in accordance with an established regulation schedule. Based on this schedule, water surface elevations in Lake Istokpoga are regulated between 37.5 and 39.5 ft-NGVD. This regulation schedule was adopted as part of the District's water shortage rule (40E-22, F.A.C.).

District canals that provide both drainage and water supply deliveries in the Istokpoga-Indian Prairie Basin are as follows:

Northern basin area

C-41A, situated between S-68, S-82, S-83, and S-83 to S-84

C-39A, situated between S-82, S-75, and S-70

Southern basin area

C-40, (Indian Prairie canal) situated between S-75 and S-72/G-208

C-41, (Harney Pond canal) situated between S-70 and S-71/G-207

L-59, situated between G-34 and S-72/G-208

L-60, situated between S-72/G-208 and S-71/G-207

L-61, situated between S-71/G-207 and the intersection of the L-50

Land use in the area is predominantly agricultural, with citrus, vegetables, sugar cane, and ornamentals being the most common crops. Beef cattle production is also a significant industry in the basin. Agricultural areas within the basin and south of Lake Istokpoga depend on the lake for their primary irrigation supply.

Groundwater is not used extensively in the Lake Istokpoga basin. Some groundwater is used to irrigate citrus in the northern part of this basin, but availability is limited in the south. Wells located south of the Glades-Highlands county line show elevated concentrations of chlorides, a situation that worsens further south. Consequently, surface water is the primary source for irrigation and other agricultural demands in the basin's southern portion.

Due to periodic water shortages in the Indian Prairie Basin, the District determined that additional water should be released from Lake Istokpoga for water supply, lowering the lake's water level. The District also installed two pump stations, G-207 and G-208, in the early 1990s to pump water from Lake Okeechobee into the southern portion of the basin during drought periods. The Kissimmee Basin Water Supply Plan evaluated the basin's water use problems. One recommendation, implemented during the 2000–2001 drought, was that of shifting the primary source of surface water in the southern basin from Lake Istokpoga to Lake Okeechobee.

The operational strategy for G-207 and G-208 during water shortage conditions is established by Agreement C-4121. Based on the Water Rights Compact, the Seminole Tribe is entitled to 15 percent of the total amount of water that can be withdrawn from SFWMD canals and SFWMD borrow canals by all surface water users within the Lake Istokpoga basin. Lake Istokpoga water availability estimates for the reservation are 26,872 ac-ft during the wet season (June through October) and 16,997 ac-ft during the dry season (November through May). If water is unavailable from Lake Istokpoga because lake stages are below the regulation schedule, G-207 and G-208 will provide water to the Brighton Reservation from Lake Okeechobee based on the Lake Okeechobee Supply Side Management criteria.

DROUGHT-RELATED THREATS TO THE RESOURCE

In the northern Kissimmee Basin planning area, sinkhole development was the primary concern driving the decision to impose water use restrictions. A decline in Floridan aquifer levels was a related concern.

Water supply planning efforts in both the SFWMD and the SJRWMD have identified long-term concerns about the Floridan aquifer's ability to satisfy future demands for a rapidly growing population without negatively impacting wetlands and spring flows or hastening the migration of saltwater into the freshwater Floridan.

These threats, coupled with the decision to keep water use restrictions simple and unambiguous in a region with thousands of new residents potentially unfamiliar with water management district boundaries, led to the decision to impose mandatory water use restrictions within the SFWMD in conjunction with those imposed by SJRWMD.

The District's primary concern in the Istokpoga-Indian Prairie Basin during the 2000–2001 drought was whether water levels in Lake Okeechobee would fall so low as to prohibit pumping of G-207 and G-208. The invert elevations of the pump intakes are set to pump water to an elevation of 7.0 ft-NGVD. During the 2000–2001 dry season, these pumps were successfully operated to supply water to the Brighton Reservation and other permitted surface water users in the southern basin area until Lake Okeechobee levels dropped to below 9.2 ft-NGVD in May 2001. At this elevation the lake bottom was exposed and water from Lake Okeechobee could not flow into the C-40 and C-41 canals. Consequently, the District was unable to pump G-207 and G-208 and deliver water to the Brighton Reservation and other permitted users in the southern basin area.

MANAGEMENT ACTIONS TAKEN TO PROTECT THE RESOURCE

After nearly two months of weekly conference calls that included SFWMD and SJRWMD officials, a modified phase II set of restrictions was developed. The modified restrictions departed from the standard set in that they allowed watering any time of the day during the two-days-a-week schedule, except between the hours of 10 a.m. and 4 p.m.

The SFWMD rules limited their focus to sinkhole development so that only Floridan aquifer sources were identified for restrictions. In the SJRWMD, all sources were restricted, which created some confusion. However, the confusion was not so great as to require additional governing board action to make the rules in the two districts more consistent.

The SFWMD area affected by the restrictions was limited to that district's jurisdiction in Orange County. The SJRWMD, however, imposed restrictions in Lake, Marion, Brevard, Volusia, and Seminole counties and in the SJRWMD's portion of Orange County. Because the media market for the region is centered in Orange County, the restrictions created some confusion in Osceola County, where the county commission enacted voluntary restrictions. Regional media perpetuated this confusion by reporting that the SFWMD restrictions extended into Osceola County.

In February 2001 in the southern Kissimmee Basin planning area's Istokpoga basin, the Florida Fish and Wildlife Conservation Commission (FFWCC) in partnership with the District took advantage of low surface water elevations in Lake Istokpoga and expedited the drawdown of the lake's water level to facilitate tussock removal. The drawdown was already being planned prior to the drought, and the schedule was accelerated after the drought began. The District worked closely with the FFWCC to coordinate the drawdown activities so the basin could benefit from the additional water being released from Lake Istokpoga. The District coordinated and held meetings to inform the public of the drawdown schedule and the lake environmental enhancement activities. An Emergency Order (No. 2001-17-DAO-WS) was issued enabling surface water permittees within the Istokpoga basin to store as much of the water released from Lake Istokpoga as possible within stated time frames. These withdrawals were allowed during the time when S-68 was releasing water and basin canals were above their minimum levels. Once the releases ceased, the District encouraged permitted users to use the stored water to minimize demand on the basin canals and maintain high stages in the canals for the longest period possible.

The Lake Istokpoga drawdown occurred at a crucial point in the drought and provided necessary relief to permitted users in the basin. For several weeks all canals in the Lake Istokpoga basin were above the minimum levels established in 40E-22, F.A.C., allowing permitted users to withdraw their allocations. The District encouraged water conservation during this time and, for the most part, water users complied with the request.

After the drawdown, and as the Istokpoga Basin canals again began dropping, a drought information hotline was established at the District's Okeechobee Service Center for consumptive use permittees with a surface water source. This hotline was updated prior to 6:00 a.m. daily to provide permitted users with current canal stages and inform them whether surface water was available for withdrawals on a given day. It was the permittees' responsibility to access this information and make use of available water from basin canals, as allowed. This information was also posted on the District's Website as an alternative means of conveying the information to permitted users. The hotline remained fully operational until water restrictions were rescinded for the Istokpoga basin.

In addition to the hotline, the SFWMD Operations Department issued the "Operational Intent of Supply Side Management Implementation" weekly for those permittees located within the boundaries of the Lake Okeechobee Service Area. Since the southern portion of the Lake Istokpoga basin was heavily dependent on the operation of G-207 and G-208, the District e-mailed the preliminary operating plan and schedule for the upcoming week to permitted users in the area. The operating plan provided the pumping schedule for G-207 and G-208 and designated "allocation days" among the Seminole Tribe and other users in the area. These designated allocation days were established so the tribe could receive its allocation without competing with other users. Typically, the tribe's allocation was delivered on Thursdays. The non-tribe allocations were delivered on Fridays.

RESULTS AND OUTCOMES

In the northern Kissimmee Basin planning area, all consumptive use permit holders reported dramatic drops in pumpage. On average, the declines in water use hovered between 20 and 25 percent, which is substantial considering the District's stated objective of a 15-percent reduction. Central Florida has not experienced such a situation for many years; therefore, water use that predates the restrictions likely includes a substantial amount of waste. Nevertheless, most water users took the restrictions seriously. Some of the largest water users, by volume, took impressive actions to conserve water resources. Disney, for example, greatly expanded its water re-use systems, employed separate systems for fire protection to allow pressure reductions for potable uses, and maintained regular contact with the SFWMD to ensure compliance with the rules.

Enforcement of the restrictions was not substantial. Just a handful of violators were fined, though hundreds of water users received warning tickets. Enforcement was handled by code enforcement sections of the city of Orlando and Orange County and the town of Windermere Police Department. Orange County also contracted with an outside vendor, which organized enforcement teams. However, those workers were only allowed to hand out informational literature and warning tickets. The enforcement teams also followed up to determine if warnings led to compliance. When warnings were repeatedly ignored, those violators were turned over to code enforcement officers. Water use reductions in excess of the target 15 percent tempered the call to seek a greater response by local governments, so ultimately the SFWMD did not challenge the local decision not to impose stricter enforcement of restrictions. Furthermore, the strategy at the SJRWMD also supported a "softer" enforcement strategy. In the future, water managers may want to consider drawing up an enforcement plan and having it in place long before enactment of any Central Florida water use restrictions.

Further south, drought conditions within the Lake Istokpoga basin were severe. The District worked diligently with permittees to minimize the loss of crops and livestock in the area by scheduling public meetings and site visits, establishing the drought hotline, and issuing various emergency orders for the Istokpoga basin. When unforeseen opportunities, such as the Lake Istokpoga drawdown, arose, the District enabled permitted users to maximize their ability to capture and store the additional available water. Without the additional water from the lake drawdown in February 2001, it is possible that the Istokpoga basin could have suffered tremendous losses of both agricultural and livestock. The importance of cooperation and daily communication between permitted users and District staff during this time was evident.

Considering the severity of the drought, the number of water use violations encountered was not as high as it could have been. Many violations came from users who did not have a consumptive use permit.

A significant discovery during the drought was the inability of G-207 and G-208 to operate when Lake Okeechobee reached 9.2 ft-NGVD, the result of lake-bottom shoaling at the terminus of the C-40 and C-41, which prohibited lake water from flowing into these canals. This situation occurred in mid-May 2001, when G-207 and G-208 could not be operated to provide water to the Brighton Reservation and other permitted users until Lake Okeechobee water levels rose above the 9.2 ft-NGVD threshold. SFWMD and USACE employees discussed at length the possibility of dredging each canal to re-establish a physical connection with the lake. Ultimately, however, the District and USACE determined that such a project would be time-prohibitive. Should drought conditions similar to those experienced in 2000 and 2001 appear likely in the future, the shoaling problem at the terminus of the C-40 and C-41 canals must be considered early on to allow time for corrective action, particularly if dredging is the selected method of remediation.

UPPER EAST COAST

DESCRIPTION OF THE AREA AND ASSOCIATED WATER RESOURCES

The Upper East Coast (UEC) planning area encompasses Martin and St. Lucie counties in their entirety, as well as an eastern portion of Okeechobee County (**Figure 6-3**), and covers approximately 1,200 square miles. The majority of water supply and flood protection is achieved through four major canals located throughout the area. The C-44 basin, which is part of the UEC, is connected to Lake Okeechobee, while most of the remaining area (the C-23, C-24 and C-25 basins) are independent of the lake. As a result, the UEC was under three different Water Shortage Orders during the drought. Specifically, the C-44 basin, located entirely in Martin County, was under water shortage restrictions imposed by the Lake Okeechobee Supply Side Management Plan. Water was allocated to the C-44 basin three times a week, depending on Lake Okeechobee's stage, canal stage, and permitted water use allocations. The C-23, C-24, and C-25 are a network of canals independent of the Lake Okeechobee watershed that discharge into the St. Lucie Estuary and the southern Indian River Lagoon. This portion of the UEC is often referred to as the St. Lucie Agricultural Area. Water shortage restrictions were implemented when these canal stages fell below 14.0 ft-NGVD. Water users were allowed to pump daily from 6:00 a.m. until noon, as long as canal stages remained above the threshold of 14.0 ft-NGVD. If canal stages did not rebound above 14.0 ft-NGVD, then water withdrawals from the canals for that day were not permitted. The C-23 and C-24 basins dropped below the 14 ft-NGVD threshold in April 2001. As a result, daily canal stage notices (posted at 6:00 a.m.) were provided to agricultural stakeholders via e-mail or the water shortage hotline at the District's Martin/St. Lucie Service Center. The C-25 canal did not drop below the threshold of 14.0 ft-NGVD; therefore, water shortage restrictions were not imposed for the C-25 basin. The third water shortage restriction implemented within the UEC was imposed by Martin County Utilities due to infrastructure problems and water use permitting issues. These pertained only to those residents who got water from Martin County Utilities. The District's phase II water shortage restriction guidelines were implemented by Martin County Utilities.

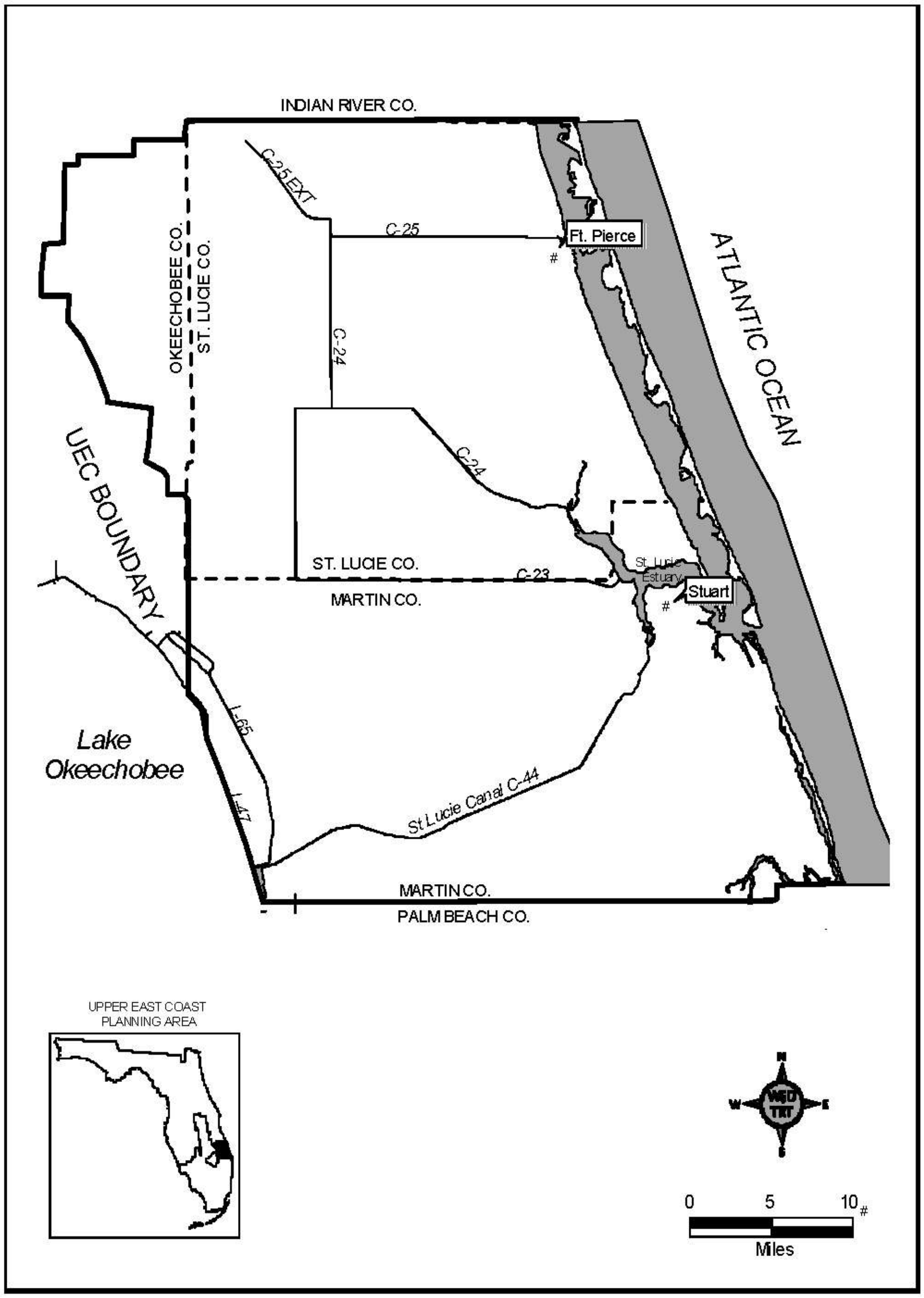

Figure 6-3. Map of Upper East Coast planning area

RESOURCE IMPACTS

As a result of water shortage conditions in the C-44 basin, increased canal-side bank sloughing was noticed along several areas of canal reach. Low stage levels in the C-44 canal made it problematic for several agricultural users to withdrawal their permitted allocation due to pump cavitation. In addition, low canal and Lake Okeechobee stages obstructed navigation.

The C-23 and C-24 basins also showed signs of increased canal-side bank sloughing, as well as pump cavitation, resulting in reduced water withdrawals for several agricultural users. Consequently, some citrus growers experienced a smaller percentage of fruit "setting," which resulted in a significantly smaller citrus harvest and a negative economic impact on the industry.

RESOURCE PROTECTION

Water users in the C-44 basin were allocated water three times a week, as prescribed under the Lake Okeechobee Supply Side Management Plan. Allocated pumping withdrawals were allowed on Wednesday, Friday, and Monday, depending on canal and Lake Okeechobee stages. In addition, compliance sweeps were made during non-pumping times in an effort to ensure appropriate use of available water resources. Citrus growers requested that they be allowed to reduce allocated pumping for older growth groves in exchange for increased pumping allocation for young (one to two years old) groves. This gave grove managers the flexibility to provide more water to younger trees in an attempt to decrease the risk of tree mortality.

To protect and maximize water resources in the C-23 and C-24 basins, real-time water level readings were communicated daily to basin stakeholders via e-mail or the water shortage hotline. Messages were updated daily at 6:00 a.m. to inform stakeholders whether pumping was allowed for that day and, if so, the scheduled times for allocated pumping. In May 2001, the C-25 basin was getting some relief from isolated local rainfall events. As a result, canal stages in the C-25 were approximately six feet higher than in the C-23 and C-24. This provided the District with a management option to transfer water from the C-25 basin to the C-24 and, to a lesser extent, the C-23 basin.

RESULTS AND OUTCOMES

The UEC planning area did not experience the significant water resource impacts that affected the majority of the District during the drought, primarily because C-23, C-24, and C-25 were independent of the water shortage requirements associated with Lake Okeechobee. Continuous and open communication between the District and local stakeholder groups proved beneficial in managing the region's water resources.

Due to increased water levels in C-25, in May 2001 the District was able to transfer water from C-25 to C-24 and, to a lesser extent, C-23. As a result, it became apparent that infrastructure improvements will need to be made between G-78 (C-23) and G-79 (C-24) to increase the conveyance capacity between C-23, C-24 and C-25. With respect to increasing the District's ability to move water between C-23 and C-24, a partnership between the District and the City of Port St. Lucie may provide an avenue of increased conveyance. The City of Port St. Lucie has a conveyance system of canals and ditches that run perpendicular to the C-24 and C-23 canals. These facilities could potentially be utilized to transfer water between the two basins.

LOWER EAST COAST

DESCRIPTION OF THE AREA AND ASSOCIATED WATER RESOURCES

The Lower East Coast (LEC) planning area covers approximately 9,000 square miles and includes Palm Beach, Broward, and Miami-Dade counties as well as portions of Monroe, Hendry, and Collier counties. Land use within the LEC ranges from urban in the east to undeveloped natural landscapes in the west, with significant agricultural areas south of Lake Okeechobee and in south Miami-Dade County. The area includes world-renowned environmental resources, such as the Everglades ecosystem and Lake Okeechobee, the largest freshwater lake in the southern United States. In addition to the LEC, the entire Lake Okeechobee Service Area, which includes parts of Martin, Okeechobee, Glades, and Lee counties, relies on Lake Okeechobee for a portion of its water supply. Highly productive coastal estuaries, such as Biscayne Bay and Florida Bay, exist along the area's shores.

Groundwater resources are the principal source of urban water supply for most of the LEC. These resources consist of the Surficial Aquifer System, which includes the Biscayne aquifer, and the Floridan aquifer system. The Biscayne aquifer is unconfined and is one of the most productive aquifers in the world. In contrast, areas around Lake Okeechobee rely on the lake as a surface water source for potable water supply.

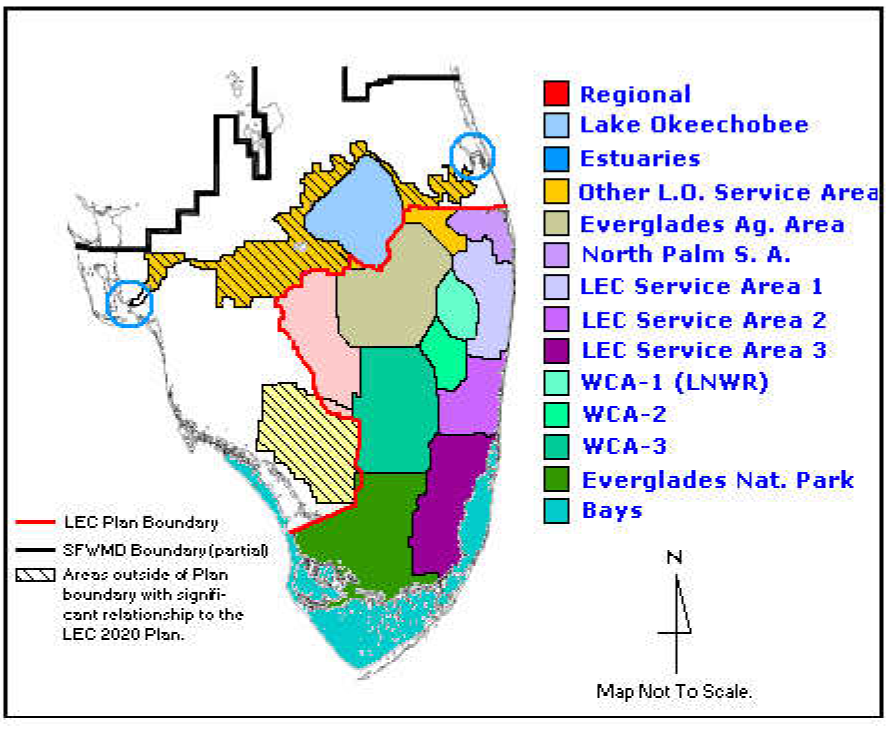

Figure 6-4. Lower East Coast map

LAKE OKEECHOBEE UTILITIES: RAW WATER INTAKE

During the 2000–2001 drought, Lake Okeechobee was at an extremely low level and no rainfall was expected in the foreseeable future. Projections of lake levels indicated that Lake Okeechobee would reach record lows within a few months. A survey of the public water supply utilities that depend on withdrawal of water from the lake indicated that existing intake configurations would not be able to furnish water with Lake Okeechobee levels at or below 10 ft-NGVD. Lack of funding and resources prevented the utilities from responding; therefore, the District, in coordination with the state Emergency Operations Center (EOC), took the engineering, contracting, and construction lead to ensure dependable intake capacity designed for lake levels as low as 6 ft-NGVD. The District reviewed the configurations for each of the utilities' intake facilities and determined that temporary fixes were not feasible. With the expectation that the low-level conditions would last for some time and would likely recur in the near future, the District determined that more permanent retrofits were necessary.

PROJECT PURPOSE AND OBJECTIVES

The purpose of the project was to ensure that existing utilities would have a continuous and uninterrupted water supply from Lake Okeechobee surface water sources. In addition, the forecast was for below-average rainfall for the upcoming wet season, which had the potential to result in multi-year-low lake stages. The project design assumed a need for lengthy and continuous service, with the potential to last well into the following wet season and the subsequent dry season. It should also be noted that the affected utilities had less than 24 hours of available water storage in their systems. Given the possibility that the proposed facility would need to have a long service period and would likely be exposed to severe weather or open-water conditions, the following design objectives and desired features were established:

1. Reliability by use of redundant systems
2. Reliability because of a robust design
3. Designed for future high lake stages
4. Designed for continuous, long-term service to address the potential of a multi-year drought
5. Designed to address vandalism and public safety concerns
6. Operate to a low lake level of 6.0 ft-NGVD
7. Sixty-day implementation
8. Minimal risk of delay
9. Design addresses major maintenance
10. Structure is operational in less than 24 hours
11. Pump capacity satisfies plant demand

IMPLEMENTATION PLAN CONSIDERATIONS

The following considerations were incorporated in the design and contract package development:

1. Incorporate resources of cities, including use of consulting firms under contract, to develop conceptual and detailed design
2. Develop, design, and build strategies that have the shortest implementation schedule
3. Designs shall minimize permit requirements to expedite implementation schedule
4. Use District resources to expedite implementation schedules

City of Pahokee

EXISTING FACILITIES

The intake consisted of a single, 14-inch diameter ductile iron supply line with a screened intake tee outside the marina channel 825 feet west of the water plant. The lake bottom at the intake was an approximate elevation of 6.2 ft-NGVD. Modification of the intake was considered effective to a lake stage of 9.0 ft-NGVD. The two intake pumps were located in the treatment plant south of the levee. These supply pumps had a capacity of 1,200 gpm and 45 feet of total dynamic head (TDH). They were Aurora centrifugal pumps, model no. 411 BF, driven by 60-hp, 1,180-rpm, 240/480-volt three-phase motors. Aurora is a division of Simonds Pump Co. The pump is classified as a horizontal, split-case, electrically driven fire pump.

DISCUSSION

The intake was considered at risk of failure with a lake level below elevation 9.0 ft-NGVD. Wind setup and wave action provided the opportunity for the entrance of air in the line. Because of the shallow depth of the line at the intake, further modification to increase submergence was not possible. An alternative for modification of the intake required the cutting of the suction line near shore and construction of a headwall. The existing intake drew water from the lake outside the influence of the poorer water quality of the marina. The city wished to keep the existing intake for future use because of this preferred water quality.

The pump's required net positive suction head (NPSH), as well as the system characteristics, were not known. The centrifugal pumps within the plant were primed with a vacuum system. The pump's name plate rating indicated that the pumps, at the time of inspection, were operating below their rated design points, with a meter reading of 900 gpm. With the lake at approximately 9.5 ft-NGVD, the pumps were incapable of being primed. With the observed decreasing output and increased difficulty in priming the pumps, it was assumed that a lake level of 9.5 ft-NGVD would result in pump shutdown.

There was no backup system for the supply pumps. The operator's emergency plan, given the inability to prime the Aurora pumps, was to connect a portable pump unit to an existing clean-out tee in the suction line near the water's edge to supply the existing pumps. The city had a mobile pump with a small, attached fuel tank that had been used on numerous occasions for this purpose. However, because of the receding shoreline the city lacked the sufficient 8-inch diameter suction/discharge line. Therefore, the SFWMD rented sufficient line, a 150-gallon, skid-mounted fuel tank and a backup diesel-driven, skid-mounted pump for the city's use until the selected alternative was constructed and tested.

The plant's 1950s-era emergency 125-kW generator was not operational for some time, and because of its age, replacement parts were not available. The District had two surplus, 125-kW generators from the modification of pump station S-331 and offered one of them to the City of Pahokee as a replacement. The District transferred the unit, and the city accepted it.

ALTERNATIVE EVALUATION

Design efforts initially focused on a turbine pump station mounted on a structural steel platform that utilized the existing concrete piles of the fishing platform. However, upon review of the preliminary drawings, the utility voiced concerns about vandalism and public safety. The design of an enclosure for the pumps was initiated but was subsequently dropped for being too costly due to wind load and possible wave impact considerations. There was also a concern regarding storm effects on the wood platform superstructure of the fishing pier and the possibility of its failure, as well as loss of access to the pumps. As a result, an alternative design was proposed that included installing a wetwell and valve box with duplex electric submersible pumps located adjacent to the fishing pier. The pumps were sized to supply the plant demand of 1,200 gpm at a total head of 44 feet. A 220-foot, 24-inch diameter HDPE intake line with a grated intake supplied water to the well from deep water located near the north end of the fishing pier. A 14-inch diameter discharge line connected to the existing suction line. At the plant manager's request, the intake pumps were sized to discharge directly to the plant treatment tank. The plant supplied electrical service and control. The bid price for the project was $465,000. Total construction cost was $532,361.

City of Belle Glade

EXISTING FACILITIES

The current intake pump station was formerly a booster station and has undergone several modifications, including the abandonment of the Torry Island intake and the conversion of the booster station to the intake. The original station had two 18-inch diameter, 4,600-gpm, 200-hp turbine pumps in 36-inch diameter cans. A third variable-speed, 250-hp pump was added and was connected to the intake and discharge piping. The 36-inch diameter steel intake pipe had an invert elevation of 2.6 ft-NGVD.

DISCUSSION

The two original pumps were out of service because of cavitation problems that occurred with the lake stage at approximately 10.5 ft-NGVD. The performance characteristics of these pumps were not known. Because of a modification to facilitate the drawing of water from a gravity intake line in lieu of water supplied from the original intake station, it was suspected that the original pump design was significantly changed. Therefore, the variable-speed pump was operated at a greatly reduced speed to reduce the submergence and NPSH required.

The City of Belle Glade had just completed construction of a new submersible pump intake withdrawing from a rock pit on Torry Island, with its discharge line connected to the old supply line to the booster station. The purpose of this intake was to provide water of good quality that would be blended with the water of the rim canal at the current intake. The performance testing of the new campground station indicated that a significant amount of time would be necessary to recharge the pit. Therefore, this station was not considered to be a continuous source of water supply but would provide approximately one day of available storage given the shutdown of the rim canal station.

The emergency plan required the mobilization of a portable pump at the existing rim canal intake. This portable pump was connected to an existing, 8-inch diameter bypass line to supply water directed to the intake pumps. Because of a concern about the failure of the last remaining pump, the District decided to mobilize, test, and keep the portable unit hooked up and ready until the new facility was constructed, tested, and operational.

ALTERNATIVE EVALUATION

The initial design focused on a wetwell and valve box with two submersible electric pumps constructed adjacent to the existing raw water pump station. The wetwell was supplied by gravity through a 30-inch diameter HDPE supply line with a grated, pre-cast concrete intake. The discharge line connected to the existing 20-inch diameter supply line, which connected to the plant approximately 13,000 feet to the south. The pump rating point was 4,000 gpm and 90 feet of total head. On the initial pricing of the job, it was disclosed that the cost and delivery time for this relatively large unit exceeded the initial estimate. Additionally, construction of the deep wetwell required significant sheeting. The District decided to design an alternative unit consisting of two turbine pumps mounted on a pre-cast, concrete, pile-supported platform with an access ramp. The pumps would use the current service from the existing station. Quotes for both alternatives were requested because the city wanted the wetwell alternative.

After the bid, the city expressed a concern about navigation with regard to the platform's proximity to the channel. The U.S. Army Corps of Engineers (USACE) expressed the same concern after the bid. Consequently, the District relocated the platform more than 60 feet to the north, farther from the Torry Island bridge restriction. However, the USACE did not want the platform any further out in the channel than the bulkhead of the existing intake. Therefore, a steel, sheet-pile bulkhead was designed to allow the platform to be located in the canal bank. The additional cost was addressed in change order number 1.

Turbine pumps/platform mounted: $305,000 + C/O No.1 for bulkhead, estimated $40,000

Wetwell: $385,000

Construction cost: $446,828

City of South Bay

EXISTING FACILITIES

The intake consisted of an elevated pump house on concrete pile located in the rim canal. The canal bottom elevation at the intake was 1.0 ft-NGVD. Three vertical pumps and three 750-gpm turbine pumps with 15 hp motor drivers were manifolded to one 12-inch and one 8-inch ductile iron supply pipe. The bottoms of the pump bells were estimated at elevation 7.0 ft-NGVD. One pump was sufficient to meet the plant's demand; one pump was inoperable due to a mechanical problem. The flow rate of one of the pumps appeared to vary proportionately with the lake stage, especially when the upper stage bowl was exposed. From the design drawings produced by the firm Barker, Osha & Anderson Inc., the following table indicates the original design parameters:

Pump	Suction	Discharge	GPM	TDH	Efficiency percent	RPM	Power
1	8 inch	8 inch	750	60	80	1200	240/480
2	8 inch	8 inch	750	60	80	1200	240/480
3	8 inch	8 inch	750	60	80	1200	240/480

DISCUSSION

The pumps were apparently not operating at maximum efficiency, resulting in an increase in the NPSH required. There were no records available on the low stage assumed in the pump design rating.

During the subsequent pump installation by District personnel, platform movement was noted with wave action within the rim canal. Because of stability concerns, District staff evaluated the pump platform to determine the need for structural improvements.

ALTERNATIVE EVALUATION

Since the canal bottom beneath the platform had sufficient depth, District staff decided that the most cost-effective solution would be to replace the pumps. Because of a significant risk of pump failure, District personnel also decided to immediately replace each of three turbine pumps with pumps that satisfied the design requirements for a projected low lake stage of 6.0 ft-NGVD. The total cost of the new equipment was $30,000, at a total construction cost of $111,945 (including structural modifications to the platform).

City of Okeechobee

EXISTING FACILITIES

The City of Okeechobee's intake was located in the Government Cut channel, with a 30-inch diameter supply pipe at an invert of 6.2 ft-NGVD to 6.4 ft-NGVD at the pump station. The intake was approximately 600 feet south of the pump station. The pump station had two 10-inch, 3,000-gpm, and one 8-inch, 2,000-gpm, mixed-flow pumps. The 24-inch diameter discharge line from the station extended 650 feet under the rim canal and over the dike to the plant. The plant supplied electric service. The city also used a well to supply 17.5 mg/month. The plant demand was indicated to be 3,800 gpm, which required the city to operate two pumps simultaneously to meet this requirement. The intake station appeared to be in good condition.

DISCUSSION

District staff believed that the pumping system of the existing intake was capable of operating to a low lake stage of 8.5 ft-NGVD based on the assumed submergence of the mixed-flow pumps. It was unknown at what elevation the pumps would begin to experience performance problems. There was no backup to the existing intake. The District's emergency plan was to mobilize a portable centrifugal pump at the water's edge to pump water into the intake until the permanent replacement station was completed and operational.

The city had a planned plant improvement within the succeeding 18 months that included the replacement of the existing raw water intake. The city requested that the new intake be designed to satisfy the new plant design.

ALTERNATIVE DISCUSSION

A portable pump installation would have significantly exposed equipment, piping, etc. to severe weather and open-water conditions. Therefore, the District did not consider such an installation secure or reliable, nor would it have satisfied the project's objectives. Therefore, the District determined that the sole alternative was a new wetwell and valve box with duplex electric submersible pumps. Use of platform-mounted pumps was not considered because of the lengthy distance required for an access walkway and the exposure of such a platform to severe wind and open-water conditions. The plan was for the wetwell to be adjacent to the existing station to limit the distance to the connection to the existing discharge piping. The quoted design sized the pumps at 2,800 gpm at a total head of 35 feet to make use of existing electric service. Both pumps were necessary to meet demand. The city objected and requested that 3,800-gpm pumps be installed to provide redundancy. However, this proposed design required a significant upgrade of the electrical service to the station and resulted in increased equipment costs. The design was completed after the quote day and, subsequently, a price was obtained from the contractor with the lowest quote, who recommended the installation of larger pumps and a larger-capacity electrical system.

The new facility included a 450-foot, 36-inch diameter intake line with a screened intake for gravity feed to the well. The regulatory agencies were consulted regarding a channel approach to the wetwell and elimination of a significant portion of the intake line. The USACE has specific language in its regulations prohibiting permit exemptions following modification of lake-bottom topography. Consequently, because the mandatory permit process for this design would have taken several months, it was not pursued. The bid price for the project was $457,144, plus $116,580 for pump and electrical upgrades. Projected construction costs were $652,298.

City of Clewiston

EXISTING FACILITIES

The primary intake and pump station for the City of Clewiston was located approximately four miles northeast of the city. It was built in 1943 and was presumably located out in the lake for water quality reasons. The station consisted of a 40-foot diameter reinforced concrete dry/wetwell intake structure, with three 14-inch centrifugal pumps (two electric-driven pumps at 2,100 gpm and one diesel-driven pump at 5,600 gpm). The water entered the wetwell through a five-foot-square gated opening with a sill elevation of 5.3 ft-NGVD. The pump discharges were manifolded to one of three 24-inch supply lines. The treatment plant had a backup intake on the rim canal that consisted of a 12-inch diameter, 5000-gpm, 125-hp, variable-speed, electric motor-driven turbine pump. The 14-inch diameter intake to the pump had an invert of 4.3 ft-NGVD.

DISCUSSION

The city of Clewiston has contracted with U.S. Sugar Corporation for operation of their water treatment plant. U.S. Sugar considered both the primary station in the lake and the backup pump at the rim canal to be at risk below a lake stage of 8.5 ft-NGVD. The performance characteristics and the system curves for the stations and discharge lines were not provided. The lake bottom in front of the primary intake was more or less at elevation 5.0 ft-NGVD. Therefore, with extremely low water it appeared that the lake site required that a channel be excavated to deeper water. Soundings found no existing channels within several hundred feet. The rim canal station was the focus of emergency action, both because of the obvious convenience and the deeper water found in the rim canal.

One disadvantage to the rim canal site was the lack of a dedicated emergency power supply. There was a 175-kW generator located south of the levee that could have provided electric power to the 125-hp motor of the rim canal pump. However, U.S. Sugar indicated that this generator was not for use solely at this site and could potentially be relocated in the case of a higher priority. The District had two 125-kW surplus generators available from the automation of pump station S-331 and offered one unit to U.S. Sugar to ensure the rim canal generator could be dedicated solely for use as an emergency backup for this water supply station. U.S. Sugar agreed and the District transferred the unit.

ALTERNATIVE EVALUATION

There was some discussion of the use of a portable, diesel-driven pump to supply water to the lake intake by sandbagging the wetwell opening and piping water over the plug. The duration of this operation, as well as the difficulty of supplying fuel and/or emergency service, eliminated this alternative from further discussion. Also, with the assumption of an extremely low lake stage of 6.0 ft-NGVD, this site was not feasible.

A portable hookup to the rim canal pump was possible with the removal of the intake line strainer and connection of the pump's discharge to the 14-inch diameter intake line at the tee. The portable pump would be sized and operated to feed the existing pump. This was the then-current emergency plan since both stations were shut down. In lieu of pumping into the intake, the District decided to install the piping for the selected alternative from the connection to the existing 12-inch supply line to a point where a connection could be left for the portable pump.

The initial proposed design was that of a wetwell with a duplex submersible pump system. However, after reviewing the cost of such a system, a platform-mounted turbine pump was designed as an alternative. U.S. Sugar Corp wanted a diesel engine-driven pump, so two alternatives were prepared: one with an electric motor and another with a diesel motor. The platform was designed for one pump, with U.S. Sugar eventually agreeing to a single, installed unit with one backup pump. U.S. Sugar indicated it could easily and quickly replace the pump, if necessary.

The proposed drawings failed to indicate the need for a spare pump for the diesel-driven alternative, while the electric motor alternative had a second pump as a backup. The diesel-driven alternative quoted was $20,000 less than the electric motor-driven alternative. U.S. Sugar was given the choice of either the diesel engine without the backup pump, or the electric engine with the second pump. U.S. Sugar selected the latter, which consisted of one electric motor-driven turbine pump rated at 4,800 gpm at 70 feet of total head with a backup pump. The pump was mounted on a reinforced, concrete pile-supported platform with an access ramp and operated off the electrical service to the existing rim canal intake pump.

- Electric motor-driven turbine pump alternative - $340,000
- Diesel engine-driven turbine pump alternative - $320,000 + $40,000 for spare pump not quoted
- Wetwell/submersible pump alternative - $474,000
- Construction cost - $345,300

Table 6-1. Lake Okeechobee Water Utility expenditures (replace or restore raw water intakes and pump stations)

Water Utility	Expenditures*
Pahokee	$ 532,361
Belle Glade	$ 446,828
South Bay	$ 111,945
Okeechobee	$ 652,298
Clewiston	$ 345,300
Total	$2,088,732

9/28/01

* The above expenditures do not include the reimbursement paid to the cities of Belle Glade, South Bay, and Pahokee for increased treatment expenses during Lake Okeechobee water supply back pumping.

DROUGHT-RELATED THREATS TO THE RESOURCE

A primary concern during the 2000–2001 drought was the threat of saltwater intrusion into water supply wells, especially those used by public utilities along the coastal margin. Local rainfall is the primary source of recharge for the Biscayne aquifer. Seepage from the Water Conservation Areas to the west and recharge from Lake Okeechobee through canals are important sources of recharge, especially during a drought. Consequently, the extent to which water levels in Lake Okeechobee would fall to an elevation that would prohibit withdrawals was an especially important consideration. The Lake Okeechobee water level dropped to below 9.2 ft-NGVD in May 2001. At this level, significant portions of the lake bottom were exposed, and gravity flows to the WCAs and canal system were not possible. Therefore, the District installed pumps that were capable of “forward pumping” water to the LEC.

MANAGEMENT ACTIONS TAKEN TO PROTECT THE RESOURCE

The South Florida Water Management District took numerous actions to protect Lower East Coast water resources. These actions, documented in weekly reports, included closely monitoring

Lake Okeechobee water levels, as well as groundwater levels, public water supply wells (especially for utilities at risk), and diversions by special districts.

The Operations Department issued the "Operational Intent of Supply Side Management Implementation" weekly for those permittees located within the boundaries of the Lake Okeechobee Service Area. All flows out of Lake Okeechobee were monitored and compared against the Lake Okeechobee Service Area weekly allocation. Actions taken concerning the Everglades Agricultural Area, including supply side management and deliveries of water, were discussed in the previous chapter.

To monitor saltwater intrusion, specific wells were selected and data from them were collected weekly. Pumpage information from selected public water supply wells was also collected and analyzed weekly.

The following public water supplies had coastal wellfields that were monitored especially closely, since they were considered "at risk" due to saltwater intrusion: Hollywood, Pompano, Deerfield, Hillsboro, Hallandale, Dania, Broward County 3A, Florida Keys Aqueduct Authority, Florida City, Miami-Dade County-Rex, Homestead, Lake Worth, Highland Beach, Riviera Beach, Manalapan, and Lantana.

In addition, six utilities withdraw surface water directly from Lake Okeechobee: Clewiston, U.S. Sugar-Bryant, Okeechobee, South Bay, Belle Glade, and Pahokee. These utilities were considered "at risk" and were closely monitored due to all-time-low lake levels that threatened to drop below the intakes. Lee County Utilities and Ft. Myers were monitored extremely closely and were considered "at imminent risk" of saline intrusion into their intake structures due to their inability to release water from Lake Okeechobee to offset salinity coming into the Caloosahatchee River. Information on pumpage from the Old Plantation, Broward County, Sunshine, Acme, and Lake Worth special districts were collected and analyzed weekly.

RESULTS AND OUTCOMES

While the drought conditions within the LEC during the 2000–2001 drought were severe, actions taken by the District to decrease pumpage prevented permanent damage to public water supplies. The extremely low water levels recorded by Lake Okeechobee proved that the District may need to consider alternative water supplies and treatment for those utilities that currently withdraw water directly from the lake and along the coastal margin.

LOWER WEST COAST

DESCRIPTION OF THE AREA AND ASSOCIATED WATER RESOURCES

The Lower West Coast (LWC) consists of Charlotte, Collier, Glades, Hendry and Lee counties (**Figure 6-5**). During the drought, there were several areas of concern within the five counties, including saline movement within the Caloosahatchee River and groundwater levels within the lower Tamiami, Sandstone and mid-Hawthorn aquifers.

DROUGHT-RELATED THREATS TO THE AREA

The over-use of the mid-Hawthorn aquifer in the western half of Charlotte County, and the Sandstone aquifer in the eastern half of the county (near the Four Corners area), was a primary concern. Single-family homes that utilize centrifugal pumps to withdraw water from potable wells competed for water from both aquifers for agricultural and domestic use. Lack of rainfall, combined with the continual and increased use of the aquifers, lowered the water levels beyond a point that the centrifugal pumps worked.

In Collier County, over-use of the lower Tamiami aquifer was a primary concern. Within the western and northern sections of the county, there was also a major concern about saline movement within the aquifer. The aquifer was only used for potable water supply from the county line south to Pine Ridge Road and from the Gulf of Mexico east to I-75. Outside those boundaries, there were competing uses for water from the aquifer by both self-supplied commercial users and single-family homes. The potential was greater for saline water movement when water levels within the lower Tamiami aquifer dropped below 0.0 ft-NGVD. U.S. Geological Survey (USGS) water resource investigation number FL-66200 indicated that there were areas within the lower Tamiami aquifer that had annual average water levels below 0.0 ft-NGVD.

In Glades and Hendry counties, a concern existed for competing uses of the Sandstone aquifer from both agricultural and domestic use by single-family homes. These homes utilize centrifugal pumps that are also affected by groundwater levels. Additional concerns regarding the Caloosahatchee River included low water levels and the possibility of saline intrusion from the Gulf of Mexico towards Lake Okeechobee beginning in Lee County at the W.P. Franklin Lock and Dam (S79).

In Lee County, there was concern for competing water uses. The Caloosahatchee River on the east side of the W.P. Franklin Lock and Dam (S-79) supplied water to the City of Ft. Myers and also to Lee County. Two utilities – the City of Ft. Myers and Lee County – withdrew water from the Caloosahatchee River. The City of Ft. Myers pumped water from the Caloosahatchee to its wellfield located 10 miles to the south. The water flooded a 543-acre project, seeped into the surficial aquifer, and then was withdrawn using screened surficial aquifer wells. Once withdrawn from the wells, the water was pumped to a reverse osmosis plant, sanitized with chlorine gas, and distributed to customers. Lee County had a water plant adjacent to the City of Ft. Myers' withdrawal point on the river. The Lee County plant was an older plant that used aeration methods to process water. In addition, as noted above, it used chlorine gas to sanitize treated water. Lee County had installed an Aquifer Storage and Recovery (ASR) well at the Olga Water Plant. The county was testing the structure to determine its performance. Lee County depended on the District to maintain a fresh water supply on the east side of the W.P. Franklin Lock and Dam (S-79) because the plant had no way to reduce chlorides in the water. The maximum total chloride level was 200 parts per million.

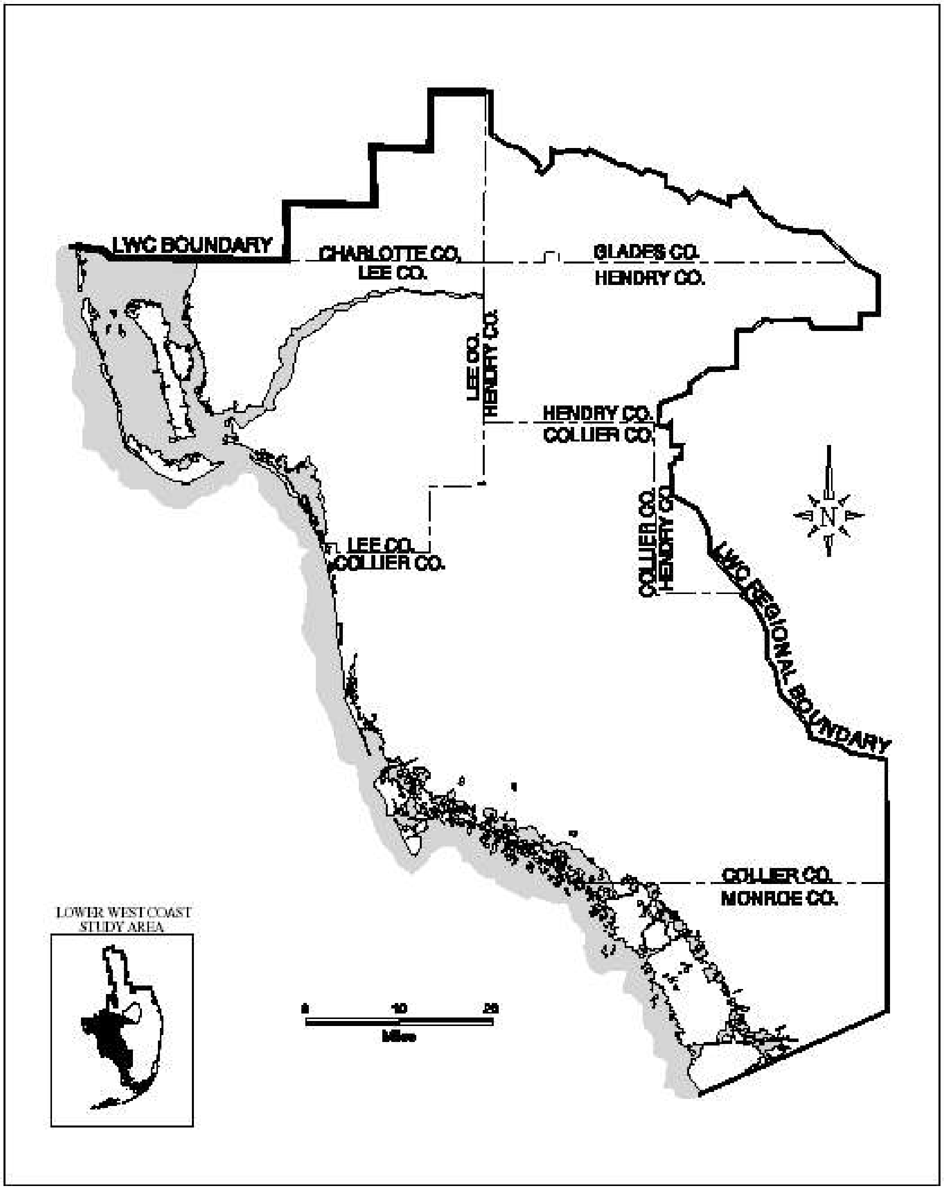

Figure 6-5. Lower West Coast planning area

The Lehigh Acres section of Lee County depends on the Sandstone aquifer for its water supply. Demand in the northern section of Lehigh Acres is predominantly from single-family homes and commercial landscape use. Demand in the southern section is for both agricultural purposes and domestic use by single-family homes. The homes use centrifugal pumps that were affected by groundwater levels.

Cape Coral, South Ft. Myers, the Iona area, and Estero still use the mid Hawthorn aquifer, which has a very low transmissivity. Lack of rainfall results in continual use of the aquifer and lowers water levels to a point below which centrifugal, and some submersible, pumps can withdraw.

The primary concern in Bonita Springs north to Coconut Road is over-use of the lower Tamiami aquifer. Within the southwestern section of the county, there is a major concern regarding saline movement within the aquifer.

MANAGEMENT ACTIONS TAKEN TO PROTECT THE RESOURCE

On November 29, 2000 the District issued phase II water restrictions for the LWC and phase III water restrictions for all uses of the Caloosahatchee River east of the W.P. Franklin Lock and Dam (S-79). By instituting the phase II restrictions for the Surficial, lower Tamiami, Sandstone and mid Hawthorn aquifers, the District was able to help stabilize groundwater levels. This was achieved by limiting groundwater use for irrigation to two days a week.

In addition, District staff from the Ft. Myers Service Center created a group that met weekly to discuss any issues of concern to local utilities that withdraw water from the Caloosahatchee River on the east side of the W.P. Franklin Lock and Dam. A primary concern was the saline wedge that penetrated the W.P. Franklin Lock and Dam and headed eastward towards Lake Okeechobee. The group continues to meet quarterly to discuss the status of both utilities.

RESULTS AND OUTCOMES

A positive result achieved by both instituting groundwater irrigation restrictions and restricting the use of the Caloosahatchee River was a significant reduction in the number of “out-of-water” complaints from single-family homes. Additionally, the Caloosahatchee River utilities group that met weekly to assess the availability of fresh water in the river helped to promote the District’s commitment to preserve the resource.

Chapter 7: Environmental and Economic Impacts

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SUMMARY

As the drought progressed, South Florida's varied ecosystems were monitored for drought conditions to attempt to predict areas of concern. The South Florida Water Management District (District) conducted ecological assessments for the Kissimmee River basin, Lake Istokpoga, Lake Okeechobee, the coastal estuaries, the water conservation areas, Everglades National Park, and Florida Bay. In addition, the District monitored water quality conditions in Lake Okeechobee, the water conservation areas, and Everglades National Park. Because the natural system normally experiences wide variation in weather conditions, not all the observed effects from the drought were negative. However if the drought had continued, greater impacts would likely have been observed.

Although quantitative data are limited, the drought resulted in significant economic impacts to user groups throughout the District. Public water supply utilities experienced unanticipated revenue losses associated with reduced pumpage, and, in some cases, higher production costs resulting from increased use of alternative water sources. Agriculture, plant nurseries, and the landscaping and golf course industries also experienced significant negative economic impacts. Small recreational and tourism businesses surrounding Lake Okeechobee were especially hard-hit by the drought. The drought emergency took an unanticipated economic toll on the District, as well. By the end of the fiscal year in September 2001, the District had spent $9.7 million of its unbudgeted funds on drought-related expenditures.

ENVIRONMENTAL RESPONSES, WATER QUALITY, AND ENVIRONMENTAL IMPACTS

During the 2000–2001 drought, there was a critical need to provide up-to-date ecological and environmental science to decision makers for both short-term and long-term water management. The drought affected all of South Florida and created unprecedented low water level conditions in some Everglades sub-regions. Under these conditions, Everglades water levels had the potential to be drawn down below preferred levels for the ecosystem's biological components. Drought conditions during 2000 and 2001 created situations that necessitated striking a balance between water supply and environmental needs, which required protecting wellfields and conserving critical water supplies while minimizing and mitigating adverse impacts to the environment.

KISSIMMEE RIVER BASIN

No long-term impacts of drought were observed in the Kissimmee Basin, though water levels in the Upper Chain of Lakes were between 0.5 feet and 1.0 foot below regulation schedules. However, impediments to navigation as a result of low water levels during the drought were encountered.

Despite the drought, continuous discharge from Lake Kissimmee to the Kissimmee River for environmental restoration was re-established in June 2001. As a result, numerous initial positive responses were documented within the river/floodplain ecosystem, including:

- Historic river channel substrate and sandbar characteristics were re-established.
- The cover of nuisance aquatic plants decreased in the river channel, and levels of dissolved oxygen increased.
- Broadleaf marsh was re-established over portions of the re-inundated floodplain, with increased utilization of floodplain habitats by river channel fishes.
- Four species of waterfowl, including hundreds of blue-winged teal and eight species of shorebirds using floodplain and river channel habitats, returned to the revitalized wetlands.
- There has been an increased occurrence of the endangered bald eagle and wood stork in the restored area.

Lake Istokpoga Environmental Enhancement

As a result of the drought, a three-month muck and tussock removal project was initiated to capitalize on the already low lake stages and obviate the need to discharge excessive quantities of water to Lake Okeechobee in the future. The Florida Fish and Wildlife Conservation Commission (FFWCC) was scheduled to conduct a Lake Istokpoga drawdown and muck removal project during 2002 and 2003. Since the District expected the lake to naturally drop to a level that would allow muck removal to occur, and because lake users were already being impacted, the District lowered the lake's water level by approximately one foot in February 2001 to allow the work to proceed during the dry season. By the time the lake started to refill in June 2001, 1,300 acres, or two-thirds, of the perimeter shoreline had been scraped and harvested and 2.4 million cubic yards of material were removed. Two-thirds of the material were consolidated on wildlife islands along 21 miles of shoreline; the remaining third was transported to upland disposal. The muck and sand islands will become covered with weeds, brush, red maple trees and, eventually, cypress in conjunction with future FFWCC efforts. The FFWCC conducted additional cleanup efforts using an aquatic weed harvester to enhance areas along the shoreline that could not be completed during the drawdown. The FFWCC also planned to conduct some revegetation work in the enhanced areas. But for the most part the lake's response to the completed work was beneficial for fishing interests because of the re-establishment of desirable native plant communities.

LAKE OKEECHOBEE

Positive Changes to the Lake

Lake Okeechobee experienced a number of positive ecological changes in response to the low lake stages, reflecting the ecosystem's recovery after years of damage from high water levels. These positive responses included:

- Renewed growth of submerged plant beds in regions of the lake where no plants grew in the late 1990s, and widespread growth of bulrush, spikerush, and other emergent marsh plants in shoreline regions
- Very clear water in the shoreline regions, with dense submerged and emergent plants; there was heavy utilization of the lake by wading birds, ducks, and shore birds

- Fishing in the shoreline area was reported to be excellent, with evidence of good recruitment of young-of-year bass, according to recent information from the Fish and Wildlife Conservation Commission (FFWCC)
- Widespread oxidation and compaction of organic muck that had accumulated in the lake's shallow shoreline areas
- Large-scale littoral zone fires, either purposely set by management agencies or due to unknown causes, burned tens of thousands of acres of dense cattail, melaleuca, and torpedo grass during the drought, opening up the habitat for potential re-colonization by native plants
- The opportunity for physical removal of an organic berm along the western lakeshore, a project carried out by the FFWCC, with funding from the District and the U.S. Army Corps of Engineers (USACE).

Impacts to the Lake

One significant negative ecological consequence of the extreme low lake stage was that torpedo grass expansion into native plant communities in the interior littoral zone was more rapid than in earlier years. However, the District and the Florida Department of Environmental Protection (FDEP) are working together to treat these areas of expansion with herbicide, in addition to the ongoing program to eradicate torpedo grass from larger areas where it had already become established. The District is also screening a variety of herbicides to determine if there is a control agent that offers more selectivity (not harmful to native plants) than chemicals currently being used.

Another adverse impact to the lake's ecology resulted from a decision to backpump water into Lake Okeechobee. As the drought progressed during the spring of 2001 the District's Executive Director declared a water emergency on March 27, 2001. The governing board subsequently concurred with that decision during an emergency meeting on the same date. In response, the FDEP issued the first Emergency Final Order (OGC no. 01-0715) on April 27, 2001 authorizing the District to initiate water supply backpumping into the lake through the structures at S-2 and S-3 at the south end of Lake Okeechobee. In the ensuing months, as the drought continued and as concerns escalated about the impending dry season, the FDEP authorized the District in a second Emergency Final Order (OGC no. 01-1202) dated and issued on August 3, 2001 to continue water supply backpumping and allow augmentation of the pumping and gravity flows of water into the lake through the structures at S-4, S-77, S-308, S-352, and culvert 10-A. As part of those permitted operations, the orders mandated intensive water quality and biological monitoring programs, the implementation of certain operational constraints, and activities required to offset potential negative impacts of the backpumping events. These activities included planting bulrush in previously denuded areas and removing an organic berm in the lake.

Water Quality Monitoring

In general, the water entering the lake through the augmentation structures contained lower total phosphorus concentrations than water entering the lake from other sources. All sampling and analyses were conducted in accordance with the conditions detailed in the emergency final orders of April 27, 2001 and August 3, 2001.

During the period from June 1 through September 21, 2001, backpumping from S-2 and S-3 contributed 22 percent, or approximately 325,000 ac-ft, of the total water inflow into the lake, but only 9 percent, or 37.9 metric tons, of the total phosphorus (TP) contribution to the lake (**Table 7-1**). Flows from all augmentation sources addressed in the second Emergency Final Order, including backpumping and gravity flow, contributed 39 percent of the flow and 25 percent of the TP when compared to all water sources contributing to the lake at that time. These relative contributions resulted in an average flow-weighted mean concentration (FWMC) of TP from all backpumping and augmentation sources of 146 parts per billion (ppb); the FWMC of TP entering the lake from all sources, including the backpumping and augmentation flows, averaged 228 ppb.

Calculated loads for total nitrogen (TN) indicate that the load entering the lake for the augmentation period and coming from the augmentation structures represented 46 percent of the total nitrogen load from all sources. The FWMC of TN entering the lake from all sources during the period was 2.53 mg/l (2,532 ppb), whereas the FWMC of TN from the flows coming through the structures being used for water supply backpumping and augmentation was 2.99 mg/l.

The monitoring programs specified by the emergency final orders also required additional water quality monitoring of the inflows into the lake for parameters other than nutrients, including pesticides, trace level mercury, and general water quality parameters. Though trace levels of pesticides were found in some samples, no pesticide concentrations exceeded class I water quality standards. Trace level mercury monitoring for all structures involved in augmentation flows to Lake Okeechobee indicated that no analyzed and reported water sample exceeded the state criterion of 12 ng/l total mercury.

Analyses of general water quality parameters indicated that there were no significant violations of class I water quality standards at any location, except for variations from the dissolved oxygen (DO) standard and a few exceedances of the standard for iron. Concentrations below the 5 mg/l DO standard are common in ambient South Florida surface waters and do not necessarily indicate an adversely impacted water quality. The FDEP is reviewing this standard, and it is anticipated that it will be revised to more accurately reflect naturally occurring conditions in South Florida. The exceedances observed for iron that were in excess of the class I standard were still within the class III standard. Since the water samples were collected on the upstream, or canal side, of the structures and, therefore, were collected in class III waters, there is a question as to which standard should apply. Furthermore, iron in concentrations greater than the class I standard of 0.3 mg/l in surface water is generally in the form of particulate iron associated with suspended sediments and should settle out in the lake. This would allow the water to meet class I standards in that water body before the water reaches any public water supply intake point. A detailed tabulation of all water quality analyses can be found in the full report on the Lake Okeechobee backpumping and augmentation activities in **Appendix 3A-1**.

Table 7-1. Summary: June 1, 2001 through September 21, 2001 water supply backpumping and augmentation sites compared to all lake inflows

Total Phosphorus (TP)			
STATION	Total Phosphorus (TP)		% of total lake-wide inflow
	loads (metric tons)	FWMC (ppb)	
S2	23.96	99.0	6%
S3	13.95	87.3	3%
CULV10A (L8)	9.52	103.0	2%
S77	13.13	153.8	3%
S308	40.09	357.3	10%
S4	2.29	153.9	1%
S352	0.82	229.2	<1%
Sum of above sites	**103.76**	**146.1**	**25%**
% of all lake-wide inflow	**25%**		
Lake-wide total inflow	**413.52**	**228.0**	
Total Nitrogen (TN)			
STATION	**Total Nitrogen (TN)**		**% of total lake-wide inflow**
	Loads (metric tons)	**FWMC (ppb)**	
S2	894	3,697	19%
S3	559	3,499	12%
CULV10A (L8)	206	2,227	4%
S77	169	1,977	4%
S308	238	2,118	5%
S4	40	2,669	1%
S352	24	6,752	1%
Sum of above sites	**2,129**	**2,999**	**46%**
% of all lake-wide inflow	**46%**		
Lake-wide total inflow	**4,592**	**2,532**	

Biological Monitoring

The FDEP required the District to expand its biological monitoring program in the lake in an effort to identify any negative ecological impacts resulting from backpumping. The District had the benefit of nearly two years of biological monitoring background data to assist in the identification of potential effects. The focus of the monitoring, as detailed in the two emergency final orders (OGC no. 01-0715 and OGC no. 01-1202) provided by the FDEP, was on submerged aquatic vegetation (SAV) and water transparency. The lake's SAV is a valued ecosystem component that provides habitat for fish and other aquatic biota. Submerged aquatic vegetation is a sensitive indicator of water quality because its aboveground tissues are in direct contact with the lake water. Documented research on Lake Okeechobee and other shallow, freshwater ecosystems has shown that underwater light availability is a prime determinant of SAV growth. Therefore, the biological monitoring program also included a detailed analysis of underwater light in the southern region of the lake in proximity to the S-2 and S-3 pump stations, as well as at other stations that could be used as "reference" locations for comparison.

In summary, biological monitoring indicated no negative impacts of the backpumping operations on SAV or water transparency. There were typical seasonal and location variations in SAV occurrence similar to those that have been previously documented for Lake Okeechobee. There were also changes in water transparency associated with increased water depths, lake-wide effects from wind, and lake-wide changes in dissolved organic color. However, none of these changes was associated with the emergency water supply backpumping operations. These results do not indicate that backpumping will never have negative ecological impacts on the lake; rather, only that such effects were not observed during the 2000–2001 drought.

The full report on the Lake Okeechobee backpumping and augmentation activities (**Appendix 3A-1**) provides detailed discussions of all biological data.

DROUGHT IMPACTS ON THE EVERGLADES CONSTRUCTION PROJECT

STA-1W

Drought impacts on STA-1W were minimal despite record low stages in all treatment cells. Seepage inflow from WCA-1 almost eliminated the need for emergency water deliveries to STA-1W. In May 2001, however, the District diverted 830 ac-ft of water into the project to protect more than 2,000 acres of SAV from dryout. Because the District kept STA-1W flooded throughout the drought, the underlying peat soils were protected from oxidation. No significant long-term impacts on treatment performance or the vegetation communities are anticipated.

STA-2

The sawgrass and woody plant communities of the former Brown's Farm Wildlife Management Area make up most of the treatment area within STA-2 and are naturally drought tolerant. Consequently, no drought impacts were evident in either cell 1 or cell 2. When water depth in cell 3 dropped below six inches in March 2001, the District made emergency water deliveries totaling approximately 1,600 ac-ft to that cell to protect the developing SAV community from drying out. Significant long-term impacts from the drought are not expected on treatment performance or the vegetation communities.

STA-5

Despite extremely low water levels in STA-5, the drought's impact on vegetation communities was minimal. To protect the developing SAV community in cell 1B, the District diverted roughly 3,000 ac-ft of water into that cell to maintain a minimum depth of six inches, as directed by permit. No plant mortality was observed in the SAV cell. There was a net gain of cattail in the remaining three cells despite having water levels that fell below the average ground surface elevation. While some isolated mortality occurred in cattail stands located at the highest ground elevation, the plants recovered quickly when the cells were reflooded. Water quality was monitored closely at STA-5 to determine if the drought was having any adverse influence on treatment performance.

STA-6

Because STA-6 usually experiences an annual dryout, the 2000–2001 drought did not adversely impact the wetland's ecological integrity. Both treatment cells experienced two separate dryout events and, subsequently, two re-flood periods. No emergency water deliveries were required for STA-6 because the mixed grass and sawgrass plant communities are drought tolerant. In fact, re-growth of the SAV and periphyton communities in cell 5 seemed to follow a predictable annual pattern once the wetland reflooded. Pre- and post-drought phosphorus removal did not differ significantly, which indicated that the drought had minimal, if any impact on treatment performance.

DROUGHT IMPACTS ON WATER CONSERVATION AREAS AND EVERGLADES NATIONAL PARK

To assist water managers in evaluating drought conditions, District staff created a series of indices that formalized knowledge of the effects of drought on ecosystem attributes. Water level, muck fire, wading bird habitat, and general ecological risk assessment models were developed as tools for assessing then-current, as well as predicted, 2000–2001 drought effects within the WCAs, wildlife management areas, and Everglades National Park. District staff created formulae using the Environmental Protection Agency's REMAP data and the South Florida Water Management District's Stormwater Treatment Area receiving areas' Monitoring and Research and Threshold Program data. SFWMD staff used these formulae to estimate the then-current, as well as predicted, ecological conditions in the Everglades that might have occurred as a result of the drought. The indices were compiled in Drought Ecological Impact reports. The April 2001 report contains background information on how the ecological risk assessment models were specifically developed. In addition, a draft manuscript for publication, "Assessing Drought Related Ecological Risk in the Florida Everglades" (Smith et al., 2002), has been developed.

The output from these models in the form of system-wide maps provided a qualitative tool for understanding the spatial and temporal variability of ecological risk during the 2000–2001 drought. This proved valuable in developing piecemeal water management plans in this highly compartmentalized system, where each component functions differently and can differ substantially in terms of risk. Overall it was a good year for the Everglades ecosystems when evaluating the ending, dry-season conditions of May 2001. Several marsh sites identified by the muck fire hazard index exceeded the critical water level threshold of one foot below ground elevation. Fortunately, the numerous fires that occurred throughout the Everglades during this time were restricted to healthy surface burns and did not result in damaging muck fires. All the wading bird colonies successfully fledged young this nesting season, though some colonies were more successful than others were.

In addition to providing continuous, updated assessments throughout the drought period, the models were linked with position analyses (predictions of future stages) to evaluate the ways various water management alternatives might exacerbate or alleviate ecological stress. Assessments were completed for various operational schemes, all of which sought to lower the minimum allowable stages for the WCAs in various ways for the benefit of water supply. The assessments revealed that such deviations in the regulation of WCAs 1 and 2A, for example, would result in little or no increase in ecological risk, but that deviations in WCA-3A would be unwise. The assessments also revealed that parts of northern WCA-3A were already in the high-risk category for peat fire and the spatial extent of suitable wading bird habitat.

Water Quality Monitoring

Potential effects of the drought on water quality were evaluated for the Loxahatchee National Wildlife Refuge (Refuge), Water Conservation Area 2 (WCA-2), Water Conservation Area 3 (WCA-3), and Everglades National Park (Park). Water quality samples were collected at 111 routinely monitored stations (**Figure 7-1**). Monitoring stations located within each region were divided into sub-regions as inflow, interior, or outflow sites. Inflow sites were defined as those stations that convey water into a region. Marsh and canal stations, as well as those structures that convey water within each region, are defined as interior sites. Outflow sites are defined as those that convey water from a region. In addition, the Refuge has a rim canal component for analysis of inflows being conveyed in rim canals that border the east and west Refuge levees and discharge into outflow structures in the south levee. This classification scheme is presented in the *2000*, *2001*, and *2002 Everglades Consolidated Report* (ECR) (Bechtel et al., 1999; Weaver et. al., 2000; Weaver et al., 2001).

Changes in water quality and compliance with Class III criteria were used to evaluate any potential effects of the drought for the period from May 2000 through September 2001. This evaluation was limited to the following parameters:

water temperature	dissolved oxygen*
specific conductance*	pH*
alkalinity*	total suspended solids
turbidity*	total nitrogen
total phosphorus	

* Numeric criteria pursuant to Chapter 62-302, F.A.C.

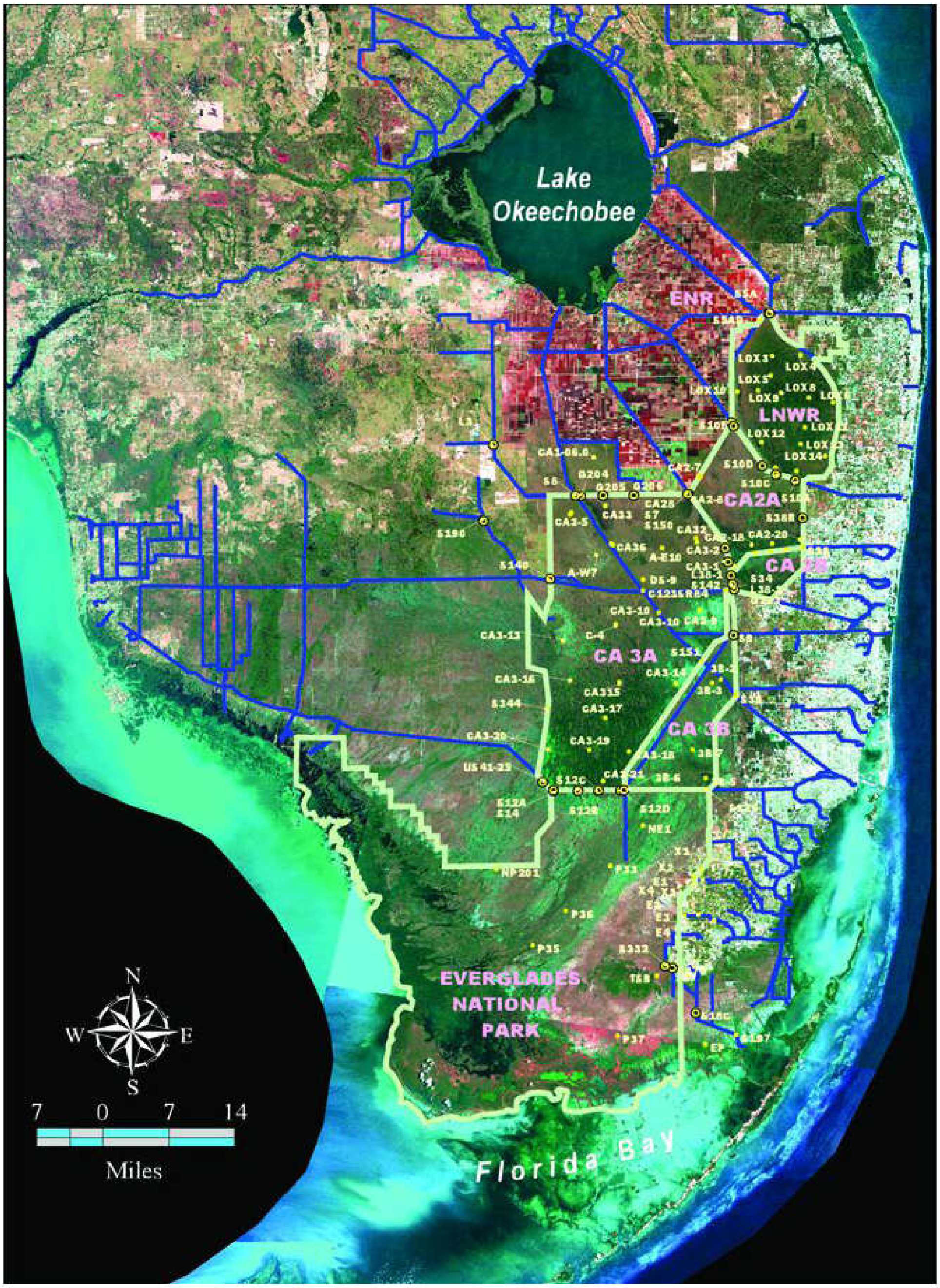

Figure 7-1. Location of monitoring sites in the Loxahatchee National Wildlife Refuge, Water Conservation Areas, and Everglades National Park

Loxahatchee National Wildlife Refuge

A summary of water quality data for the drought period is presented in **Table 7-2**. In addition, a graphical presentation of the data is presented in **Figures 7A-1-1** through **7A-1-16** in **Appendix 7A-1** for each parameter. These plots show: (a) the total number of samples collected per month by parameter at each sub-region, as well as the number of excursions from class III standards; and (b) the average monthly level for each parameter in the specified sub-regions.

Specific conductivity, dissolved oxygen, alkalinity, turbidity, and pH levels in the Refuge did not meet the class III criteria during the drought period. Of these parameters, only dissolved oxygen and pH had a greater percent of excursions during the drought than during previous years of monitoring. The remaining parameters (alkalinity and turbidity) had percent excursions similar to or below previous years of monitoring.

Approximately 91 percent of dissolved oxygen measurements at the interior sites were below the 5.0 mg/L limit compared with 76 percent for the historic period (1978 through 1999) and 77 percent for the 2000 Water Year (Weaver et. al., 2001). The percent excursion for the 2001 Water Year was similar to the drought period because the first 12 months of the drought period are represented in the 2001 Water Year.

One of the more obvious effects of the drought was the number of stations that were dry. Bechtel et al., (2002) reported that approximately 33 percent fewer samples were collected for total phosphorus from January through September of 2001 than for the same period in 2000 at interior sites. This trend was also observed for other parameters at interior sites.

The interior sites of the Refuge had monthly mean dissolved oxygen concentrations below the class III criteria during the drought period. Outflow structures exhibited a slightly greater percentage of dissolved oxygen excursions (2 to 3 percent) during the drought than in previous periods (Weaver et al., 2001).

Dissolved oxygen concentrations are typically depressed in macrophyte-dominated marsh environments, such as interior sites in the Refuge, due to natural processes of photosynthesis and respiration (Belanger and Platko, 1986; McCormick et al., 1997). These low dissolved oxygen concentrations represent the natural variability in this type of ecosystem. Therefore, the class III criterion of 5.0 mg/L is not believed to be appropriate for the Everglades system (Weaver et al., 2000; Weaver et al., 2001). However, an increase in the percent excursions may be indicative of drought effects within the interior of the Refuge.

Overall, the mean dissolved oxygen concentration reported for the drought period (**Table 7-2**) in the Refuge was comparable to the average reported for the 2001 Water Year (Weaver et al., 2001) and lower than that reported for the 2000 Water Year (Weaver et al., 2000). As stated previously, the majority of the data reported for the drought period (except for May 2001 through September 2001) was reported for the 2001 Water Year in the ECR. Therefore, similarities between these two data sets are not surprising. However, any deviations observed between the drought period data and the 2001 Water Year summarization (as reported by Weaver et al., 2001) can be attributed to the last five months of the drought.

Table 7-2. Summary of water quality data collected at monitoring sites in the Loxahatchee National Wildlife Refuge during the drought period from May 2000 through September 2001

Parameter	No. of Samples	Min.	Median	Max.	Mean	Standard Deviation	Class III Criteria
Inflow Structures							
Physical							
Temperature (°C)	316	15.0	26.9	32.6	25.4	4.1	Not Applicable
Dissolved Oxygen (mg/L)	316 (230)	0.08	3.46	13.51	3.73	2.24	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	316 (23)	313	1059	1461	984.8	259.9	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	316 (2)	5.15	7.42	8.57	7.47	0.30	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	154	108.1	221.4	390.7	228.7	65.8	Not less than 20 mg/L
Total Suspended Solids (mg/L)	125	<1.0	4.4	40.0	7.2	7.8	Not Applicable
Turbidity (NTU)	154 (1)	0.6	4.2	46.4	6.6	6.6	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	221	<0.50	2.43	7.09	2.57	1.07	
Total Phosphorus (μg/L)	413	14	49	356	68	56	
Rim Canal							
Physical							
Temperature (°C)	70	7.4	25.6	30.7	24.8	4.7	Not Applicable
Dissolved Oxygen (mg/L)	84 (58)	0.55	3.68	8.46	4.04	1.83	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	94 (3)	444	931	1420	908.6	210.1	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	60	7.01	7.43	8.15	7.47	0.23	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	65	116.0	240.0	346.0	237.9	54.9	Not less than 20 mg/L
Total Suspended Solids (mg/L)	41	4.0	6.0	77.0	10.0	12.8	Not Applicable
Turbidity (NTU)	29 (2)	1.6	7.2	35.0	10.1	8.9	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	65	0.68	2.40	5.60	2.51	0.88	
Total Phosphorus (μg/L)	70	19	59	263	75	45	
Interior Sites							
Physical							
Temperature (°C)	313	11.3	25.4	33.2	24.2	4.2	Not Applicable
Dissolved Oxygen (mg/L)	350 (318)	0.19	2.35	9.68	2.60	1.65	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	384 (1)	8	277	1412	418.7	322.4	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	289 (65)	5.43	6.81	7.66	6.71	0.54	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	210 (25)	10.0	128.5	345.0	133.7	87.8	Not less than 20 mg/L
Total Suspended Solids (mg/L)	126	2.1	4.0	29.0	4.6	2.5	Not Applicable
Turbidity (NTU)	92	0.4	0.7	3.5	0.9	0.6	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	210	<0.50	1.71	4.76	1.76	0.67	
Total Phosphorus (μg/L)	312	<4	11	120	14	14	
Outflow Structures							
Physical							
Temperature (°C)	96	14.5	28.1	32.3	26.6	3.8	Not Applicable
Dissolved Oxygen (mg/L)	96 (68)	0.21	3.69	9.73	3.94	2.11	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	95 (1)	168	718	1287	743.1	252.1	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	96	6.79	7.45	8.34	7.46	0.31	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	83	62.5	185.4	380.7	198.7	76.0	Not less than 20 mg/L
Total Suspended Solids (mg/L)	80	<1.0	3.1	39.6	5.6	7.0	Not Applicable
Turbidity (NTU)	83 (1)	0.8	2.7	36.7	4.8	5.4	Less than or equal to 29 NTU above background
Nutrients							

Alkalinity excursions were only observed at interior sites of the Refuge (**Table 7-2**). Approximately 12 percent of alkalinity measurements were below the 20-mg/L standard specified in Section 62-302.530, F.A.C. During previous years, the percent of samples with alkalinity levels below this criterion ranged from 15 to 30 percent (Weaver et al., 2001). This sub-region receives most of its hydrologic load through rainfall, which results in lower alkalinities compared with the other sub-regions of the Refuge. For the drought period, alkalinity at the interior sites of the Refuge averaged 133.7 mg/L (**Table 7-2**) compared with 44 to 136 mg/L for previous years. The higher alkalinities observed during the drought at these sites (as well as the lower percent excursions) suggest that the water quality for interior sites may have been affected by the drier conditions.

Generally, the other parameters (including total nitrogen and total phosphorus) exhibited similar levels to those reported in previous years. Only mean specific conductance at the interior sites of the Refuge was higher than in previous years. This apparent increase in specific conductance may have resulted from the drought.

Water Conservation Area 2

Water quality in WCA-2 for selected parameters collected during the drought are summarized in **Table 7-3** by sub-region. The total number of monthly samples collected for each parameter, as well as the number of excursions from class III criteria, are depicted in **Figures 7A-1-17** through **7A-1-32** in **Appendix 7A-1**. These figures also show mean monthly concentrations by parameter in the sub-regions of WCA-2.

Excursions from the class III dissolved oxygen standard were observed for the three sub-regions of WCA-2 (**Table 7-3**). Inflow structures and interior sites exhibited higher percent excursions during the drought than for previous periods (Weaver et al., 2001). However, mean dissolved oxygen concentrations in WCA-2 were higher during the drought at inflow and outflow structures, and lower at interior sites, than that reported for previous periods (Bechtel et al., 1999; Weaver et al., 2000; Weaver et al., 2001).

In addition, specific conductance levels at inflow and interior sites and turbidity levels at inflow sites exceeded the class III criterion for these parameters (**Table 7-3**). The percent of samples with these excursions was similar to that reported in previous periods (Weaver et al., 2001).

The mean specific conductance for the drought period was comparable to that reported previously (Bechtel et al., 1999; Weaver et al., 2000; Weaver et al., 2001). However, turbidity levels generally averaged slightly higher than those previously reported (Bechtel et al., 1999; Weaver et al., 2000; Weaver et al., 2001). No apparent changes in average nutrient concentrations during the drought period were observed from those reported in previous reports.

Table 7-3. Summary of water quality data collected at monitoring sites in Water Conservation Area 2 during the drought period from May 2000 through September 2001

Parameter	No. of Samples	Min.	Median	Max.	Mean	Standard Deviation	Class III Criteria
Inflow Structures							
Physical							
Temperature (°C)	95	14.2	27.7	31.4	26.1	4.2	Not Applicable
Dissolved Oxygen (mg/L)	95 (67)	0.21	3.75	9.73	3.98	2.06	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	94 (2)	388	837	1466	836.7	229.4	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	95	6.91	7.46	8.34	7.52	0.29	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	79	102.4	222.9	380.7	230.3	69.3	Not less than 20 mg/L
Total Suspended Solids (mg/L)	57	<1.0	3.0	39.6	6.3	7.9	Not Applicable
Turbidity (NTU)	78 (1)	0.5	2.8	36.7	5.7	6.4	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	102	<0.50	2.11	5.13	2.16	0.94	
Total Phosphorus (μg/L)	113	9	47	306	58	46	
Interior Sites							
Physical							
Temperature (°C)	312	10.6	26.2	31.9	25.4	3.9	Not Applicable
Dissolved Oxygen (mg/L)	326 (273)	0.13	2.91	9.44	3.12	1.90	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	334 (13)	159	843	2525	805.9	282.3	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	261	6.43	7.41	8.18	7.39	0.27	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	259	78.0	213.0	462.0	217.3	62.9	Not less than 20 mg/L
Total Suspended Solids (mg/L)	234	<1.0	4.0	36.0	4.2	3.2	Not Applicable
Turbidity (NTU)	78	0.3	0.7	7.2	1.1	1.2	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	259	<0.50	2.10	5.70	2.19	0.82	
Total Phosphorus (μg/L)	331	<4	13	240	29	36	
Outflow Structures							
Physical							
Temperature (°C)	86	14.6	27.1	32.0	25.7	3.9	Not Applicable
Dissolved Oxygen (mg/L)	86 (46)	0.90	4.38	8.58	4.41	2.12	Not less than 5.0 mg/L
Specific Conductance (μmhos/cm)	84	300	728	1114	746.0	159.6	Not greater than 50% above background or to 1,275 μmhos/cm
Water pH	86	6.70	7.47	8.42	7.54	0.36	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	86	83.8	194.8	304.4	191.4	40.1	Not less than 20 mg/L
Total Suspended Solids (mg/L)	84	<1.0	1.5	13.0	2.2	2.2	Not Applicable
Turbidity (NTU)	86	0.3	1.3	12.4	1.9	1.9	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	86	0.76	1.56	2.90	1.61	0.42	
Total Phosphorus (μg/L)	86	4	18	87	25	19	

Values in parenthesis indicate number of samples that exceeded the Class III standard

WATER CONSERVATION AREA 3

A summary of water quality data for selected parameters monitored in WCA-3 during the drought period is provided in **Table 7-4**. The total number of monthly samples collected by parameter, as well as the number of excursions from class III criteria, are depicted in **Figures 7A-1-33** through **7A-1-48** in **Appendix 7A-1**. Mean monthly concentrations for each parameter in the sub-regions of WCA-3 are also depicted in these figures.

The number of excursions from class III standards observed for dissolved oxygen, specific conductance and turbidity during the drought period are presented in **Table 7-4**. The percent of samples with excursions for these parameters were similar to those previously reported in Weaver et al., 2001. Excursions for specific conductance were only observed at inflow stations while turbidity excursions occurred at both the inflow and interior sites (**Table 7-4**). Conversely, dissolved oxygen excursions were observed throughout WCA-3 (**Table 7-4**).

Mean nutrient concentrations at inflow structures were lower during the drought period than reported in the previous periods while concentrations at interior and outflow sites were similar to previously reported values (Weaver et al., 2001).

Table 7-4. Summary of water quality data collected at monitoring sites in Water Conservation Area 3 (the Refuge) during the drought period from May 2000 through September 2001

Parameter	No. of Samples	Min.	Median	Max.	Mean	Standard Deviation	Class III Criteria
Inflow Structures							
Physical							
Temperature (°C)	333	13.1	27.2	32.0	26.0	3.7	Not Applicable
Dissolved Oxygen (mg/L)	331 (67)	0.52	3.82	11.02	4.12	2.16	Not less than 5.0 mg/L
Specific Conductance (µmhos/cm)	331 (2)	9	728	1558	724.6	160.8	Not greater than 50% above background or to 1,275 µmhos/cm
Water pH	333	6.12	7.43	8.61	7.49	0.36	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	201	106.1	222.9	366.1	221.4	48.9	Not less than 20 mg/L
Total Suspended Solids (mg/L)	179	<1.0	2.4	20.8	3.0	2.7	Not Applicable
Turbidity (NTU)	201 (1)	0.4	2.1	32.9	3.0	3.3	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	297	<0.50	1.49	5.18	1.68	0.62	
Total Phosphorus (µg/L)	574	8	26	289	39	38	
Interior Sites							
Physical							
Temperature (°C)	177	9.7	26.6	34.7	25.6	4.0	Not Applicable
Dissolved Oxygen (mg/L)	195 (273)	0.29	2.84	10.32	3.25	1.94	Not less than 5.0 mg/L
Specific Conductance (µmhos/cm)	220 (13)	149	437	1160	495.2	215.9	Not greater than 50% above background or to 1,275 µmhos/cm
Water pH	177	6.54	7.21	8.29	7.23	0.24	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	92	71.0	188.3	347.3	185.0	62.9	Not less than 20 mg/L
Total Suspended Solids (mg/L)	47	<1.0	3.6	38.0	4.7	5.8	Not Applicable
Turbidity (NTU)	92	0.3	1.1	32.5	2.3	3.6	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	93	<0.50	1.43	2.90	1.44	0.47	
Total Phosphorus (µg/L)	175	4	11	310	20	30	
Outflow Structures							
Physical							
Temperature (°C)	281	14.6	27.4	32.1	26.3	3.7	Not Applicable
Dissolved Oxygen (mg/L)	280 (46)	0.66	3.13	8.94	3.53	1.68	Not less than 5.0 mg/L
Specific Conductance (µmhos/cm)	281	211	403	819	443.6	132.6	Not greater than 50% above background or to 1,275 µmhos/cm
Water pH	281	6.16	7.33	8.27	7.35	0.23	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	169	90.7	166.2	288.1	170.0	42.0	Not less than 20 mg/L
Total Suspended Solids (mg/L)	165	<1.0	1.5	23.6	2.7	3.2	Not Applicable
Turbidity (NTU)	169	0.4	1.5	8.0	2.0	1.4	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	179	<0.50	1.15	2.14	1.16	0.27	
Total Phosphorus (µg/L)	279	6	19	90	23	15	

Values in parenthesis indicate number of samples that exceeded the Class III standard

EVERGLADES NATIONAL PARK

Of the five parameters with class III criteria, only dissolved oxygen levels did not comply with the class III standard. Approximately 76 percent of samples at the inflow stations and 60 percent of samples at interior sites had dissolved oxygen concentrations below the 5.0-mg/L criteria (**Table 7-5**). During the drought, mean dissolved oxygen concentrations at inflow stations were slightly higher than previously reported for this region (Bechtel et al., 1999; Weaver et al., 2000; Weaver et al., 2001). However, the mean dissolved oxygen concentration at interior sites during the drought was similar to averages reported in previous reports (Bechtel et. al. 1999; Weaver et. al., 2000; Weaver et al., 2001).

During the drought, the average total phosphorus concentration at inflow sites was slightly higher than the mean annual concentrations reported for previous years of monitoring (Weaver et al., 2001). Otherwise, mean nutrient concentrations at other sub-regions of the Park were similar to those reported previously (Weaver et al., 2001).

A graphical presentation of the selected water quality parameters examined for the drought period are presented in **Figures 7A-1-49** through **7A-1-64** in **Appendix 7A-1**. These figures include the number of samples collected monthly for each parameter (including the number of excursions from class III criteria) and monthly mean concentrations for each parameter.

Table 7-5. Summary of water quality data collected at monitoring sites in Everglades National Park during the drought from May 2000 through September 2001

Parameter	No. of Samples	Min.	Median	Max.	Mean	Standard Deviation	Class III Criteria
Inflow Structures							
Physical							
Temperature (°C)	357	14.6	26.9	32.1	26.2	3.4	Not Applicable
Dissolved Oxygen (mg/L)	357 (67)	0.30	3.76	8.67	3.87	1.70	Not less than 5.0 mg/L
Specific Conductance (µmhos/cm)	357 (2)	227	465	697	457.4	112.3	Not greater than 50% above background or to 1,275 µmhos/cm
Water pH	357	6.16	7.35	8.12	7.41	0.24	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	190	101.5	184.7	258.1	174.9	36.7	Not less than 20 mg/L
Total Suspended Solids (mg/L)	187	<1.0	1.5	22.0	2.0	2.3	Not Applicable
Turbidity (NTU)	190 (1)	0.4	1.5	9.0	1.9	1.3	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	203	<0.50	0.98	2.14	0.98	0.38	
Total Phosphorus (µg/L)	356	4	13	81	18	14	
Interior Sites							
Physical							
Temperature (°C)	108	10.7	28.2	36.4	27.1	5.5	Not Applicable
Dissolved Oxygen (mg/L)	109 (273)	0.27	4.55	12.02	5.03	2.65	Not less than 5.0 mg/L
Specific Conductance (µmhos/cm)	108 (13)	216	424	1156	448.3	153.9	Not greater than 50% above background or to 1,275 µmhos/cm
Water pH	109	6.98	7.55	8.42	7.61	0.29	Not less than 6.0 or greater than 8.5
Alkalinity (as $CaCO_3$ mg/L)	109	75.6	154.4	264.2	154.9	36.8	Not less than 20 mg/L
Total Suspended Solids (mg/L)	101	<1.0	1.5	25.0	2.2	3.2	Not Applicable
Turbidity (NTU)	109	0.4	1.0	13.4	1.8	2.1	Less than or equal to 29 NTU above background
Nutrients							
Total Nitrogen (mg/L)	109	<0.50	1.06	3.97	1.18	0.71	
Total Phosphorus (µg/L)	109	<4	6	68	9	11	

Values in parenthesis indicate number of samples that exceeded the Class III standard

DROUGHT IMPACTS IN THE CALOOSAHATCHEE AND ST. LUCIE ESTUARIES AND FLORIDA BAY

The long-term impacts of drought or lack of freshwater on estuarine systems may be summarized from studies of Florida's Apalachicola Bay and other estuaries throughout the world. At the beginning of a drought, when land-derived nutrients are still plentiful, the increased water clarity and light penetration lead to an increase in estuarine productivity. For example, a short-term increase in the production of oysters and clams may occur, as has been observed in San Francisco Bay and Apalachicola Bay. Over time the supply of nutrients is exhausted, and productivity declines. Multi-year droughts seem to cause a shift from highly productive food webs in the water column to low-productivity communities dominated by bottom-dwelling plants and animals.

Salinity in both the Caloosahatchee and St. Lucie estuary increased until mid-June 2001. Enhanced water clarity and reduced turbidity accompanied this increase. Although salinity was relatively high in the St. Lucie Estuary, it reached critical levels (25 ppt at the Roosevelt Bridge) only during the last few weeks of the drought. By contrast, salinity in the Caloosahatchee River at Fort Myers exceeded critical levels (30-day average >10 ppt) from mid-November 2000 to mid-July 2001. Tape grass beds in the upper Caloosahatchee were virtually wiped out by the drought, with the last specimens being recorded in January 2001. Re-growth of the beds, presumably from seed, was first recorded in November 2001. The more marine regions of the Caloosahatchee did not appear to be negatively affected by the drought. In the lower Caloosahatchee River the drought probably hastened the recovery of shoal grass beds damaged during the managed recession of Lake Okeechobee.

As the drought persisted into the spring and summer of 2001, Florida Bay experienced hyper-saline conditions. No negative impacts were noted, however, due to the relatively short duration of these conditions.

REPORTED EXTERNAL ECONOMIC IMPACTS

The record drought of 2000 and 2001 had tremendous impacts in the area around and north of Lake Okeechobee, where agriculture and recreation are the driving forces of the local economy. With water levels in Lake Okeechobee dropping to record lows, navigation on Lake Okeechobee, Lake Istokpoga, and the Kissimmee River was severely impeded. Eventually, navigation was only possible by airboat. Agriculture, the largest water user in the area north of Lake Okeechobee, also was adversely impacted by water supply restrictions necessitated by low surface water levels.

This section describes and, when possible, quantifies impacts on agriculture, irrigation users (golf courses and nurseries), businesses, recreation, public water supply utilities, and other water users, particularly around Lake Okeechobee.

The SFWMD region experienced numerous impacts during and shortly after the 2000–2001 drought. The Everglades Agricultural Area (EAA) and recreation businesses around Lake Okeechobee were among the most severely impacted sectors. However, published data series for the drought period are not yet available to ascertain quantifiable impacts on agriculture and employment. *County Business Patterns*, a U.S. Census Bureau publication, shows employment and payroll data by type of establishment. The 2000 edition is not yet available. Florida Agricultural Statistics Service (FASS) provides crop yield information, but data on yields for the growing season of interest have not been published.

PUBLIC WATER SUPPLY

Public water supply utilities within the SFWMD reduced pumpage during the time period of water use restrictions by 15 percent weekly overall, according to the District's Regulation Department. The actual percentage by reporting utility varied weekly.

For some utilities the reduction in pumpage resulted in an unanticipated revenue reduction with which they had to contend during and after the drought. In addition, shortly after the District rescinded drought restrictions, there was a significant rainfall event during which no irrigation took place and some utilities again experienced significant revenue reductions. Some utilities reported revenue reductions as great as 10 percent. In response, some utilities lowered water pressure to cope with the drop in revenues. For most utilities, fixed costs constitute the bulk of their rate base; consequently, any revenue shortfall has a significant effect on water utility operations.

In certain cases, some water utilities had already scheduled for automatic rate increases to go into effect once drought restrictions were implemented. In such cases, the temporary rate increase corresponds to the percentage cutback, goes into effect automatically, and remains in place for the duration of water use restrictions, increasing as cutback levels increase.

Some utilities added a flat-rate surcharge to customers' water bills to recover revenue shortfalls brought on by water use reductions. The surcharge, while crude, makes up for revenue shortfalls without sending an inappropriate economic signal to customers. Utilities that levied the surcharge did so for all their customers, whether or not they cooperated in the cutbacks. In this way, the surcharge was also regressive, that is, charging a higher rate at the lower levels and becoming a smaller percentage of the additional amount of water used as the customer uses more water.

Utilities using alternative water supplies experienced additional impacts. Such utilities' production costs and fixed costs tend to be higher than utilities using conventional water sources. Therefore, revenue impacts for utilities using alternative water supplies can be more severe. In such cases, water restrictions were imposed uniformly without regard to the water source or the use of alternative water supplies.

One Palm Beach County utility using desalinization reported monthly losses of more than $200,000 during the period of water restrictions. Production costs of desalinization are 35 percent more than conventional treatment, and desalination was used at a higher percentage to avoid withdrawal of water from the Biscayne aquifer. This, along with revenue reductions due to water use cutbacks, combined to create a negative revenue impact for the utility.

One way to evaluate the impact of water restrictions on an area is to review the variances that were issued to individuals, organizations, and businesses and which allowed for deviations in water use restrictions so those entities could avoid economic and other losses associated with restricted water use. Types of variance requests may mirror the impacts to an area. The District received more than 1,000 requests for nonagricultural variances, with 85 percent of those requests coming from the Lower East Coast and Kissimmee Basin regions. Nearly 40 percent of the variance requests involved irrigation systems, for either estate-sized lawns or condominium landscapes. A significant number of the requests were necessitated by the inadequacy of irrigation systems, representing an inefficient use of water. Interestingly, the District occasionally granted variances for religious reasons. For example, in some cases Orthodox Jews, who are not permitted to work on the Sabbath ("work" would include turning on sprinklers), requested a variance to change their irrigation day from Saturdays (the Jewish Sabbath) to Sundays. Similarly, some church groups requested a variance to change their watering day from Sundays, when many congregations meet, to Saturdays. The District routinely granted such requests.

AGRICULTURE

Yield data for the sugar crop in 2002 are not yet available from FASS. The *Sugar and Sweetener Situation and Outlook* report from the USDA made a preliminary projection of the 2002 sugarcane harvest. The most recently published report indicates Florida sugarcane production (**Table 7-6**) is projected at 1.990 million STRV (short tons raw value). The National Agricultural Statistics Service (NASS) estimates Florida sugarcane acreage harvested at 446,000 acres, an increase of 19,000 from the previous year. NASS estimates sugarcane for sugar yield at 35.3 tons per acre, down from 37.5 tons realized the previous year. Sugarcane for sugar production is estimated at 15,744 million tons. Sugar recovery through early January was good, implying a season average recovery rate of approximately 12.65 percent.

Table 7-6. Florida sugarcane for acreage, production, yield and prices (1996-2002)

Year	Sugarcane for sugar	Sugarcane for sugar	Production	Yield	Price
	Sugarcane for Sugar Acreage Florida	Acreage Martin and P.B. county	(short tons)	short tons/acre	$/ton
1996	417,000	328,000	13,803,000	33.3	$29.40
1997	421,000	352,000	15,535,000	36.9	$28.70
1998	426,000	356,000	17,083,000	40.3	$29.50
1999	443,000	370,000	12,996,000	35.1	$27.20
2000	427,000	357,000	15,505,000	38.3	#N/A
2001 N/A					
2002	446,000		15,743,800	35.3	$0.2145

Sources:

http://www.ers.usda.gov/publications/agoutlook/sep2000/ao274e.pdf

http://www.nass.usda.gov/fl/rtoc0cr.htm

Reduction in yield: 38.3 to 35.3 = 3 tons per acre

3 tons per acre

446,000 acres

$27.20 per ton

Value of reduced production = $36,393,600

(Yield data on citrus and vegetables are not yet available).

Statewide, Florida citrus production was down from 297,660,000 boxes from 1999 through 2000, to 278,290,000 boxes in 2000 through 2001, a decline of approximately 6.5 percent. Attributing the total reduction in production to the drought, at a weighted-average 2000 price of $2.79 per bushel, the value of reduced citrus output statewide was approximately $54,000,000 based on 2000 FASS data. The data showed that approximately 66 percent of Florida citrus production occurred in a 16-county area. Apportioning statewide damages in proportion to acreage, an initial estimate is a loss of $36 million.

A realistic assessment of drought losses must await more accurate county-level price, acreage, and yield data. Future yield data will also be necessary to determine if any long-term citrus tree damage occurred.

LAKE OKEECHOBEE REGION AGRICULTURE

Farmers in both the upper and lower Indian Prairie Basin between Lake Okeechobee and Lake Istokpoga were required to cut their water consumption nearly by half during the most severe period of the drought. Though farmers and District staff worked together to lessen the impacts as much as possible, some impacts were unavoidable due to low surface water conditions. Particularly notable was the loss of several hundred acres of sugar cane on the Brighton Seminole Reservation when low canal levels prevented irrigation during a freeze. Farmers also were required to move cattle to areas in close proximity to canals or provide watering by alternative means, including increasing the depth and size of watering ponds, installation of wells, and/or trucking water into the area. The District assisted farmers in these efforts by easing permit restrictions and fast-tracking permit applications through an emergency order approved by the District governing board. Still, some cattle ranchers were forced to sell yearling cattle prior to the optimal time, resulting in an economic loss that has not yet been measured.

NURSERIES AND LANDSCAPING

The University of Florida's Institute of Food and Agricultural Sciences (IFAS) conducted an economic impact study of Florida's environmental horticulture industry in 2000 via a telephone survey of more than 2,200 businesses and households. Economic impact estimates were developed separately for six Florida regions and 13 counties that have significant nursery industry production: Miami-Dade, Broward, Palm Beach, Orange, Lake, Lee, Hillsborough, Manatee, Duval, Volusia, Alachua, Marion, and Gadsden. The IFAS study evaluated the effect of the ongoing severe drought and water use restrictions in Florida and found that nurseries and landscape firms experienced a net decrease in sales of $245 million. Retailers, on the other hand, reported increased sales, particularly for large-volume outlets.

Anecdotal evidence indicated that many horticulture businesses suffered severely because of the drought because of the limited availability of water for irrigation, the impact of water use restrictions, and loss of sales resulting from a lower demand for plants. However, the drought also had the potential to benefit some horticultural businesses as a result of the demand for replacement plants and water-conserving equipment or supplies. The IFAS study attempted to document the drought's economic impact by asking respondents whether, during the last four years, the drought had affected sales or purchases of plants. A majority of nurseries, landscape firms, and institutional consumers indicated that sales had been affected by the drought, while somewhat less than 50 percent of retailers and households expressed this opinion. Among those respondents who indicated that they had been affected, more than three-quarters said sales or purchases had decreased rather than increased. Moreover, for every group the magnitude of change was more negative than positive. The percentage change in sales or purchases was multiplied against the estimated total sales or purchases for each respondent, and was then expanded and added to reflect the net change in total industry sales or purchases. The net impact of the drought for all groups, with the exception of retailers, was negative.

Nurseries and landscapers were estimated to have suffered a net decrease in sales of $61 million and $184 million, respectively, while households and institutions reduced their purchases by $109 million and $3 million, respectively. The retail sector had a somewhat different outcome, with a net increase in sales of $80 million due mainly to sales growth reported by large-volume retail chains. The total economic impact to the horticulture industry, and the net change in sales of horticultural products, due to the drought were estimated for Florida's five water management districts, which have varying water supply conditions and policies for water use restrictions. The St. Johns, South Florida, and Southwest Florida Water Management districts had horticulture industry sales exceeding $2 billion. The net change in horticulture industry sales was negative in all the water management districts. The largest change in sales as a result of the drought occurred in the Southwest Florida Water Management District, which experienced a loss of $155 million. In the SWFWMD the loss of sales represented approximately 7 percent of total industry sales. Horticulture businesses in the South Florida Water Management District and St. Johns River Water Management District also experienced significant losses in the nursery and landscape sectors, but the losses were offset by positive net changes for retailers.

(1) Source: Economic Impacts of the Florida Environmental Horticulture Industry, 2000. Alan W. Hodges, Ph.D., and John J. Haydu, Ph.D., University of Florida Institute of Food and Agricultural Sciences, Food and Resource Economics Department, and Mid-Florida Research and Education Center, P.O. Box 110240, Gainesville, FL. Telephone: 352-392-1881, x312; fax: 352-392-3646; e-mail: AWHodges@ufl.edu.

GOLF INDUSTRY

A similar economic impact study was performed by the two IFAS researchers on the golf course industry. Of over 1,300 golf operations surveyed throughout the state, 225 operations responded. Multiple courses were covered in both the mail-out and response, covering the over 1,600 existing courses in Florida. Results of this survey are to be published in the near future and were unavailable at the time of this report.

Source: Economic Impacts of the Florida Golf Industry, 2000 by John J. Haydu, Ph.D. and Alan W. Hodges, Ph.D., University of Florida Institute of Food and Agricultural Sciences

Food and Resource Economics Department and Mid-Florida Research and Education Center, P.O. Box 110240, Gainesville, FL. Telephone: 352-392-1881, x312; fax: 352-392-3646; e-mail: AWHodges@ufl.edu.

LAKE OKEECHOBEE REGION BUSINESS AND RECREATION

The Lake Okeechobee-area tourism and recreation industries suffered significant economic losses as a result of the drought. With navigation on most of the waterways virtually impossible, the recreational fishing industry suffered the worst losses. Motels, bait-and-tackle shops, fishing guides, ecotour operators, marina operators, boat sales, and other retail outlets reported significant losses of revenue. Many of these businesses are small and are unable to withstand sustained periods of low activity, which typically result in employee layoffs throughout the region. The Lake Okeechobee communities suffered additional losses when seasonal tourists, who would normally increase the population of the lake communities by two-to-three times during the winter months, avoided the area because of poor fishing conditions. Subsequently, the lake communities lost seasonal revenues associated with cottage and cabin rentals in the area, resulting in a corresponding loss in retail sales, with a resulting impact to the State of Florida in lost state sales tax revenue.

The District participated in many activities to lessen the negative economic impact of the drought on the lake communities while simultaneously capitalizing on the low water levels in Lake Okeechobee. For example, the District mobilized volunteers to re-vegetate native plants in the lake that had been harmed by several years of extraordinarily high water levels immediately preceding the drought. The District also sponsored sediment removal projects to improve navigation in some canals and marinas and provided funding – two years ahead of schedule – for a Florida Fish and Wildlife Conservation Commission project on Lake Istokpoga. Other District projects included:

Lake Okeechobee Watershed Phosphorus Control Program Navigational Sediment Removal Projects: The South Florida Water Management District appropriated $1 million to cooperatively fund three navigational sediment removal projects along the southern shore of Lake Okeechobee.

These projects included removal of sediment accumulation to regain the original design capacity of the Industrial Canal in Clewiston, the Belle Glade Marina in Belle Glade, and the Pahokee Harbor in Pahokee. Due dates for individual project completion vary, but all should be completed by September 2002. The Belle Glade project will be fully funded by the SFWMD, while the Pahokee project will be approximately 50 percent funded by the SFWMD. Both cities are providing in-kind management services at a minimum cost. Hendry County provided $100,000 for the Industrial Canal project. In addition to enhancing the navigational aspects of these major Lake Okeechobee recreational sites, this project should reduce the amount of phosphorus-laden sediments that could potentially be redeposited into Lake Okeechobee or transported downstream into the Everglades system.

Lake Okeechobee Utilities Assistance Projects: The District undertook various capital projects to mitigate the impact of severe drought conditions on public drinking water supplies taken from Lake Okeechobee. Examples included extending intake pipes further into Lake Okeechobee, building new pump station platforms, and purchasing and repairing pumps. In addition, the District reimbursed the city of Belle Glade for additional treatment chemicals and filters. These capital expenditures were unbudgeted emergency measures to ensure the continued ability of the lake utilities to operate during the drought. The lake communities did not have adequate funds or staffing resources to undertake these emergency measures, and the SFWMD stepped in to provide this assistance. The capital projects expenditure by community is detailed in Chapter 6.

Lake Istokpoga environmental enhancement project: The SFWMD was able to provide $2.75 million in funds to the Florida Fish and Wildlife Conservation Commission (FWC) to entirely fund an environmental enhancement project on Lake Istokpoga. To take advantage of low water levels resulting from drought conditions, this project commenced two years ahead of schedule. It had been planned for FY2003 by the FWC. By completing this project during a time of naturally occurring low water, the state was able to forego the need to artificially drawdown the lake a second time in two years, providing a much needed water supply for downstream agricultural users and avoiding future economic hardship to recreation-based businesses around Lake Istokpoga. The FWC is expected to reimburse the SFWMD for these expenses in FY 2003. Highlands County provided in-kind services but was not required to provide matching funds.

Lake Okeechobee berm removal project: During the extraordinarily wet years preceding the drought in 2001, vegetation that was dislodged from the floor of Lake Okeechobee gathered at the edge of the lake’s northwest marsh area, creating a berm that was nearly seven miles long. The FFWCC became concerned that this berm would prohibit fish from moving into the lake’s spawning areas and would harm the Lake Okeechobee commercial and recreational fishing industry. The SFWMD, FFWCC and the USACE contributed funding to remove a majority of the berm. Rising water levels in the lake during the rainy season prevented complete removal.

Assistance with development of a regional water supply for communities south of Lake Okeechobee: The SFWMD worked with the Florida Department of Environmental Protection (FDEP), Palm Beach County, and the cities of Pahokee, Belle Glade and South Bay to find solutions to problems with drinking water quality for Palm Beach County’s western communities. Though a number of options were suggested, the group identified the creation of a single water plant featuring membrane or reverse osmosis technology as the best long-term solution for these communities.

ECONOMIC IMPACTS OF DROUGHT MANAGEMENT TO THE DISTRICT

FUNDING FY00-01 DROUGHT-RELATED EXPENDITURES

During Fiscal Year 2000-01 (FY00-01), the South Florida Water Management District governing board, facing one of the most severe droughts on record, authorized more than $10.8 million of emergency drought-related expenditures. As the fiscal year came to a close the District had expended $9.7 million of the total $10.8 million authorized.

Funding these emergency related needs proved challenging because they were neither budgeted nor anticipated when the District adopted its annual FY00-01 budget. To identify the funds to meet these unbudgeted needs, the District employed three basic strategies. First, the District tapped into its budgeted contingency reserves. The District, in accordance with adopted financial management policies, annually appropriates specific reserve amounts to meet unanticipated or emergency needs. Second, the District redirected staff, available resources, and budgeted appropriations to higher-priority, drought-related needs. Certain contracts, staff resources, and expenditures were reviewed in context of the pending emergency and were redirected and/or deferred to the next fiscal year. Third, the District re-examined projected fund balances and remaining contract encumbrances/balances and redirected those resources to emergency drought-related needs. Through the use of these three approaches and with the cooperation of project managers throughout the agency, the District was able to identify the resources required by the drought.

STREAMLINED PROCUREMENT PROCESS

The District governing board delegated authority to the executive director through a series of motions for "Waivers of Competition" for the procurement of goods and services that were a direct result of immediate needs due to severe drought conditions. The District's Engineering and Procurement divisions worked together with the water shortage team using the following process for expediting the procurement process:

1. **Understand a specific drought need**. The water shortage team described a condition requiring an immediate District maintenance and/or construction response.
2. **Define the project**. The Engineering Division analyzed a situation and defined a project based on immediate needs and long-term solutions.
3. **Propose a solution**. The Engineering Division proposed a solution or solutions to correct the immediate situation using District inhouse resources, external vendor resources, or a combination of both to best meet a project's challenges.
4. **Obtain management approval**. The proposed plan was presented to the water shortage team and to management for their input and approval to proceed with an action plan.
5. **Release a solicitation**. The Engineering and Procurement divisions created an RFQ (Request for Quotations) solicitation specifying project requirements and the expected completion date.
6. **Award the project**. Upon recommendation by Engineering, Procurement awarded the solicitation to the vendor submitting the quote that met the RFQ's requirements at the lowest cost.
7. **Manage the construction**. The Engineering Division assigned a project manager to each project to supervise project activity and monitor the awarded vendor's progress.
8. **Pay the invoice**. The Engineering and Procurement divisions reviewed the project's progress and requested payment for work accomplished.

Upon granting the executive director authority to approve Waivers of Competition, the water shortage team sought competition among those vendors having the capability to meet a project's requirements within expected parameters of work quality, time, and price. The normal solicitation timeframe to procure goods and services using the Request for Bid and Request for Proposal did not fit the District's immediate needs as driven by the drought situation. Therefore, a modified Request for Quotation (RFQ) solicitation format was used to meet the more immediate timeframe demanded by the ongoing drought (see **Appendix 7A-2**). The Procurement Department supplied the RFQ document to recognized manufacturing and industry leaders and a pool of vendors listed in the District's financial system vendor database. After an onsite pre-solicitation meeting with vendors, the Procurement Department opened and awarded the solicitation to vendor(s) meeting a project's Statement of Work (SOW) requirements at the lowest cost. Upon award and receipt of the required bonds and certificate of insurance, the vendor(s) and the District executed a contract (see **Appendix 7A-2**).

DROUGHT EXPENDITURE SUMMARY

A Drought Expenditure Summary kept track of the expenditures throughout the drought period, detailing the governing board waiver authority and current expended/obligated amounts (see **Appendix 7A-2**). The Procurement Department maintained all purchase orders, contracts, and supporting documentation at one location, supporting the drought-related transactions listed in the Drought Expenditure Summary. After six governing board motions, the board delegated $8,685,159 to the executive director, who then designated the funds for drought-related expenditures. District staff payroll and benefits directly associated with the drought are estimated at $2,118,133. Combined drought expenditures and staffing costs amounted to $10,803,292.

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Chapter 8: Outreach and Communications

Jo Ann Hyres and Aneta Sewell

SUMMARY

This chapter provides an overview of the South Florida Water Management District's (District's or SFWMD's) Office of Media Relations (OMR) and Department of Public Information (DPI) functions during the 2000–2001 drought. During the drought, the goal of both departments was to increase public awareness of the drought, facilitate public understanding of drought-related issues and actions, develop the public's trust in how these issues and actions were being handled, and increase overall awareness of the SFWMD's mission. To achieve these goals, the Office of Media Relations and the Department of Public Information used many communication tools, including water shortage team meetings; press releases and news briefings; daily media contact; media buys and media campaigns; fact sheets; a citizen information hotline (phone bank); a water shortage Website; and other drought-related public information tools and services.

MEDIA RELATIONS

The 2000–2001 drought was a consuming issue for area media covering the South Florida Water Management District. The press saw the drought as a major story and covered it with zeal. The District saw the drought as a primary challenge in its goal to manage the region's water resources. News reporters kept in constant contact with the District's Office of Media Relations, examining various angles of the drought. Television meteorologists reported frequently on the ongoing drought conditions and on area and regional water use restrictions. The extensive media coverage of the drought gave the District a high profile as the primary agency handling the emergency. When Florida Governor Jeb Bush began speaking about the drought the issue was elevated to a statewide media platform, and media interest became even more intense. District staff worked daily, including weekends, to respond to the intense interest the story generated from all branches of the media, including television and radio stations, newspapers, and magazines. Area media became a valued partner in lifting the District's water conservation message to a higher level of awareness and understanding among South Florida residents. That, in conjunction with a multi-tiered approach to communication, gave the general public a better understanding of the South Florida Water Management District and its mission.

The team approach was crucial in organizing and communicating District strategies for handling drought-related issues, water restrictions enforcement, media interest, and public awareness. Daily media interest was so intense that from May 4 through June 29, 2001 the District held daily and weekly media briefings. Some of the topics covered in the briefings included the latest Lake Okeechobee water levels, water restrictions enforcement, local government coordination, drought signage, drought publications, water conservation tips and conservation information. These daily and weekly briefings kept local news reporters interested in covering the story of the drought.

The Office of Media Relations also contributed to media awareness through regular press releases and proactive phone calls. Since the challenges of the drought varied depending on their location within the District, SFWMD regional service centers were particularly helpful in spreading the word and calming the public's fears about the drought and water conservation.

The Office of Media Relations had to respond quickly and effectively to rumors, public criticism, or new problems that arose as a result of the drought. The OMR responded daily to incorrect information and/or rumors generated by misinformed citizens or area media. The Office of Media Relations also worked closely with District Operations Division staff to ensure that drought information remained as updated and accurate as possible.

The District's water shortage team relied on a series of four drought-themed campaigns for its radio and television "spots." The campaigns were coordinated according to the severity of the drought. The first campaign theme began in September 2000 and included television, radio, and print materials revolving around the theme "*Turn it Off*," a familiar campaign theme used in previous droughts and which asked for voluntary water conservation by South Florida residents. The "*Turn it Off*" campaign helped educate the public about South Florida's water shortage crisis and encouraged residents to respond by conserving water.

In response to worsening drought conditions, the District's second drought-themed campaign was more emphatic. Titled "*Wasting Water is a Crime*," the second campaign began in April 2001.

During the rainy season, beginning in June 2001 the SFWMD implemented a drought-themed campaign having a more sensitive, less urgent message and theme. Titled "*It's Just a Drop in the Bucket*," the campaign's central emphasis was a reminder that "It may be raining now, but it's just a drop in the bucket so we should continue to conserve water." During summer and through fall 2001, as drought conditions continued to improve, the District's water conservation theme became "*Save water now, we'll need it later*." This theme helped keep the public thinking about lowering their water consumption and set the stage for the development of a year-round water conservation campaign by the District.

PROACTIVE MEDIA STRATEGIES

From the inception of the water shortage team to the end of the drought, an OMR representative attended and participated in each Emergency Operations Center (EOC) water shortage meeting. This enabled media relations staff to obtain drought information first-hand and to quickly discuss issues and develop and disseminate an appropriate message. OMR representatives also gave the water shortage team guidance regarding strategies for communicating the District's message to the public and the media.

As the drought persisted, OMR representatives responded daily to questions from news reporters, talking to them in person or by telephone, fax, or e-mail; arranging interviews with key District staff for newspaper, television, and radio reporters; and issuing more than 100 press releases (see **Appendix 8A-1**). OMR staff also wrote editorials and letters to the editor to clarify inaccurate information on backpumping, water use restrictions enforcement, and the lowering of Lake Okeechobee (see **Appendix 8A-2**).

The Office of Media Relations held daily and weekly live and teleconferenced "Water Shortage News" briefings supplemented with priority points. The news briefings were extremely popular with reporters and were well attended. (see **Appendix 8A-3**).

In addition, OMR staff worked with local television meteorologists to incorporate water restrictions reminders, as well as information on the latest Lake Okeechobee water levels, into their daily weather forecasts to further emphasize the seriousness of the drought situation (see **Appendix 8A-5**).

OMR staff also used press releases, interviews, and follow-up (see **Appendix 8A-4**) to increase the public's understanding about how the regional water supply system is ultimately connected to Lake Okeechobee. OMR staff facilitated media buys (see **Appendix 8A-6**) to distribute radio and television public service announcements (PSAs) and inform the public about water restrictions and the importance of water conservation. Details are discussed in the "Media Placement, Public Poll Summary" section of this chapter (see **Appendix 8A-9**).

Strong internal communication was crucial to ensuring accurate and timely dissemination of drought information to news reporters. OMR staff had direct, 24-hour-a-day access to designated District experts and water shortage team members as resources for media questions. OMR staff working at SFWMD service centers were regularly updated on current drought conditions and worked closely with Department of Public Information staff to develop public outreach tools and strategies, including PSAs, flyers, signage, and the District's water shortage Website. Outreach tools and strategies are discussed in more detail in the "Public Information" section of this chapter.

Other functions facilitated by OMR staff included the preparation of responses to the Department of Environmental Protection's (DEP's) periodic requests for overall drought management status reports (see **Appendix 8A-7**). The OMR also facilitated requests for additional drought management coordination information.

MEDIA PLACEMENT, PUBLIC POLLS

Following the implementation of water use restrictions in November 2000, the SFWMD realized the necessity of reaching a large and diverse South Florida audience with a water conservation message and specific information on mandatory water restrictions. The District determined that the best way to reach this large audience was to use broadcast media (radio and television). Because of the severity of the drought conditions, the District concluded that the use of free public service airtime alone would be insufficient. Therefore, the SFWMD sought emergency funding, which was authorized to pay for drought-themed PSAs, with the stipulation that free public service airtime would augment the paid ad schedule.

To best optimize the emergency funding for a media campaign, the District solicited bids from media planners and buyers in the Miami/Fort Lauderdale, West Palm Beach, and Fort Myers media markets. Proposals were received and contracts with two vendors were executed in January 2001. Each contractor agreed to reimburse the District for at least 50 percent of the commission paid. This provided additional revenue to the emergency spending fund.

After the proposed media plans were approved, District-produced radio and television announcements began to air throughout South Florida. The announcements were produced in English, Spanish, and Creole. Media vendors were instructed to place media buys for ads that would reach a target audience of adults over the age of 25 through the use of various program formats to reach the largest segment possible of the region's multi-ethnic, multi-cultural population. A sample of the media buys is included with this report as **Appendix 8A-8**.

The contractors provided analyses on campaign efficiency by reporting the number of spots aired, the percentage of a target audience reached, how often an audience was reached, and the total cost of reaching an audience. Updates on drought-themed media campaign achievements were presented monthly to the District's governing board. Through the first quarter of 2001 the District was able to reach more than 90 percent of its target audience approximately 10 times. Additionally, the District contracted an independent study to measure the media campaign's effectiveness. The study is included in this report as **Appendix 8A-9**.

Ongoing drought conditions demanded that the District continue to provide information to South Florida residents about water conditions and mandatory water use restrictions into the second quarter of 2001. Therefore, the Office of Media Relations made a decision to continue to use a media planner/buyer to place media announcements. To streamline this process, one contractor was selected to continue media planning and placement through two succeeding quarters. In addition to the District's radio and television campaign, OMR added Internet advertising to its drought strategy, and the campaign continued to reach a multi-ethnic, multi-cultural audience via varied program formats. Monthly campaign reports to the District's governing board also continued, and audience "reach" and "frequency" numbers remained high.

The media campaign continued through the fourth quarter of 2001, with minor variations to the campaign strategy. During the quarter, in addition to using a media planner to place announcements throughout the District, part of the media budget was used to contract with minority vendors to specifically place ads on minority-formatted radio stations throughout Central and South Florida.

During the course of the campaign thousands of drought-themed ads were broadcast. Consequently, the District effectively promoted water conservation and adherence to mandatory water use restrictions using broadcast media at a fraction of what it would have cost to reach such a large audience via other methods.

A second research survey was completed at the conclusion of the OMR's drought and water conservation information campaign. The primary purpose of the second poll was to evaluate the public's awareness of the campaign at a second point in time, as well as to follow up on some of the issues identified in the first poll. The results of the second poll are included in this report as **Appendix 8A-10**.

PUBLIC INFORMATION DURING THE DROUGHT

The need to keep up-to-date drought information in front of the public became apparent during the 2000–2001 drought. Initially, the District's Department of Public Information (DPI) used existing informational materials to quickly disseminate information. In September 2000 the District's governing board authorized $400,000 for television and radio airtime. Subsequently, DPI purchased airtime to broadcast public service announcements originally produced in the early 1990s (during a previous drought). During the 2000–2001 drought, DPI staff revised and re-edited the PSAs with updated contact information and tag lines. The theme of the first series of PSAs was "Turn it Off!"

DPI also began producing printed materials, called "splashes," based on templates that could be used to create a series of quick-turn-around fact sheets. The splashes were used to print flyers indicating the latest regional water restrictions and other, related topics, such as *Xeriscape Principles*, *Sensible Sprinkling*, and *50 Ways to Save Water*. DPI also developed a 10-minute presentation, titled, *Water, a Precious Commodity*, which included an accompanying brochure. District staff conducted the public presentations at meetings of area homeowner and civic groups.

As the drought became more serious, so did the District's message to area and regional water users. In response, DPI developed new television and radio PSAs and accompanying materials, with the theme, "Wasting Water is a Crime." The District printed color-coded fact sheets listing the latest commercial and residential water restrictions information. When water use restrictions changed (that is, with the implementation of phase I, phase II, and modified phase II restrictions), DPI updated, reprinted and posted the information on the District's water shortage Website for the duration of the drought.

Other public information initiatives by DPI included notices in South Florida residents' water bills, as well as working with townships and utilities to erect signage announcing the latest water use restrictions at city boundaries. The District also contacted the Publix supermarket chain and arranged to place flyers reminding residents of the latest water use restrictions in shoppers' grocery bags. In addition, countertop "tent" cards listing water conservation tips, for use in hotel restrooms, were developed and distributed with the assistance of the District's Lower East Coast service centers.

Three workshops were also held to train District employees as outreach ambassadors for water conservation throughout the District community. The employees were armed with signs, brochures, videos, and enthusiasm and were encouraged to take the conservation message into their own neighborhoods, schools and clubs.

As drought conditions eased, the District changed its water conservation theme from "Wasting Water is a Crime" to "Be Water Smart." Water conservation materials, including new television and radio PSAs, were distributed. Promotional items, including buttons, sponges, magnets, and stickers, with the new theme were mailed to all elementary and middle schools in Palm Beach, Broward, Miami-Dade, Monroe, Collier, and Lee counties. The culmination of this outreach effort was a hugely successful competition in which students in the counties developed water conservation-themed posters and audio and video PSAs. Winners from the six counties were recognized and rewarded for their efforts at the District's April and May governing board meetings.

The District's Public Information Department handled thousands of telephone calls and responded to e-mail throughout the many months of the drought. When necessary, DPI located knowledgeable District staff to answer the occasionally complicated questions from the public and from municipalities and various locations throughout the 16 counties the District serves. The District's citizen information hotline and the water shortage Website proved important tools in facilitating communication with the public. Drought conditions became a daily part of local television weather reports that also displayed the citizen information hotline number on TV screens.

The Water Conservation Creative Team, composed of graphic artists and writers, as well as marketing, Web, video, and media specialists, met weekly to craft messages and develop appropriate outreach tools to disseminate those messages. Over a seven-month period, the SFWMD governing board authorized $1,231,000 for the District's water conservation campaign. Of that amount, the District spent a total of $971,360.

PUBLICATIONS TO PROMOTE WATER CONSERVATION

Initially, updated water conservation materials were used for fast distribution. The "splash" fact sheets were invaluable for quick-turn-around production and frequent changes. Printing was out-sourced for materials requiring more than 10,000 pieces because it is more cost-effective to produce larger quantities. In contrast, all photocopying was done in-house.

Distribution was a large initiative. The Department of Public Information used all established avenues and invented more. District service center and headquarters employees distributed materials to public building lobbies, schools, community libraries, video rental stores, bookstores, community festivals, retail stores, and parks. Listed below are the types and numbers of materials DPI developed and distributed. Copies of these materials are archived in the South Florida Water Management District Reference Center located at 3301 Gun Club Road in West Palm Beach.

Printed through outside contract

The "*Below the Surface*" series, an in-depth look at:

"*Water–A Precious Commodity.*" 35,000 copies (also in video format)

"Water Conservation." 10,000 copies

"*Water Drops*," a student educational booklet for insertion in newspapers. 30,000 copies

Fact sheet (splash) on conserving water. In English. 95,000 copies

Fact sheet (splash) on conserving water. In Spanish. 95,000 copies

"Neighborhood Water Restrictions." In English. 520,000 copies

"Neighborhood Water Restrictions." In Spanish. 20,000 copies

Fact sheet (splash), *"Phase II."* 3,000 copies

Fact sheet (splash), "*Collier County Phase II.*" 25,000 copies

Flyer, "Residential Water Restrictions-Phase II." 125,000 copies

Flyer, "Commercial Water Restrictions-Phase II." 125,000 copies

Brochure, "*Be Water Smart.*" 10,000 copies

Brochure, "*Share the Resource.*" 5,000 copies

Fact sheet (splash) for Broward County water conservation campaign. 80,000 copies

Fact sheet (splash), "*Water Conservation.*" In English. 30,000 copies

Fact sheet (splash), "*Water Conservation.*" In Spanish. 30,000 copies

Fact sheet (splash), "*Xeriscape.*" In Spanish. 15,000 copies

Fact sheet (splash), "*Sensible Sprinkling.*" 12,000 copies

"Freddy the Alligator Skateboard Coloring Sheets" for schools. 40,000 copies

Printed in-house:

Various "splash" fact sheets explaining each phase of commercial and residential water use restrictions (phase I, phase II, modified phase II) for the East Coast, West Coast, and Orlando; 500,000 copies.

URL Web cards, "*Who to Call at SFWMD.*" In English. 10,000 copies

URL Web cards, "*Who to Call at SFWMD.*" In Spanish. 10,000 copies

PROMOTIONAL ITEMS

The District used its staff and was in constant contact with its regional service centers to employ all contacts and community connections for distribution of water conservation and water restrictions materials. Extensive mailouts to schools encouraged public interest in water conservation and drought awareness. District staff contacted regional directors of large retail chains for permission to send flyers and posters for distribution and posting. Tent cards were mailed to hotel chains or, in some areas, were hand delivered. The District's Miami-Dade, Broward, and Monroe county service centers worked particularly hard to disseminate these materials. Other service centers were erratic in their outreach efforts. District staff had difficulty meeting demand for printed materials that were ordered and re-ordered.

The District kept a large supply of signs, posters, and flyers in the B-1 lobby for the duration of the drought for employees to obtain and distribute. Consequently, the ready availability of these materials encouraged others to assist with distribution.

Drought-related promotional items

District poster that was part of the "*Be Water Smart*" campaign: 15,000 copies

District poster "*Water Conservation*": 10,000 copies

Corrugated plastic signs for posting in public places: 2,500 copies

Tent cards for hotel bathrooms: 10,000 pieces

Spanish-language tent cards for restaurant tables: 40,000 pieces

Tent cards for hotels: 150,000 pieces

Creole-language tent cards for restaurant tables: 2,000 pieces

English/Creole-language tent cards: 10,000 pieces

Sponges for the "*Be Water Smart*" campaign: 35,000 pieces

"Water drop" magnets for the water conservation campaign: 30,000 pieces

Celluloid buttons promoting water conservation: 15,000

Flyers for stuffing in Publix grocery bags: 50,000 pieces

Violation warning signs, East Coast: 4,000 copies

Violation warning signs, West Coast: 6,000 copies

Tickets for violating water use restrictions: 285,000 copies

31 Television Spots, 3 Languages (Public Service Announcements)

Drought-themed television "spots" (public service announcements, or PSAs) ran in all 16 counties within the District's jurisdiction. The District bought TV airtime and also solicited free airtime. These media buys helped ensure that the District's message to the public to conserve water was being disseminated. The effort proved effective in creating interest in and awareness of the drought (the frequency of PSAs had a direct correlation to the number of calls to the phone bank). Copies of the following television PSAs are archived on CD distributed with the executive summary of this report.

Television PSAs

"*Water Follies*": three versions

"*Turn It Off*": four versions, in English, Spanish, and Creole

"*Wasting Water Is A Crime*": two versions, in English, Spanish, and Creole

"Guy Harvey, Citizen/Fisherman": one version

"David Viker, Loxahatchee Refuge Deputy Manager": one version

"*Just A Drop In The Bucket*": one version, in English, Spanish and Creole

"*Rainy Season*": one version, in English and Spanish

"*Faucet*," "*Shower Head*," "*Sprinkler*," and "*Hose*": one version each

"Your Way Of Life": one version

Seven spots, in Spanish only

Six spots, in Creole only

Public Announcements in Public Places

Several ideas generated by Office of Media Relations and Department of Public Information staff were disseminated at no cost to the District. The ideas included a message on an electronic billboard and an announcement at Pro Player Stadium in Broward County prior to a Florida

Marlins baseball game and during the radio broadcast of the game; an announcement at Roger Dean Stadium in Jupiter during a Florida Hammerheads baseball game; and large signs at town and city boundaries reminding residents about current water use restrictions.

Radio Public Service Announcements

As with television spots, some radio spots were provided free of charge, but the District also purchased some airtime to guarantee prime exposure. Radio public service announcements included:

- A series of 16 spots that were a revised "*Turn It Off*" series – two spots included 15-, 30-, and 60-second versions in English, and 30- and 60-second versions in Spanish and Creole
- A series of two spots, titled, "*Why restrictions*?" 30 and 60 seconds, English only
- A series of nine spots, titled, "*Wasting Water is a Crime*." One spot in 15-, 30- and 60-second versions. In three languages
- A series of nine spots, titled, "*A Drop in the Bucket*." One spot, in 15-, 30- and 60-second versions in three languages
- A series of nine spots, titled, "*Summer: It's Raining*." One spot, in 15-, 30- and 60-second versions in three languages
- A series of nine spots, titled, "*Conserve All Year*." One spot, in 15-, 30- and 60-second versions in three languages

Copies of the radio PSAs are archived on CD available with the executive summary of this report.

Billboards

The District placed billboards, with the hard-hitting message "Wasting Water is a Crime," in six counties. Spanish-language billboards bearing the same message were placed in Miami-Dade. Photos of the billboards are archived in the South Florida Water Management District's Reference Center at SFWMD headquarters in West Palm Beach.

Speakers Bureau

The SFWMD speakers bureau was formed to disseminate information about the South Florida Water Management District. In 2001 nearly every presentation the speakers bureau made was to relay information about the drought, to define water restrictions, and to explain what the District was doing to alleviate the impacts of the drought. The speakers bureau made 41 offsite presentations on these subjects during the 2000–2001 drought. This compares with an annual average of 26 presentations made during the previous five years.

Water Ambassadors Program for District Employees

The SFWMD conducted three workshops for its employees, training them as water conservation ambassadors who could spread the District's message of conserving water. A total of 600 employees participated in the workshops, out of which came many creative ideas regarding how the District could best disseminate its water conservation message. The training educated employees about historical and current water conditions in the South Florida region, and employees were provided with District materials and publications to distribute among communities, civic groups, clubs, and schools. As part of their message, water conservation ambassadors added a humorous touch to a serious situation by employing a Jeopardy-style skit to teach the public about water conservation. The skit was popular and useful in encouraging public participation.

Citizen Information Line

The District trained more than 500 employees to handle the more than 31,000 telephone calls received from the public requesting information about the drought and water restrictions. A phone bank was set up in the District's Emergency Operations Center (EOC) at District headquarters in West Palm Beach. Employees had to learn how and where to obtain current and pertinent drought-related information, the process of activating the telephone system, and protocols for speaking with sometimes demanding and distraught callers. In addition, employees were instructed on the latest water use restrictions to keep callers informed.

By the end of April 2001, the phone bank had received 23,000 calls, with nearly 1,000 calls coming in on a single day. The number jumped dramatically on days when water use restrictions were changed. At the height of the drought the phone bank was receiving up to 900 calls each day; at one point, 10 employees were assisting callers, while 31 more callers were put on hold. In addition, an administrative person was added to the phone bank staff to compile daily and weekly reports and to mail out copies of current water use restrictions and other information to callers who requested it. Many callers were also referred to the District's water shortage Website.

Calls were received throughout the night and day, and it became necessary to answer them long after the drought had eased. The District also hired temporary staff and trained them to answer the hundreds of calls about water use restrictions. The District has since established a special, permanently staffed telephone line for answering questions and providing information on water use restrictions and water conservation.

Water Shortage Website

The SFWMD's water shortage Website was redesigned at the beginning of the drought to meet the public's need for drought-related information. The water shortage Website began as a small site, with less than 50 Web pages providing primarily technical information and links to maps, weather and water-storage conditions, and "live" data on water levels. However, the site quickly grew to several hundred pages, including "Top of the Page" newsbrief updates on the Website's homepage. In a few sentences, updates of greatest interest to the general public and the media could be highlighted (see **Appendix 8A-11**).

A less high-profile version of the water shortage Website had existed for about three years prior to the 2000–2001 drought. The Website was originally created to post information related to specific geographic areas that were historically prone to drought. Prior to the 2000–2001 drought, the Website had featured numerous links to data about wells and weather forecasts and depicted areas where potential water shortages might occur or where restrictions had been in place as normal, seasonal wet-dry periods affected the water supply in limited areas throughout the District.

Subsequently, at the beginning of the 2000–2001 drought, the Website was revised and was continuously updated to handle the vast amounts of information necessary to communicate drought-related information to the public during this period.

The water shortage Website homepage was supplemented with links to electronic copies of all print materials created to educate the public and the media about the drought. An FAQ (frequently asked questions) page was created and updated daily or weekly, based on questions posed by site visitors and those calling the citizen's information telephone line. Nearly 3,000 e-mails were sent to the Website and included requests for drought-related information, as well as comments on the drought or local water restrictions enforcement or SFWMD operations. Each e-mail received a response within one to three days. The Website also provided links to District news releases, Office of Media Relations news briefings and news conferences, updated maps and brochures with more detailed drought information, technical and legal documents, and current and historic water data. In addition, the Website included links to materials for specialized audiences, such as seasoned "SFWMD beat" reporters, commercial businesses, farms, and other drought-impacted local and state governments. Much of the information on the Website was available in English, Creole, and Spanish.

The water shortage Website's high-priority pages were updated regularly, often several times a day. Some lower-priority pages were also updated frequently (some daily and others weekly). As information was requested, or, based on the developing needs of the public or affected groups, new or updated information and links, and even new pages within the main Website, were quickly added. Callers to the citizens information line regularly were directed to the Website for immediate access to online versions of all printed documents. On the Website, the District urged residents to download and print out information and share it with their neighbors, friends, and family. The site also encouraged residents to insert the printed information in the doors of neighbors who appeared to be violating restrictions.

Media and police enforcement officials promoted the Website as a source for the latest information on the water shortage. The Website was also promoted in all educational and promotional materials for the water shortage – in television and radio PSAs, in all printed materials, and in special community signage. Many local governments and enforcement agencies used the Website as a resource for drought-related information. In addition, the District posted reports tallying the latest numbers of enforcement actions taken by local governments, as well as by the District (reporting on non-compliance) on the Website.

Staff from the Office of Media Relations and the Department of Public Information co-managed the water shortage Website. The Department of Public Information managed the site's high-priority pages, as well as pages and files linking to materials designed for the general public or specialized audiences. DPI staff also answered most of the incoming e-mail from the public.

Staff from several District technical departments updated and continuously added links to "live" data in demand by special audiences. Area news media, the general public, and several special interest groups expressed an interest in daily changes in water levels in Lake Okeechobee, for example. The groups were also interested in information concerning their local area. Staff from District technical departments answered the more technical questions received via e-mail. Information about changing trends in the types of information visitors were seeking was forwarded to the DPI's Website team members. Having this information available on the Website allowed technical experts and Office of Media Relations staff to focus on more in-depth, unusual, or very specific information requests.

The OMR and DPI teams worked together to reconfigure the water shortage Website a number of times, especially the top-level (high-priority) pages in response to feedback from those site visitors seeking specific types of information. Website staff from the Public Information Department, as well as several Webmasters from the District's Water Supply, Operations, Lake Okeechobee, GIS, Emergency Management, and Environmental Monitoring departments and divisions met regularly to ensure that the various groups that were part of the water shortage team were satisfied with the Website. Their collaboration helped ensure that all existing and new drought-related information would be included within a structure that was comprehensive and easy to navigate.

The "Be Water Smart" School Education Campaign on Water Conservation

As part of the South Florida Water Management District's efforts to inform area residents about the drought, 45 schools in six South Florida counties competed for cash awards in a campaign to educate students about the need for water conservation. The District awarded 58 cash prizes to winners among the elementary (best posters), middle (best verses or jingles) and high (best audio or video PSA) schools of Miami-Dade, Broward, Palm Beach, Lee, Monroe, and Collier counties.

The District sent water information packets to each elementary, middle, and high school in the six counties. The District recognized the winners at its April (East Coast winners) and May (West Coast winners) governing board meeting. By order of the executive director, and to encourage widespread contest participation within a short period of time, nearly $56,000 was spent on competition awards, certificates and mail-outs.

CONCLUSIONS: PUBLIC INFORMATION

It is difficult to ascertain the most effective outreach tool employed during the 2000–2001 drought. The volume of calls to the citizen information hotline indicates that local weather reports that included the hotline number and information on regional drought conditions were highly successful. Many members of the general public also telephoned or wrote to the District in praise of many of the PSAs. Visitors to the water shortage Website, including the more specialized users, appreciated the volume and the timeliness of information made available there. Area schoolteachers incorporated District materials on water conservation into their lesson plans, and those materials have continued to generate interest.

The 2000–2001 drought provided the South Florida Water Management District with an opportunity to newly educate the many South Florida residents who, prior to the drought, knew little, if anything, about the District and its mission.

The District continued its water conservation campaign, attempting to instill a year-round water conservation ethic among South Florida residents. The SFWMD collaborated with the St. John's River Water Management District (SJRWMD) and the Southwest Florida Water Management District (SWFWMD) in a statewide 2002 water conservation campaign titled, *Florida's Water: It's Worth Saving*. Campaign materials included brochures, PSAs, display boards and other promotional items, including bookmarks based on the winning elementary school poster from the 2000–2001 drought. The water shortage Website continued to receive regular visitors even though the SFWMD lifted water use restrictions. The Website's message included the theme, *Florida's Water: It's Worth Saving*. The District also created an Earth Day poster that included Everglades photos and a poem by Maya Angelou as part of its design. The poster was distributed at area schools and community festivals. During April 2002, for Earth Day and during Water Conservation Month, District volunteers participated in 27 community events to continue to tout the District's water conservation message.

CHALLENGES: WHAT CAN BE DONE BETTER NEXT TIME

Office of Media Relations (OMR) staff encountered many challenges while facilitating reporters' requests for drought-related information. Some of the items most-requested by the public included maps and documents, such as legal papers (letters and orders), water restrictions fact sheets, and rainfall charts. During the next water shortage emergency, better coordination between District GIS experts and graphic designers in providing material in a more timely manner is recommended, as various maps, publications, and other information had to be created quickly in response to the worsening drought conditions.

Another challenge OMR staff faced was that of comprehending the many accompanying scientific, technical, and complicated legal issues that arose as a result of the drought. It was crucial for OMR staff to fully understand these issues to provide the public with accurate and timely information about the drought. During future droughts, drought managers could help improve the media's understanding of highly technical information by designating a "translator" or point person to help with simplifying technical and legal issues for lay people.

Because the Office of Media Relations has no control over what news the media ultimately choose to report, OMR staff, despite their best proactive efforts, must respond to area news reporters' requests for information with the best information available. During future droughts, the District might want to consider whether it should rely as heavily on the external news media to communicate the District's message to the public. While the print media can be an important tool for publicizing a message, future drought managers might want to consider investing in and relying more heavily on other methods of communicating with the public, modes in which the District has more control over the message. Examples include direct mail, greater use of newspaper inserts and print advertisements, special events, Web page promotion, billboards, signage, television and radio public service announcements, and joint partnerships with water utilities. Combined with area-wide news coverage, these broad-based communication tools, while more costly for the District to implement, could potentially yield greater, more accurate outreach results.

LESSONS LEARNED: MEDIA RELATIONS

One lesson the Office of Media Relations learned as a result of the drought-themed media outreach is that the District must have an aggressive and involved media relations team in place for future droughts to ensure that area and regional media, as well as the general public, understand and support the District's water supply protection actions during a drought.

Secondly, the District must acknowledge that it will have to invest a considerable amount of money in mass media campaigns. For the 2000–2001 drought, the District spent $971,360, primarily in purchasing broadcast time on television and radio for public service announcements and targeted outreach campaigns. Those campaigns were very effective in reaching a large percentage of the population, including those who might not regularly read newspapers or watch or listen to broadcast news. Use of a variety of media is recommended to get the District's message to the greatest percentage of the public during future droughts.

Thirdly, early coordination is needed among the District, county governments, public utility departments, municipalities, and law enforcement agencies in preparing for effective campaigns that promote public awareness of a drought and corresponding positive actions to conserve water.

Fourthly, regarding any media outreach strategy, the District must take a decisive approach to a drought emergency. While the District is highly vulnerable to criticism as the primary handler of a drought emergency, it is also in a position to capitalize on more widespread recognition of its abilities if it handles such an emergency openly and with competence and professionalism. Because of the District's size and level of public exposure, it is important for drought managers to work to gain and maintain the public's trust and respect and to handle drought emergencies with competence and intelligence.

Finally, the 2000–2001 drought elevated the public's awareness of the District through its role in managing the area's water resources. The District hopes to build from this base an even more knowledgeable public that truly understands the SFWMD's mission. One effective strategy the Office of Media Relations staff used to build public awareness from the drought's outset was patient, and competent professionals. The OMR designated specific spokespersons who gained the trust of reporters who covered the drought story for many months. The District's drought spokespersons helped the media clarify drought-related facts and information for the public.

Appendix 3A-1: Lake Okeechobee Water Supply Backpumping and Water Supply Augmentation after Action Report

[Note: This report was previously issued by the South Florida Water Management District on December 14, 2001.]

LAKE OKEECHOBEE WATER SUPPLY BACKPUMPING AND WATER SUPPLY AUGMENTATION AFTER ACTION REPORT

FINAL REPORT

December 14, 2001

Prepared for

Florida Department of Environmental Protection

by

South Florida Water Management District

DISCLAIMER

The information in this report is derived from a variety of sources, including but not limited to the U.S. Army Corps of Engineers, the U.S. Geological Survey, the National Weather Service and other federal, state and local government agencies. Different reporting formats and methods are used by contributors and may result in minor variations in data. ~ The District does not warrant, guarantee, or make any representations regarding the use, or the results of the use of information provided to you by the District -- in terms of correctness, accuracy, reliability, completeness, usefulness, timeliness or other similar terms. ~ The user recognizes that the information, data, apparatus, products, processes and materials are dynamic, and may change over time without notice. However, the District makes no commitment to update these items. ~ The disclaimer applies to individual use of the data and aggregate use with other data.

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INTRODUCTION AND BACKGROUND

This report has been prepared in compliance with and as a fulfillment of the requirements of the Emergency Final Order (O G C No. 01-1202) issued by the Florida Department of Environmental Protection (Department) on August 3, 2001. The order made provisions for allowing the South Florida Water Management District (District) to take specific necessary action or actions to augment flows to Lake Okeechobee to mitigate the effects of the severe drought conditions experienced across much of the State of Florida during 2001. These actions were intended to increase the stage of Lake Okeechobee, an essential and critical source of water for South Florida.

During the first half of 2001, Florida experienced one of the most severe droughts in recorded history. In spite of the imposition of Phase II (severe) and Phase III (extreme) water restrictions by the District's governing board, water supplies were severely impacted in South Florida. These impacts included water levels in Lake Okeechobee falling to historic lows. Since the early portion of the 2001 rainy season experienced rainfalls that were only of average intensity, the Lake was recovering slowly, raising the possibility of even more severe water shortages during the approaching dry season. As a direct result of the drought, the Executive Director of the District declared a Water Emergency on March 27, 2001 which the governing board subsequently concurred with in an emergency meeting of the Board on that same date. In response to the declared Water Emergency, the Department found that an emergency existed that required immediate action.

As a result of those findings, the Department issued the first Emergency Final Order (OGC No. 01-0715) on April 27, 2001, in which the District was authorized by the Department to initiate backpumping into the lake through the existing structures at S-2 and S-3 at the south end of Lake Okeechobee. As part of those permitted operations, the order required intensive water quality and biological monitoring programs, the implementation of certain operational constraints, and activities required to offset the potential impacts of the backpumping events which included planting bulrush plants in previously denuded areas and removal of an organic berm in the lake. In addition, the District was directed to work with the agricultural interests in the EAA and the Department of Agricultural and Consumer Services (DACS) to enhance the effective management of the use of pesticides and herbicides.

In the ensuing months, as the drought continued and concerns escalated regarding the impending dry season, the District was authorized by the Department in a second Emergency Final Order (OGC No. 01-1202) dated and issued on August 3, 2001 to continue backpumping as well as allow augmentation of the pumping and gravity flows of water into the lake through the structures at S4, S77, S308, S352, and Culvert 10A. In addition, the District was authorized to install temporary pumps to backpump additional water as required. Operation of the temporary pumps did not occur, however, because increased rainfall during the latter part of the rainy season and gravity inflow through key structures sufficiently raised lake water levels before the pumps became operational. Flow augmentation and backpumping operations, coupled with the increased rainfall during the latter part of August and early September, sufficiently raised Lake Okeechobee water levels to allow the discontinuance of the activities authorized by the Emergency Final Orders on September 21, 2001.

It should also be noted that several isolated heavy rainstorms resulted in operation of the pumps to mitigate flooding during the Spring and the month of September. Although these events resulted in backpumping water into the lake, these operations were required for flood protection and carried out in accordance with established flood protection pumping criteria. These pumping events were not considered part of the water supply augmentation efforts covered in this report.

WATER QUALITY REPORT

Water quality data obtained during the backpumping and augmentation period are presented in the accompanying tables. In general, the quality of the water entering the lake through the augmentation structures contained lower total phosphorus concentrations than the water entering the lake from other sources. All sampling and analyses were conducted in accordance with the conditions detailed in the Emergency Final Orders of April 27, 2001, and August 3, 2001. All results are summaries or compilations of data previously reported to the Department by the District in prior monthly After Action Reports.

During the period from June 1 through September 21, 2001, backpumping from S2 and S3 contributed 22%, or approximately 325,000 acre-feet of water, of the total inflow into the lake, but only 9%, or 37.9 metric tons, of the total phosphorus (TP) contribution to the lake (Table 1). Flows from all augmentation sources covered in the second Emergency Final Order, including both backpumping and gravity flow, contributed 39% of the flow and 25% of the TP when compared to all water sources contributing to the lake during that time period. These relative contributions resulted in a flow weighted mean concentration of TP from all backpumping and augmentation sources that averaged 146 ppb, whereas the flow weighted mean concentration of TP entering the lake from all sources, including the backpumping and augmentation flows, averaged 228 ppb.

Calculated loads for Total Nitrogen (TN) indicate that the load of nitrogen entering the lake for the augmentation period coming from the augmentation structures represented 46% of the total load from all sources. The flow weighted mean concentration of TN entering the lake from all sources during the period was 2.53 mg/l (2,532 ppb), whereas the flow weighted mean concentration of TN from the flows coming through the structures being used for water supply backpumping and augmentation was 2.99 mg/l.

Table 2 reiterates flow and load data for each structure broken down into monthly intervals for the total augmentation and backpumping period.

The data summarized in Tables 1 and 2 are graphically put into perspective for the lake as a whole by the figures shown in Figure 1 through Figure 4. Figure 1 indicates the flow weighted concentration of TP from each inflow into the lake including those presented in Tables 1 and 2. The concentrations indicated in Figure 1 are then multiplied by the total flow to calculate the load of TP entering the lake from each source. Those loads are shown in Figure 2. Figure 3 likewise indicates the flow weighted concentration of TN entering the lake from each source, and Figure 4 shows the load of TN based on the flow weighted concentration and the total flow from each source.

A monthly summary of lake stage and rainfall reported by tributary basins is provided in Table 3. Individual daily flow and pump operation logs have been provided in the monthly After Action Reports previously submitted. A graphical representation of lake stage and regulation limits for the period from January 1, 2000 to the termination of the backpumping and flow augmentation activities on September 21, 2001, is provided in Figure 5.

The monitoring programs specified by the Emergency Final Orders also required additional water quality monitoring of the inflows into the lake for parameters other than nutrients. Sampling stations used to collect water quality monitoring samples are indicated on the map in Figure 6. The results of those monitoring activities are reported in Tables 4 through 23.

Tables 4 through 9 specify the pesticides detected at each structure during the sampling period. Any pesticide that had a positive value reported at any time at any location during the monitoring program are reported for each sampling event at each sampling point, even if the pesticide was not found at that particular sampling point. The pesticide results were reported in this manner to enable easier cross comparisons between sampling events and locations. Tables 4 through 9 list only those pesticides for which at least one positive value was obtained during the monitoring required for the backpumping and augmentation operations, whereas Table 10 provides a complete list of all the pesticides for which analyses were performed. A BDL value in Tables 4 through 9 indicates that the concentration of the pesticide was below the analytical detection limit for that specific pesticide at that sampling event. No pesticide concentrations found exceeded Class I water quality standards.

Trace level mercury monitoring for all structures involved in augmentation flows to Lake Okeechobee are reported in Table 11. In no case was the state criterion of 12 ng/l total mercury exceeded for any water sample analyzed and reported. A "ND" value in Table 10 indicates that no data are available for that sample due to quality control issues with that particular datum. A value proceeded by a less-than symbol (<) for a sample indicates that the results for that analysis were below the method detection limit for that analyte; the value reported for those analyses is the detection limit for that particular determination.

Summaries of the water quality data for each sampling station are presented in tables 12 through 23. These summaries indicate that there were no significant violations of class I water quality standards at any location except for variations from the Dissolved Oxygen (DO) standard and a few exceedances of the standard for iron. Concentrations below the 5 mg/l DO standard are common in ambient South Florida surface waters and do not necessarily indicate adversely impacted water quality. This standard is currently under review by the Department and it is anticipated that it will be revised to more accurately reflect naturally occurring conditions in South Florida. The exceedances observed for iron were in excess of the Class I standard but were still within the Class III standard. Since the water samples were collected on the up-stream or canal side of the structures, and thus were collected in Class III waters, there is a question about which standard should apply. Furthermore, iron in concentrations greater than the Class I standard of 0.3 mg/l in surface water are generally in the form of particulate iron associated with suspended sediments and should settle out in the lake, allowing the water to meet Class I standards in that water body before the water reaches any public water supply intake point. A value proceeded by a less-than symbol (<) for a sample indicates that the results for that analysis were below the method detection limit for that analyte; the value reported for those analyses is the detection limit for that particular determination.

BIOLOGICAL MONITORING REPORT

OVERVIEW

The Department required that the District expand its existing program of biological monitoring in the lake in order to identify any ecological impacts of backpumping. The District had the benefit of nearly two years of biological monitoring background data to assist in the identification of potential effects. The focus of the monitoring, as detailed in the two Emergency Final Orders (OGC No. 01-0715 and OGC No. 01-1202) provided by the Department, was on submerged aquatic vegetation (SAV) and water transparency. The lake's SAV is a valued ecosystem component that provides habitat for fish and other aquatic biota. Submerged aquatic vegetation is a sensitive indicator of water quality because its aboveground tissues are in direct contact with the lake water. Research on Lake Okeechobee and in other shallow freshwater ecosystems has documented that underwater light availability is a prime determinant of SAV growth. Therefore, the biological monitoring program also included a detailed analysis of underwater light in the southern region of the lake in the proximity of the S2 and S3 pump stations, as well as other stations that could be used as "reference" locations for comparative purposes.

In summary, biological monitoring indicated no negative impacts of the backpumping operations on SAV or water transparency. There were typical variations in SAV occurrence with season and location, similar to what has previously been documented in Lake Okeechobee, and changes in water transparency associated with increased water depths, lake-wide effects of wind, and lake-wide changes in dissolved organic color. However, none of these changes were associated with the emergency water supply backpumping operations. These results do not indicate that backpumping will never have negative ecological impacts on the Lake, just that in this particular case such effects were not observed as of the date of this report.

METHODS

The District, in a document dated August 1, 2001 previously supplied the Department with a detailed description of the biological monitoring program. Therefore only a brief overview is included here. Biological monitoring included monthly assessment of the biomass, spatial extent, and taxonomic composition of SAV at over 50 sites around the south, west, and north perimeter of the lake, and reporting of this information in the form of GIS maps. The monitoring also included weekly measurements of water transparency with a Secchi disk; these measurements were restricted to locations at the lake's southern end. The primary aim of transparency monitoring was to have an "early warning" of impacts on light conditions that might give rise to future declines in plant growth. As indicated above, no such early warnings ever arose.

MONITORING THE STATUS OF SAV

To evaluate SAV status over the period when water supply backpumping and augmentation occurred and when the second Emergency Final Order (OGC No. 01-1202) was in effect (August and September 2001), the District increased the frequency of its SAV sampling program from quarterly to monthly. The sampling sites occur in the south, west, and north near-shore areas that are shallow enough to support plants when conditions are favorable for their growth. The sampling sites occur along transects from shoreline out to deeper water, with three sites per transect and a total of 45 sites (depending on lake stage).

EVALUATION OF UNDERWATER LIGHT AVAILABILITY

The SAV monitoring was accompanied by more frequent (weekly) sampling of underwater light availability at locations that were expected to experience inputs of water from backpumping and augmentation (i.e., the 21 stations around the south and southwest edge of the lake, from Pelican Bay to Mayaca Cut). This sub-network includes transects extending outward into both South Bay and the shallow bay to the west of Ritta Island, lakeward of the S2 and S3 pump stations, respectively. At the 21 sites, District staff carried out sampling during morning hours (to minimize the influence of afternoon thunderstorms and associated wind-induced mixing and sediment resuspension) on a weekly basis in August and September. The sampling method was based on past experience that the simplest and most useful approach is to measure Secchi disk transparency and total depth. The ratio of Secchi / total depth then is an indicator of underwater light conditions for plant growth. Sites with ratios in excess of 0.5 typically have well above the critical irradiance needed for plant growth, while sites with ratios below 0.25 might be considered "stressed" from the perspective of plant growth.

AUGUST RESULTS

SUBMERGED AQUATIC VEGETATION

The SAV community was sampled on August 21 (Figure B1). A total of 21 sites had SAV and 14 sites did not. Sites with SAV occurred in shallower water closer to the shore. The plants were responding to increased lake stages with the appearance of small *Chara* (shrimp-grass) plants around the shoreline at many of the sites that previously were dry (Figure B4). Two sites along the southwest shore also had a high biomass of *Vallisneria* (eelgrass). The pattern of SAV occurrence at this time was very similar to what was observed at the start of the growing season last year and it did not indicate any effects of water supply backpumping.

TRANSPARENCY

Transparency was measured on August 7, 14, and 21 at sites located along 7 transects parallel to the lake shore (Figures B2-B4), including Pelican Bay (one transect), South Bay (three transects), and three transects west of Ritta Island. On all three occasions, percent Secchi depth was greater than 75% (high light for plant growth) at most sites that were sampled. Of the 51 measurements (one transect in South Bay was dry and not sampled, and the innermost station along the transect near the Mayaca Cut also was dry), there were only 4 cases of percent Secchi below 50% (two each on August 14 and 21). Field crew reported that these lower values were associated with wind-driven mixing of the water column and sediments at exposed locations. The percent Secchi data do not indicate any particular influences of backpumping on water quality during the month of August. It is noteworthy that the lake has displayed a high degree of color in the water, probably reflecting the presence of humic materials. However, this color was observed system-wide (as far north as the Okeechobee pier), as opposed to just the southern region of the lake.

SEPTEMBER RESULTS

SUBMERGED AQUATIC VEGETATION

The SAV community was sampled again in the 3rd week of September (Figure B5). At that time 26 sites had sparse SAV (<100 g/m^2 dry weight), one site had dense SAV (>100 g/m^2 dry weight), and 27 sites had no SAV. Dominant types of SAV were *Chara* spp. (shrimpgrass) and *Vallisneria americana* (eelgrass). The number of sites with SAV in September was somewhat higher than in August (when 21 out of 35 sampled sites had plants), but the number of sites with dense SAV decreased from 3 in August to 1 in September. The results of SAV sampling did not indicate any causal relationships between plant distribution or biomass and water supply backpumping.

TRANSPARENCY

During September, water transparency (Figures B6-B9) continued to be monitored using the Secchi disk method at stations located along 7 transects perpendicular to the lake shore in Pelican Bay (one transect), South Bay (three transects), and west of Ritta Island (three transects). A total of 19 stations were monitored on September 4, 11, 18, and 25. Dense emergent vegetation prevented sampling with the Secchi disk at certain locations / dates. On September 4, 13 of 16 sampled sites had good or fair conditions for plant growth and three sites had insufficient light for plant growth, based on the Secchi to total depth ratios. This was very similar to the condition observed on August 21. Nearly identical results were obtained on September 11. On September 18, conditions changed – only 8 of 17 sites had fair to good light conditions, and 10 sites had insufficient light for plant growth. Similar results persisted to September 25. The decrease in light availability for plant growth was observed at other locations in the lake during late September, and was attributed to rising lake stage, coupled with a generally high level of dissolved organic material in the water. The data collected here do not indicate any causal linkage between the reduced light availability for plants and water supply backpumping.

WATER QUALITY AND ECOSYSTEM ENHANCEMENT/RESTORATION

As part of the conditions of the Emergency Final Order, several enhancement projects have been accomplished in the lake. Prior to the initiation of backpumping, approximately 12,000 bulrush plants had been planted in the lake as specified in Emergency Final Order 01-0715. In addition, the District has budgeted funds to plant approximately 50,000 additional bulrush plants but has not yet done so due to the return to normal lake stages. The planting work is anticipated to commence when water levels in the lake recede sufficiently to allow the proposed activity.

Additionally, the District was directed to contribute $200,000 to the Florida Fish and Wildlife Conservation Commission's project to remove the organic berm in the western portion of the lake and transfer the material to several wildlife islands. In actuality, the District has contributed $400,000 to the enhancement project and it has now been completed.

The District continues to actively work with the agricultural interests in the EAA in cooperation with DACS to promote and more closely manage the use of pesticides and herbicides. These activities are partially conducted as enhancements of the active Best Management Practices program the District promulgates in the EAA.

Emergency Final Order No. 01-1202 directed that the District reimburse the City of Belle Glade and the City of South Bay public water supply utilities for any monthly incremental increases in water treatment costs directly attributable to District operation of the S-2 and S-3 pump stations during the duration of the backpumping operations. As of this date, the City of Belle Glade has supplied the District with the necessary documentation of additional costs and treatment and has been reimbursed by the District. The Cities of South Bay and Pahokee are still in the process of providing the necessary documentation required to receive reimbursement which will be forthcoming upon the District's review and acceptance of that documentation.

During the Spring of 2000, the District performed a lake recession that removed approximately 150 metric tons of TP from the lake (Table 24). The backpumping and augmentation operations performed under the emergency action order contributed 38 metric tons of TP, resulting in a net loss of 112 metric tons of TP from the lake when the two actions are compared.

In addition, although not required by the Emergency Final Orders, the District is financially participating in cooperation with other governmental entities in the maintenance dredging of the Industrial Canal, which is currently in progress, and the planned dredging of three marinas in the southern part of the lake. It is anticipated that these dredging operations will remove significant quantities of nutrient containing sediments resulting in a net reduction of nutrient loads. This reduction should have an eventual beneficial effect on the water quality in the lake.

CONCLUSION

Analysis of the data collected in the Water Quality and Biological Monitoring programs associated with the Emergency Final Orders did not indicate adverse impacts to Lake Okeechobee attributable to the emergency water supply backpumping and flow augmentation operations.

The District, in partnership with the Department of Environmental Protection and the Department of Agricultural and Consumer Services, is continuing to implement water quality improvement and lake restoration projects consistent with the Lake Okeechobee Protection Act and the Lake Okeechobee SWIM Plan.

Table 1. Final Summary for June 1, 2001 through September 21, 2001 Water Supply Backpumping and Water Supply Augmentation Sites and for Lake-wide All Inflow.

Flow

STATION	Total Inflow		% of lake-wide inflow total
	cfs	acre-feet	
S2	98,882	196,129	13%
S3	65,324	129,569	9%
CULV10A (L8)	37,753	74,881	5%
S77	34,916	69,255	5%
S308	45,860	90,962	6%
S4	6,072	12,044	1%
S352	1,455	2,886	0%
Sum for above sites	**290,262**	**575,726**	39%
% of lake-wide all inflow	**39%**	**39%**	
(Lake-wide all inflow total)	**741,275**	**1,470,298**	100%

Total Phosphorus (TP)

STATION	Total Phosporus (TP)		% of lake-wide inflow total
	loads (metric tons)	FWMC (ppb)	
S2	23.96	99.0	6%
S3	13.95	87.3	3%
CULV10A (L8)	9.52	103.0	2%
S77	13.13	153.8	3%
S308	40.09	357.3	10%
S4	2.29	153.9	1%
S352	0.82	229.2	0%
Sum for above sites	**103.76**	**146.1**	25%
% of lake-wide all inflow	**25%**		
(Lake-wide all inflow total)	**413.52**	**228.0**	100%

Total Nitrogen (TN)

STATION	Total Nitrogen (TN)		% of lake-wide inflow total
	loads (metric tons)	FWMC (ppb)	
S2	894	3,697	19%
S3	559	3,499	12%
CULV10A (L8)	206	2,227	4%
S77	169	1,977	4%
S308	238	2,118	5%
S4	40	2,669	1%
S352	24	6,752	1%
Sum for above sites	**2,129**	**2,999**	46%
% of lake-wide all inflow	**46%**		
(Lake-wide all inflow total)	**4,592**	**2,532**	100%

Table 2. Monthly summary: Water Supply Backpumping and Augmentation Sites and All Lake Wide Inflows, June 1, 2001 through September 21, 2001

Notes: All flow data are are preliminary estimations.
S2, S3, S4, and S352 loads are calculated using the auto sampler concentrations.
CULV10A, S77, and S308 loads are calculated interpolating grab concentrations.

June 1 -30

STATION	FLOW		Total Phosphorus (TP)		Total Nitrogen (TN)	
	cfs-days	acre-feet	loads (metric tons)	FWMC (ppb)	loads (metric tons)	FWMC (ppb)
S2	8,142	16,149	2.38	119.6	75.25	3,777.5
S3	3,825	7,587	0.48	51.3	35.30	3,772.5
CULV10A (L8)	930	1,845	0.30	131.7	3.53	1,551.8
S77	18,744	37,178	6.06	132.1	92.25	2,011.5
S308	7,452	14,781	4.27	234.2	33.22	1,822.1
S4	0	0	0	N/A	0	N/A
S352	0	0	0	N/A	0	N/A
Sum for above sites	39,093	77,540	13.49	141.1	239.55	2,504.6
All lake-wide total	44,539	88,341	16.24	149.0	269.28	2,471.2

July 1 - 31

STATION	FLOW		Total Phosphorus (TP)		Total Nitrogen (TN)	
	cfs-days	acre-feet	loads (metric tons)	FWMC (ppb)	loads (metric tons)	FWMC (ppb)
S2	32,393	64,251	7.38	93.1	301.12	3,799.5
S3	19,748	39,170	2.81	58.1	168.86	3,495.0
CULV10A (L8)	7,373	14,624	2.02	111.8	32.81	1,819.1
S77	13,904	27,578	6.12	179.9	66.42	1,952.5
S308	14,308	28,380	9.19	262.6	60.42	1,725.9
S4	0	0	0	N/A	0	N/A
S352	0	0	0	N/A	0	N/A
Sum for above sites	87,727	174,003	27.51	128.2	629.64	2,933.6
All lake-wide total	178,404	353,860	122.22	280.0	1,138.51	2,608.4

August 1 - 31

STATION	FLOW		Total Phosphorus (TP)		Total Nitrogen (TN)	
	cfs-days	acre-feet	loads (metric tons)	FWMC (ppb)	loads (metric tons)	FWMC (ppb)
S2	37,706	74,789	9.09	98.5	347.55	3,767.4
S3	19,964	39,598	4.55	93.2	143.55	2,938.9
CULV10A (L8)	17,644	34,996	5.18	120.0	114.43	2,650.9
S77	2,268	4,499	0.96	172.4	10.22	1,842.0
S308	14,649	29,056	18.50	516.3	105.94	2,956.0
S4	5,042	10,001	1.82	147.6	31.39	2,544.4
S352	1,455	2,886	0.82	229.2	24.04	6,752.3
Sum for above sites	98,729	195,825	40.91	169.4	777.12	3,217.3
All lake-wide total	267,956	531,483	152.81	233.1	1,831.83	2,794.2

September 1 - 21

STATION	FLOW		Total Phosphorus (TP)		Total Nitrogen (TN)	
	cfs-days	acre-feet	loads (metric tons)	FWMC (ppb)	loads (metric tons)	FWMC (ppb)
S2	20,640	40,940	5.11	101.3	170.41	3,374.6
S3	21,787	43,213	6.12	114.8	211.49	3,967.7
CULV10A (L8)	11,806	23,417	2.02	70.0	54.94	1,902.0
S77	0	0	0	N/A	0	N/A
S308	9,451	18,746	8.12	351.3	38.01	1,644.0
S4	1,030	2,043	0.47	185.0	8.26	3,279.0
S352	0	0	0	N/A	0	N/A
Sum for above sites	64,714	128,358	21.84	138.0	483.11	3,051.4
All lake-wide total	250,376	496,614	122.25	199.6	1,352.35	2,207.7

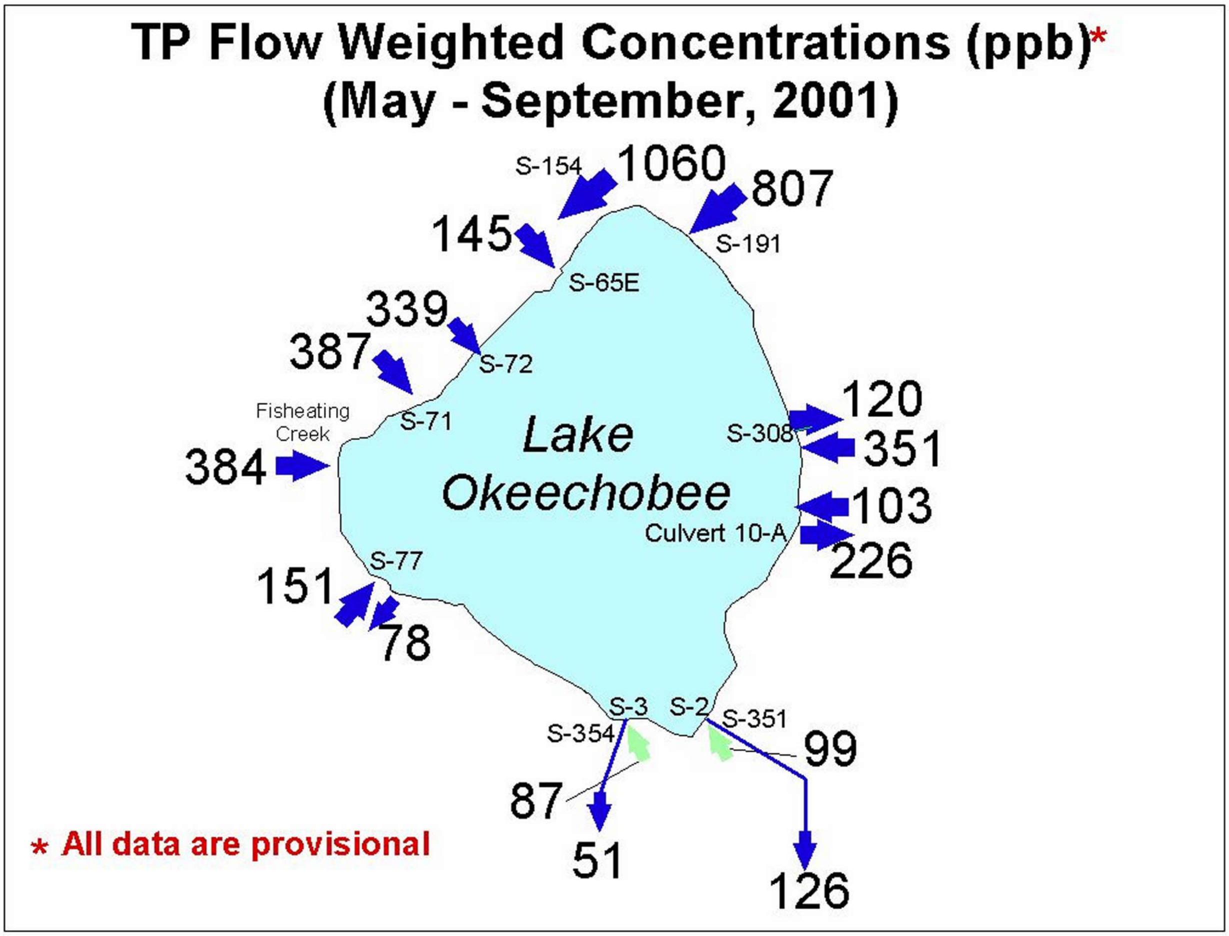

TP Flow Weighted Concentrations (ppb)*
(May - September, 2001)
S-154
1060
807
145
S-191
S-65E
339
387
S-72
Fisheating Creek
S-71
Lake Okeechobee
120
S-308
351
384
103
Culvert 10-A
226
S-77
151
78
S-3
S-2
S-351
S-354
99
87
* All data are provisional
51
126

Figure 1.

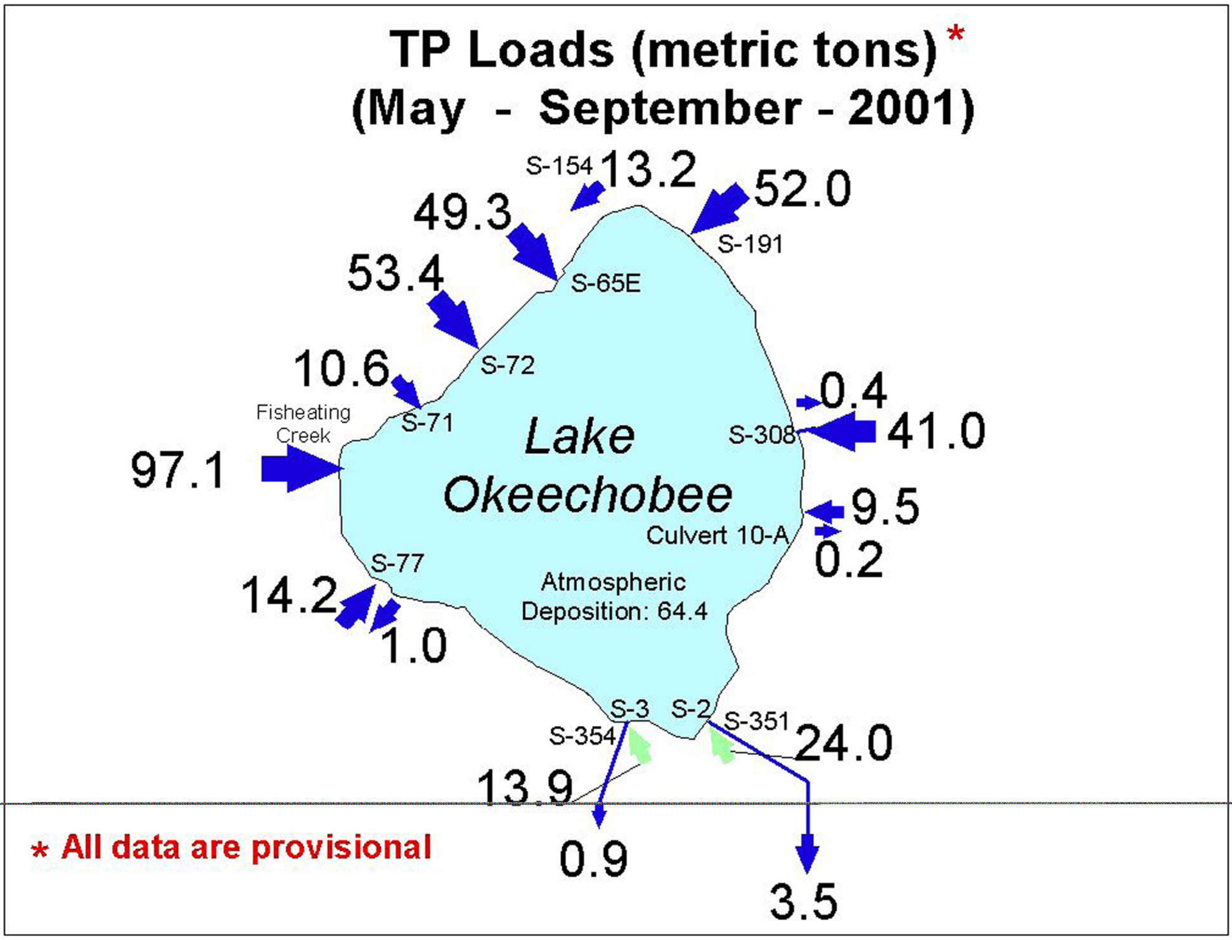

TP Loads (metric tons) *
(May - September - 2001)
S-154
13.2
52.0
49.3
S-191
53.4
S-65E
S-72
10.6
0.4
Fisheating
Creek
S-71
Lake
Okeechobee
S-308
41.0
97.1
9.5
Culvert 10-A
0.2
S-77
Atmospheric
Deposition: 64.4
14.2
1.0
S-3
S-2
S-351
S-354
24.0
13.9
* All data are provisional
0.9
3.5

Figure 2.

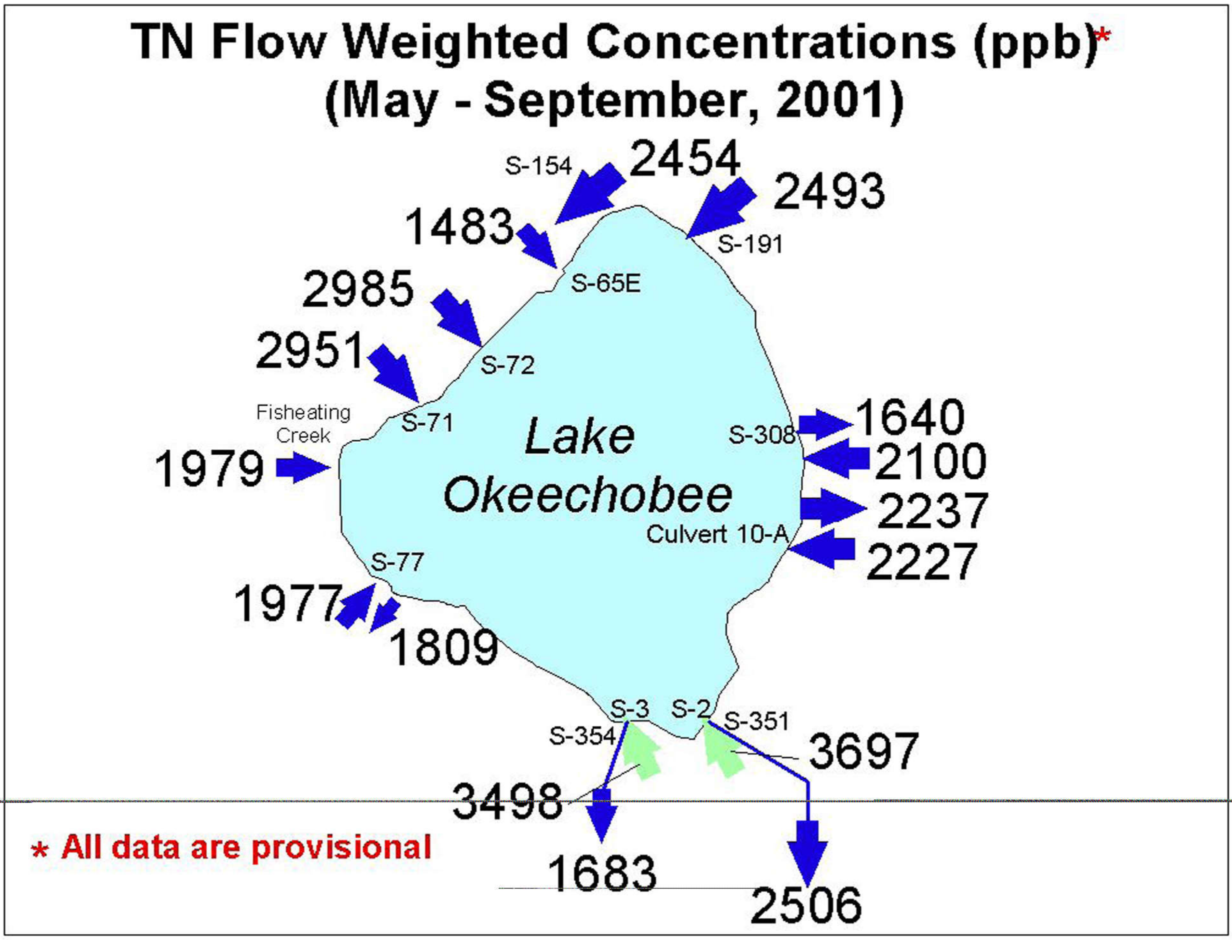

TN Flow Weighted Concentrations (ppb)*
(May - September, 2001)
S-154
2454
2493
1483
S-191
S-65E
2985
2951
S-72
Fisheating
Creek
S-71
Lake
Okeechobee
S-308
1640
2100
1979
2237
Culvert 10-A
2227
S-77
1977
1809
S-3
S-2
S-354
S-351
3697
3498
* All data are provisional
1683
2506

Figure 3.

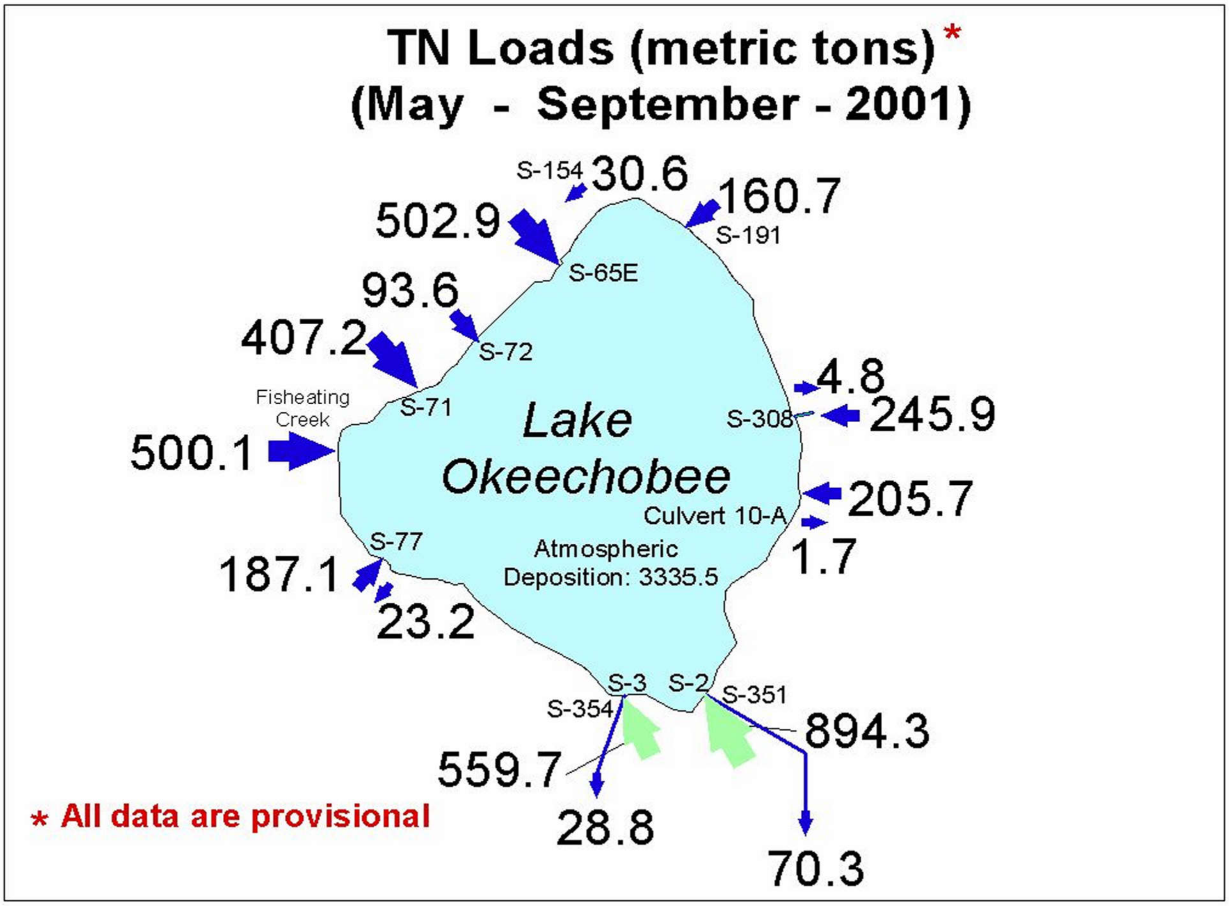

TN Loads (metric tons)*
(May - September - 2001)
S-154
30.6
160.7
S-191
502.9
S-65E
93.6
S-72
407.2
S-71
Fisheating Creek
500.1
Lake Okeechobee
4.8
S-308
245.9
205.7
Culvert 10-A
1.7
S-77
187.1
23.2
Atmospheric Deposition: 3335.5
S-3
S-2
S-351
S-354
894.3
559.7
28.8
70.3
* All data are provisional

Figure 4.

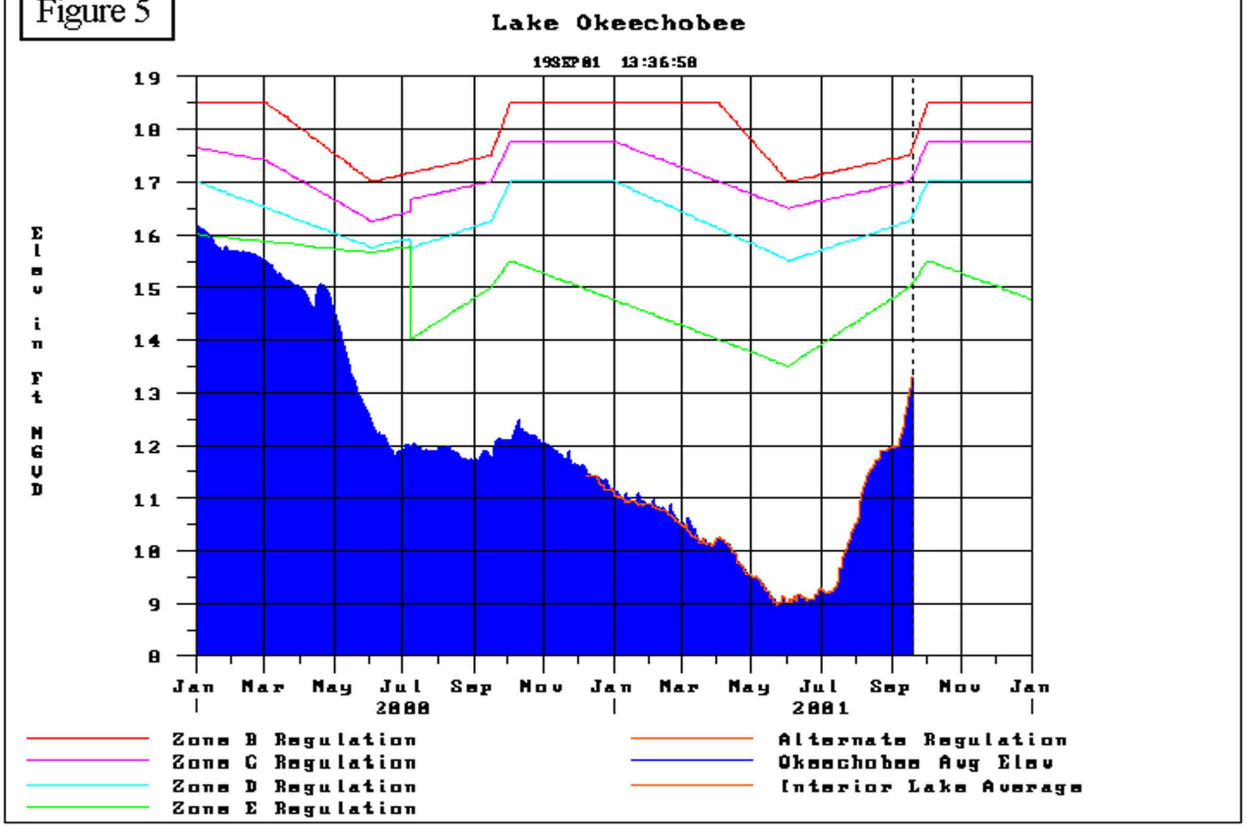
Table 3. Lake Stage and Rainfall for Lake Okeechobee and Vicinity.

Stage: COE Data. Average-daily lake average. In feet-NGVD.

Rainfall: Monthly Sum of SFWMD Provisional 24-Hour Rainfall In Inches Ending 7am EST (8am EDT) On The Indicated Date

DATE	STAGE (feet)		BASIN MONTHLY RAINFALL (inches)							
	beginning	ending	EAA West	EAA East	Lake Okeechobee	Upper Kissimmee	Lower Kissimmee	East Caloos.	MartinSt.Lucie County	Palm Beach County
June 1 -30	9.01	9.27	6.51	6.12	5.69	8.04	6.58	6.56	7.44	6.56
July 1 - 31	9.26	10.53	7.14	8.24	9.07	8.44	8.89	13.44	11.71	9.41
August 1 - 31	10.61	11.98	4.53	5.78	6.19	6.67	4.53	8.48	8.18	7.95
September 1 - 21	11.96	13.56	8.21	6.24	7.80	9.87	8.47	9.04	7.31	9.86
sum (June1 -Sept 21)	**9.01**	**13.56**	**26.39**	**26.38**	**28.75**	**33.02**	**28.47**	**37.52**	**34.64**	**33.78**

Figure 5


Lake Okeechobee
19SEP01 13:36:58
19
18
17
16
15
14
13
12
11
10
9
8
Elev in Ft NGVD
Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan
2000
2001
Zone B Regulation
Zone C Regulation
Zone D Regulation
Zone E Regulation
Alternate Regulation
Okeechobee Avg Elev
Interior Lake Average

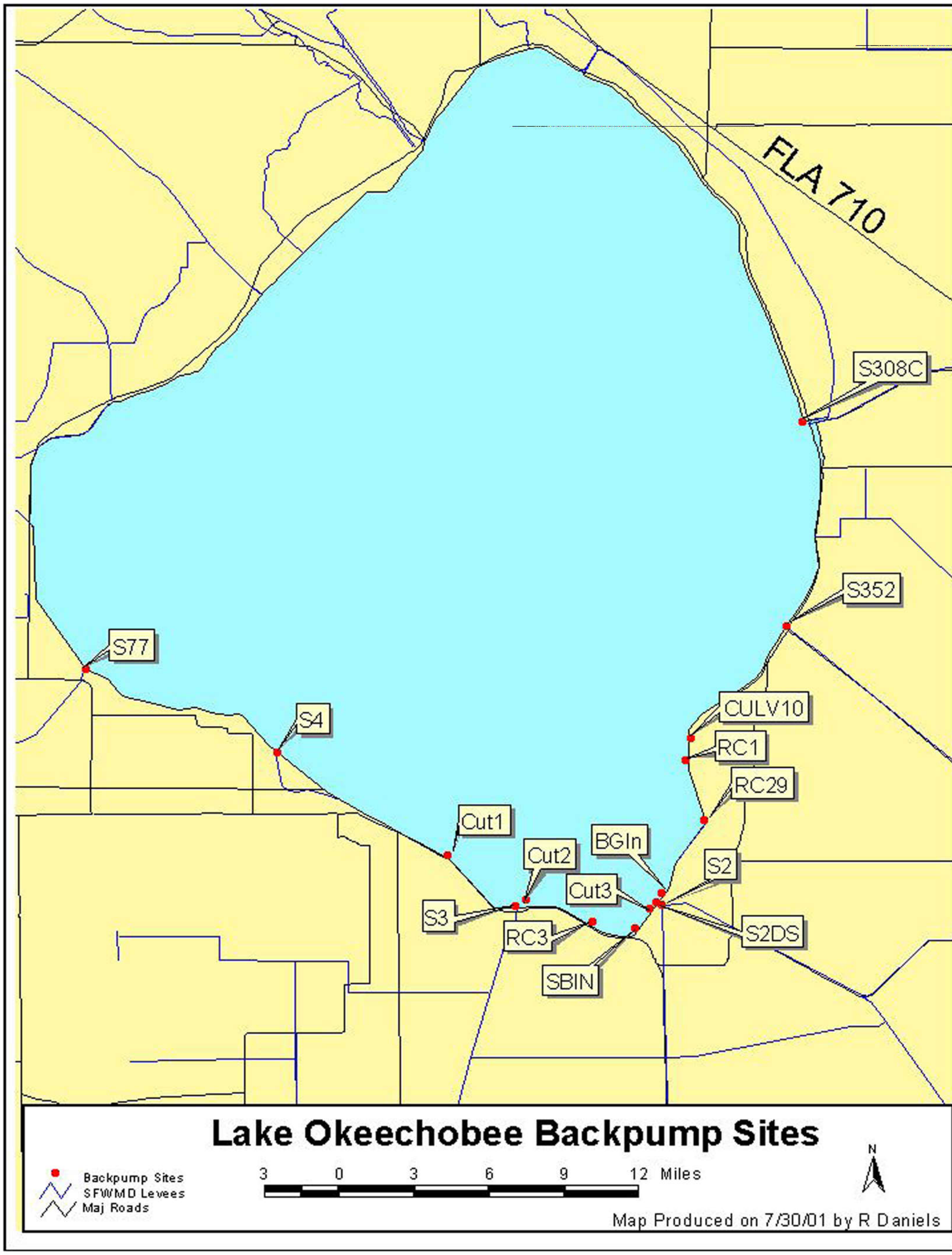


Figure 6. Lake Okeechobee Water Quality Sampling Locations

Table 4. Pesticides at S2: June 1, 2001 through September 21, 2001 Backpumping Events.

Parameters	Sampling Dates												FAC 62-302 Class I Criteria
	06/01/01*	06/08/01	06/12/01*	06/25/01*	06/28/01*	07/10/01	07/16/01	07/20/01	07/25/01	07/27/01*	07/27/01*	08/02/01, 08/03/01*	
ametryn (µg/L)	0.013	0.057	0.065	0.11	0.085	0.046	0.065	0.078	0.16	0.072	0.072	0.046	
atrazine (µg/L)	0.44	BDL	0.98	9.4	2.5	0.66	0.36	0.41	1.9	0.28	0.28	0.16	
atrazine desethyl (µg/L)	0.083	0.16	0.10	0.18	0.091	0.059	0.053	0.067	0.12	0.031	0.031	0.025	
atrazine desisopropyl (µg/L)	0.024	0.033	0.030	0.032	0.015	0.010	0.013	0.018	0.032	0.018	0.018	BDL	
bromacil (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
diazinon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
hexazinone (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	less than or equal to 0.1 mg/L
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
metolachlor (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	0.17	BDL	BDL	BDL	BDL	BDL	
norflurazon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
parathion methyl (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
simazine (µg/L)	0.019	0.021	0.021	0.043	0.012	BDL	BDL	BDL	0.019	BDL	BDL	0.027	

* average of duplicate values
BDL = below detection limit

Table 5. Pesticides at S3: June 1, 2001 through September 21, 2001 Backpumping Events.

Parameters	Sampling Dates															FAC 62-302 Class I Criteria
	06/05/01*	06/06/01*	06/07/01*	06/08/01*	06/10/01*	06/12/01	06/22/01*	06/25/01*	06/28/01*	07/12/01*	07/16/01	07/20/01	07/25/01*	07/27/01	08/02/01, 08/03/01	
ametryn (µg/L)	0.014	BDL	BDL	0.046	0.065	BDL	0.075	0.084	0.061	0.048	0.051	0.062	0.052	0.038	0.04	
atrazine (µg/L)	0.43	1.7	1.6	BDL	0.83	0.83	0.51	0.59	5.9	1.9	0.25	0.37	0.27	0.14	0.1	
atrazine desethyl (µg/L)	0.071	0.17	0.16	0.15	0.13	BDL	0.01	0.085	0.12	0.093	0.048	0.060	0.042	BDL	0.025	
atrazine desisopropyl (µg/L)	0.018	0.034	0.029	0.030	BDL	BDL	0.017	0.013	0.021	0.021	0.015	0.017	0.013	BDL	BDL	
bromacil (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
diazinon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
hexazinone (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.040	BDL	BDL	BDL	less than or equal to 0.1 mg/L
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	BDL	BDL	0.0058	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
metolachlor (µg/L)	BDL	0.14	0.14	0.11	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
norflurazon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
parathion methyl (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
simazine (µg/L)	0.014	0.014	0.014	0.016	BDL	BDL	BDL	BDL	0.025	BDL	BDL	BDL	BDL	BDL	BDL	

* average of duplicate values
BDL = below detection limit

Table 6. Pesticides at S308, S77 and Culvert 10A at L8: June 1, 2001 through September 21, 2001 Backpumping Events.

Station	S308	S77	L8	FAC 62-302
Parameter / Date	07/10/01	07/10/01	07/10/01 *	Class I Criteria
ametryn (µg/L)	BDL	0.060	0.11	
atrazine (µg/L)	BDL	0.10	BDL	
atrazine desethyl (µg/L)	BDL	0.026	0.012	
atrazine desisopropyl (µg/L)	0.014	0.011	BDL	
bromacil (µg/L)	0.51	0.26	BDL	
diazinon (µg/L)	BDL	BDL	0.049	
hexazinone (µg/L)	BDL	0.027	BDL	
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	less than or equal to 0.1 mg/L
metolachlor (µg/L)	BDL	BDL	BDL	
norflurazon (µg/L)	1.0	0.25	BDL	
parathion methyl (µg/L)	BDL	BDL	BDL	
simazine (µg/L)	0.096	0.040	BDL	

* average of duplicate values
BDL = below detection limit

Table 7. Pesticides at S2 Downstream and S3 Downstream: June 1, 2001 through September 21, 2001 Backpumping Events.

Station	S2DOWN					S3DOWN					FAC 62-302
Parameter / Date	07/17/01	07/20/01	07/24/01	07/27/01	08/02/01, 08/03,01	07/18/01*	07/20/01	07/24/01	07/27/01	08/02/01, 08/03/01	Class I Criteria
ametryn (µg/L)	0.090	0.072	0.065	0.063	0.046	0.049	0.065	0.058	0.043	0.05	
atrazine (µg/L)	0.48	0.33	0.49	0.29	0.150	0.26	0.34	0.24	0.15	0.1	
atrazine desethyl (µg/L)	0.061	0.052	0.033	0.031	0.027	0.050	0.054	0.037	0.019	0.02	
atrazine desisopropyl (µg/L)	0.024	0.017	0.012	0.017	BDL	0.010	0.017	0.010	0.0098	BDL	
bromacil (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
diazinon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
hexazinone (µg/L)	0.025	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	BDL	BDL	0.030	0.031	BDL	BDL	BDL	less than or equal to 0.1 mg/L
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
metolachlor (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Norflurazon (µg/L)	0.24	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Parathion Methyl (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.052	BDL	
simazine (µg/L)	0.042	BDL	BDL	BDL	0.018	BDL	BDL	BDL	BDL	BDL	

* average of duplicate values
BDL = below detection limit

Table 8. Pesticides at CUT1 and CUT 3: June 1, 2001 through September 21, 2001 Backpumping Events.

Parameters	CUT1					CUT3					FAC 62-302
	07/18/01	07/20/01*	07/24/01	07/27/01	08/02/01, 08/03/01	07/18/01	07/20/01	07/24/01	07/27/01	08/02/01, 08/03/01*	Class I Criteria
ametryn (µg/L)	0.065	0.059	0.062	0.042	0.04	0.081	0.077	0.055	0.057	0.06	
atrazine (µg/L)	0.30	0.22	0.22	0.17	0.1	0.73	0.30	0.25	0.24	0.2	
atrazine desethyl (µg/L)	0.049	0.037	0.033	0.034	0.02	0.079	0.047	0.041	0.026	0.03	
atrazine desisopropyl (µg/L)	BDL	0.012	0.011	0.0091	BDL	0.023	0.016	0.015	0.012	BDL	
bromacil (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
diazinon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
hexazinone (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	less than or equal to 0.1 mg/L
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
metolachlor (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
norflurazon (µg/L)	BDL	BDL	BDL	BDL	BDL	0.11	0.024	BDL	BDL	BDL	
parathion methyl (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
simazine (µg/L)	BDL	BDL	BDL	BDL	BDL	0.025	BDL	BDL	BDL	0.03	

* average of duplicate values
BDL = below detection limit

Table 9. Pesticides at PH in, BG in, SB in: June 1, 2001 through September 21, 2001 Backpumping Events.

Station	PH in*		BG in		SB in		FAC 62-302
Date / Parameter	08/17/01*	08/20/01	08/17/01	08/20/01	08/17/01	08/20/01	Class I Criteria
ametryn (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
atrazine (µg/L)	0.15	0.015	0.088	0.022	0.089	0.030	
atrazine desethyl (µg/L)	0.039	0.17	0.018	0.03	0.017	0.06	
atrazine desisopropyl (µg/L)	0.019	0.042	BDL	BDL	BDL	0.014	
bromacil (µg/L)	0.092	0.015	BDL	BDL	BDL	BDL	
diazinon (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
hexazinone (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
malathion (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	less than or equal to 0.1 mg/L
gamma-BHC (Lindane) (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
metolachlor (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
norflurazon (µg/L)	0.059	BDL	BDL	BDL	BDL	0.022	
parathion methyl (µg/L)	BDL	BDL	BDL	BDL	BDL	BDL	
simazine (µg/L)	0.045	0.047	BDL	BDL	BDL	BDL	

* average of duplicate values
BDL = below detection limit

Table 10. List of Pesticide Compounds Monitored during the Backpumping Events in 2001.

Chlorinated herbicides and organochlorine pesticides are not analyzed after 8/3/01 sampling event.
@ Prometon is added beginning 8/17/01 sampling event

Chlorinated (Phenoxy Acid) Herbicides*
2,4-D*
2,4,5-T*
2,4,5-TP (silvex)*

Organonitrogen and phosphorus Pesticides
alachlor
ametryn
atrazine
atrazine desethyl
atrazine desisopropyl
azinphos methyl
bromacil
butylate
chlorpyrifos ethyl
chlorpyrifos methyl
demeton
diazinon
disulfoton
ethion
ethoprop
fenamiphos (nemacur)
fonofos (dyfonate)
hexazinone
malathion
metalaxyl
metolachlor
metribuzin
mevinphos
naled
norflurazon
parathion ethyl
parathion methyl
phorate
prometryn
simazine
prometon@

Organochlorine Pesticides*
aldrin*
alpha-BHC*
beta-BHC*
delta-BHC*
gamma-BHC (lindane)*
carbophenothion (trithion)*
chlordane*
chlorothalonil*
cypermethrin*
DDD-p,p'*
DDE-p,p'*
DDT-p,p'*
dicofol (kelthane)*
dieldrin*
endosulfan I (alpha)*
endosulfan II (beta)*
endosulfan sulfate*
endrin*
endrin aldehyde*
heptachlor*
heptachlor epoxide*
methoxychlor*
mirex*
permethrin*
toxaphene*
PCB-1016*
PCB-1221*
PCB-1232*
PCB-1242*
PCB-1248*
PCB-1254*
PCB-1260*
trifluralin*

Table 11. Ultra-Trace Mercury Data for June 1, 2001 through September 21, 2001 Backpumping Events.

station	date	THG, ng/l	TMHG, ng/l
S2	06/08/01	2.99	0.126
	06/12/01	4.776	0.237
	06/25/01	1.81	0.222
	06/28/01	ND	0.185
	07/10/01	1.3	0.488
	07/16/01	2.28	0.222
	07/20/01	2.31	0.173
	07/25/01	ND	0.239
	07/30/01	2.43	0.195
	08/02/01	ND	0.367
S3	06/05/01	1.16	0.12
	06/06/01	1.59	0.096
	06/07/01	1.357	0.094
	06/08/01	1.58	0.098
	06/10/01	2.07	0.113
	06/12/01	1.687	0.127
	06/22/01	1.71	0.332
	06/25/01	1.59	<0.014
	06/28/01	2.03	0.124
	07/12/01	ND	0.204
	07/16/01	2.43	0.446
	07/20/01	1.71	0.138
	07/25/01	ND	0.273
	07/30/01	2.98	0.221
S2DOWN	07/18/01	ND	0.15
	07/20/01	3.64	0.193
	07/24/01	ND	0.264
	08/02/01	3.29	0.3
S3DOWN	07/18/01	2.81	0.271
	07/20/01	1.84	0.177
	07/24/01	ND	0.29
CULV10A	07/05/01	6.26	0.23
	08/14/01	5.56	1.69
S308C	07/05/01	6.47	0.33
S352	08/05/01	4.75	0.798
S77	07/05/01	ND	0.147
CUT1	07/18/01	ND	0.134
	07/20/01	2.37	0.242
	07/24/01	1.75	0.193
	07/30/01	4.84	0.18
CUT3	07/18/01	2.24	0.259
	07/20/01	2.65	0.089
	07/24/01	4.82	0.266

Note: a "ND" value indicates that the value did not meet QA/QC criteria

Table 12. Water Quality Data Summary at S2 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62<302 Class I Criteria
Physical								
Temperature (°C)	06/01/01 - 09/19/01	grab	32	25.4	32.1	28.9	1.7	
Specific Conductivity (µmhos/cm)	06/01/01 - 09/19/01	grab	32	653	1185	991	127	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/01/01 - 09/19/01	grab	32	1.6	12.5	3.4	2.2	Not less than 5.0 mg/L
Water pH (units)	06/01/01 - 09/19/01	grab	32	6.9	7.9	7.3	0.2	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/01/01 - 09/19/01	grab	30	2.7	36.0	9.7	8.2	Less than or equal to 29 NTU above background
Color (PCU)	06/01/01 - 09/19/01	grab	30	26	176	126	29	
Total Suspended Solids (mg/L)	06/01/01 - 09/19/01	grab	28	2.8	83.0	15.9	19.3	
Total Dissolved Solids (mg/L)	06/01/01 - 09/19/01	grab	24	415.0	789.0	648.8	100.5	
Hardness (mg/L as CaCO3)	06/01/01 - 09/19/01	grab	16	190.6	464.6	388.6	61.6	
Alkalinity (mg/L as CaCO3)	06/01/01 - 09/19/01	grab	29	133.9	350.7	281.4	53.9	
Nutrients								
Total Nitrogen (mg/L)	06/01/01 - 09/19/01	grab	33	1.5	9.5	3.7	1.5	
	06/01/01 - 09/19/01	comp	34	2.5	5.4	3.6	0.8	
Total Kjeldahl Nitrogen (mg/L)	06/01/01 - 09/19/01	grab	33	1.4	7.9	2.9	1.1	
	06/01/01 - 09/19/01	comp	34	2.0	4.3	3.0	0.5	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/01/01 - 09/19/01	grab	23	1.2	3.1	2.4	0.5	
Nitrate+Nitrite as N (mg/L)	06/01/01 - 09/19/01	grab	33	0.023	1.870	0.798	0.585	
	06/01/01 - 09/19/01	comp	34	0.010	1.732	0.593	0.474	
Nitrite as N (mg/L)	06/01/01 - 09/19/01	grab	33	<0.004	0.156	0.059	0.039	
Nitrate as N(mg/L)	06/01/01 - 09/19/01	grab	32	0.036	1.789	0.761	0.542	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/01/01 - 09/19/01	grab	33	0.021	0.615	0.233	0.157	
Un<ionized Ammonia as NH3 (mg/L)	06/01/01 - 09/19/01	grab	32	0.001	0.009	0.004	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/01/01 - 09/19/01	grab	33	0.033	1.136	0.124	0.185	
	06/01/01 - 09/19/01	comp	34	0.058	0.171	0.106	0.026	
Orthophosphate as P (mg/L)	06/01/01 - 09/19/01	grab	32	0.007	0.083	0.048	0.022	
Total Dissolved Phosphorus (mg/L)	06/01/01 - 09/19/01	grab	23	0.014	0.087	0.050	0.022	
Silica (mg/L)	06/01/01 - 09/19/01	grab	24	8.213	22.904	16.523	3.799	
Major Ions								
Chloride (mg/L)	06/01/01 - 09/19/01	grab	29	86.590	140.860	108.152	11.767	Equal or less than 250 mg/L
Sulfate (mg/L)	06/01/01 - 09/19/01	grab	24	16.880	125.150	66.541	29.573	
Sodium (mg/L)	06/01/01 - 08/03/01	grab	16	50.952	86.001	65.136	9.967	
Potassium (mg/L)	06/01/01 - 08/03/01	grab	16	6.620	9.862	8.036	0.793	
Calcium (mg/L)	06/01/01 - 08/03/01	grab	16	48.928	126.850	105.271	17.235	
Magnesium (mg/L)	06/01/01 - 08/03/01	grab	16	16.611	35.902	30.555	4.717	
Trace Metals								
Total Arsenic (µg/L)	06/01/01 - 08/0201	grab	11	3.2	6.1	4.7	0.8	Less than or equal to 50 µg/L
Total Cadmium (µg/L)	06/01/01 - 08/0201	grab	11	<0.3	0.3	<0.3	0.1	Less than or equal to calculated value
Total Copper (µg/L)	06/01/01 - 08/0201	grab	11	2.1	3.5	2.9	0.4	Less than or equal to calculated value
Total Iron (µg/L)	06/01/01 - 08/0201	grab	11	90.0	477.2	238.1	150.3	Less than or equal to 300 µg/L
Total Lead (µg/L)	06/01/01 - 08/0201	grab	11	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	06/01/01 - 08/0201	grab	11	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/01/01 - 09/19/01	grab	22	3.1	159.2	21.4	34.1	
Chlorophyll a2 (µg/L)	06/01/01 - 09/19/01	grab	22	2.1	150.6	17.8	32.4	
Chlorophyll b (µg/L)	06/01/01 - 09/19/01	grab	23	<1	3.7	<1	0.8	
Chlorophyll c (µg/L)	06/01/01 - 09/19/01	grab	23	<1	10.1	1.9	2.3	
Pheophytin a (µg/L)	06/01/01 - 09/19/01	grab	22	<1	13.1	5.3	3.7	
Carotenoid (µg/L)	06/01/01 - 09/19/01	grab	22	2.0	56.0	9.5	12.0	
Total Organic Carbon (mg/L)	06/01/01 - 09/19/01	grab	23	17.2	47.2	37.1	7.2	

Table 13. Water Quality Data Summary at S3 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62<302 Class I Criteria
Physical								
Temperature (°C)	06/02/01 - 09/19/01	grab	34	26.0	31.7	29.2	1.6	
Specific Conductivity (μmhos/cm)	06/02/01 - 09/19/01	grab	34	570	1124	811	133	Not greater than 50% above background or 1,275 μmhos/cm
Dissolved Oxygen (mg/L)	06/02/01 - 09/19/01	grab	34	2.1	8.2	4.3	1.7	Not less than 5.0 mg/L
Water pH (units)	06/02/01 - 09/19/01	grab	34	7.0	8.2	7.4	0.3	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/02/01 - 09/19/01	grab	33	2.3	17.6	6.4	4.1	Less than or equal to 29 NTU above background
Color (PCU)	06/02/01 - 09/19/01	grab	33	26	190	120	40	
Total Suspended Solids (mg/L)	06/02/01 - 09/19/01	grab	32	<3	26.0	8.3	5.5	
Total Dissolved Solids (mg/L)	06/05/01 - 09/19/01	grab	28	374.0	735.0	520.2	93.9	
Hardness (mg/L as CaCO3)	06/05/01 - 08/03/01	grab	20	199.1	370.7	315.8	53.4	
Alkalinity (mg/L as CaCO3)	06/05/01 - 09/19/01	grab	32	111.4	274.6	219.9	39.1	
Nutrients								
Total Nitrogen (mg/L)	06/02/01 - 09/19/01	grab	35	1.6	6.0	3.2	1.1	
	06/06/01 - 09/22/01	comp	34	2.3	5.8	3.4	0.8	
Total Kjeldahl Nitrogen (mg/L)	06/02/01 - 09/19/01	grab	35	1.5	3.1	2.4	0.5	
	06/06/01 - 09/22/01	comp	34	2.0	5.8	2.7	0.7	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/05/01 - 09/19/01	grab	27	1.2	2.9	2.1	0.5	
Nitrate+Nitrite as N (mg/L)	06/02/01 - 09/19/01	grab	34	0.049	2.926	0.894	0.799	
	06/06/01 - 09/22/01	comp	34	<0.004	2.081	0.759	0.653	
Nitrite as N (mg/L)	06/02/01 - 09/19/01	grab	34	0.007	0.132	0.049	0.035	
Nitrate as N(mg/L)	06/02/01 - 09/19/01	grab	34	0.036	2.815	0.846	0.769	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/02/01 - 09/19/01	grab	33	0.014	0.468	0.135	0.124	
Un<ionized Ammonia as NH3 (mg/L)	06/02/01 - 09/19/01	grab	33	0.000	0.008	0.003	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/02/01 - 09/19/01	grab	35	0.035	0.129	0.072	0.026	
	06/06/01 - 09/22/01	comp	34	0.032	0.506	0.086	0.080	
Orthophosphate as P (mg/L)	06/02/01 - 09/19/01	grab	34	0.004	0.091	0.030	0.027	
Total Dissolved Phosphorus (mg/L)	06/05/01 - 09/19/01	grab	27	0.011	0.099	0.040	0.029	
Silica (mg/L)	06/05/01 - 09/19/01	grab	28	6.289	17.771	9.874	2.698	
Major Ions								
Chloride (mg/L)	06/05/01 - 09/19/01	grab	32	59.690	129.640	87.847	17.877	Equal or less than 250 mg/L
Sulfate (mg/L)	06/05/01 - 09/19/01	grab	28	14.760	107.500	53.385	24.332	
Sodium (mg/L)	06/05/01 - 08/03/01	grab	20	48.583	88.322	57.556	9.301	
Potassium (mg/L)	06/05/01 - 08/03/01	grab	20	5.170	8.774	7.141	0.765	
Calcium (mg/L)	06/05/01 - 08/03/01	grab	20	50.823	113.767	94.421	18.510	
Magnesium (mg/L)	06/05/01 - 08/03/01	grab	20	11.442	27.866	19.571	3.552	
Trace Metals								
Total Arsenic (μg/L)	06/05/01 - 08/03/01	grab	15	2.8	5.5	4.0	0.8	Less than or equal to 50 μg/L
Total Cadmium (μg/L)	06/05/01 - 08/03/01	grab	15	<0.3	0.3	<0.3	0.0	Less than or equal to calculated value
Total Copper (μg/L)	06/05/01 - 08/03/01	grab	15	1.3	3.0	2.3	0.5	Less than or equal to calculated value
Total Iron (μg/L)	06/05/01 - 08/03/01	grab	14	69.1	285.3	128.7	67.6	Less than or equal to 300 μg/L
Total Lead (μg/L)	06/05/01 - 08/03/01	grab	15	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (μg/L)	06/05/01 - 08/03/01	grab	15	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (μg/L)	06/05/01 - 09/19/01	grab	26	4.8	46.9	16.6	11.5	
Chlorophyll a2 (μg/L)	06/05/01 - 09/19/01	grab	26	3.3	39.1	12.9	9.8	
Chlorophyll b (μg/L)	06/05/01 - 09/19/01	grab	26	<1	8.6	1.1	1.6	
Chlorophyll c (μg/L)	06/05/01 - 09/19/01	grab	27	<1	4.3	1.6	1.1	
Pheophytin a (μg/L)	06/05/01 - 09/19/01	grab	26	<1	12.5	5.2	3.3	
Carotenoid (μg/L)	06/05/01 - 09/19/01	grab	27	2.2	22.9	8.1	5.4	
Total Organic Carbon (mg/L)	06/05/01 - 09/19/01	grab	28	18.4	46.9	32.6	6.8	

Table 14. Water Quality Data Summary at S4 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62<302 Class I Criteria
Physical								
Temperature (°C)	06/18/01 - 09/24/01	grab	14	5.0	31.9	27.8	6.9	
Specific Conductivity (µmhos/cm)	06/18/01 - 09/24/01	grab	14	421	1136	742	230	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/18/01 - 09/24/01	grab	14	1.0	12.6	4.7	3.8	Not less than 5.0 mg/L
Water pH (units)	06/18/01 - 09/24/01	grab	14	6.6	8.3	7.3	0.5	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/18/01 - 09/24/01	grab	6	1.9	14.9	6.5	4.8	Less than or equal to 29 NTU above background
Color (PCU)	06/18/01 - 09/24/01	grab	6	80	222	149	56	
Total Suspended Solids (mg/L)	06/18/01 - 09/24/01	grab	6	1.2	38.0	13.3	13.6	
Total Dissolved Solids (mg/L)	07/16/01 - 07/16/01	grab	1			408.0		
Hardness (mg/L as CaCO3)	07/16/01 - 07/16/01	grab	1			275.5		
Alkalinity (mg/L as CaCO3)	06/18/01 - 09/24/01	grab	6	156.1	238.1	196.7	29.4	
Nutrients								
Total Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	14	2.3	4.3	3.0	0.6	
	08/04/01 - 09/19/01	comp	8	2.0	3.3	2.7	0.4	
Total Kjeldahl Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	14	1.8	4.2	2.6	0.6	
	08/04/01 - 09/19/01	comp	8	2.0	3.0	2.5	0.3	
Total Dissolved Kjeldahl Nitrogen (mg/L)								
Nitrate+Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	14	0.044	1.082	0.326	0.288	
	08/04/01 - 09/19/01	comp	8	<0.004	0.431	0.182	0.144	
Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	7	0.017	0.161	0.076	0.051	
Nitrate as N(mg/L)	06/18/01 - 09/24/01	grab	7	0.008	0.972	0.306	0.340	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/18/01 - 09/24/01	grab	14	0.015	0.822	0.383	0.266	
Un<ionized Ammonia as NH3 (mg/L)	06/18/01 - 09/24/01	grab	14	0.000	0.012	0.006	0.003	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/18/01 - 09/24/01	grab	14	0.110	0.388	0.213	0.083	
	08/04/01 - 09/19/01	comp	8	0.076	0.185	0.149	0.037	
Orthophosphate as P (mg/L)	06/18/01 - 09/24/01	grab	7	0.006	0.151	0.074	0.064	
Total Dissolved Phosphorus (mg/L)								
Silica (mg/L)	07/16/01 - 07/16/01	grab	1			13.241		
Major Ions								
Chloride (mg/L)	06/18/01 - 09/24/01	grab	6	48.330	131.120	94.753	26.765	Equal or less than 250 mg/L
Sulfate (mg/L)	07/16/01 - 07/16/01	grab	1			62.190		
Sodium (mg/L)	07/16/01 - 07/16/01	grab	1			55.615		
Potassium (mg/L)	07/16/01 - 07/16/01	grab	1			7.869		
Calcium (mg/L)	07/16/01 - 07/16/01	grab	1			85.045		
Magnesium (mg/L)	07/16/01 - 07/16/01	grab	1			15.342		

Table 15. Water Quality Data Summary at S77 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/18/01 - 0/24/01	grab	11	27.9	36.3	30.3	2.4	
Specific Conductivity (µmhos/cm)	06/18/01 - 0/24/01	grab	11	247	694	578	166	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/18/01 - 0/24/01	grab	10	1.0	11.8	5.3	3.2	Not less than 5.0 mg/L
Water pH (units)	06/18/01 - 0/24/01	grab	11	6.6	8.5	7.5	0.5	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/18/01 - 0/24/01	grab	11	1.6	9.1	3.7	2.4	Less than or equal to 29 NTU above background
Color (PCU)	06/18/01 - 0/24/01	grab	11	73	532	167	138	
Total Suspended Solids (mg/L)	06/18/01 - 0/24/01	grab	11	2.0	19.2	7.4	5.7	
Total Dissolved Solids (mg/L)	06/18/01 - 0/24/01	grab	1			383.0		
Hardness (mg/L as CaCO3)	06/18/01 - 0/24/01	grab	2	238.2	242.7	240.4		
Alkalinity (mg/L as CaCO3)	06/18/01 - 0/24/01	grab	11	42.8	204.6	165.1	57.3	
Nutrients								
Total Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	15	1.7	2.9	2.0	0.4	
Total Kjeldahl Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	15	1.5	2.6	1.9	0.3	
Nitrate+Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	15	<0.004	0.577	0.115	0.162	
Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	11	<0.004	0.089	0.018	0.025	
Nitrate as N(mg/L)	06/18/01 - 09/24/01	grab	8	<0.004	0.488	0.110	0.163	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/18/01 - 09/24/01	grab	15	<0.009	1.013	0.169	0.253	
Un-ionized Ammonia as NH_3 (mg/L)	06/18/01 - 09/24/01	grab	11	0.000	0.006	0.002	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/18/01 - 09/24/01	grab	15	0.105	0.268	0.185	0.054	
Orthophosphate as P (mg/L)	06/18/01 - 09/24/01	grab	11	0.011	0.207	0.096	0.070	
Silica (mg/L)	06/18/01 - 09/24/01	grab	1			11.582		
Major Ions								
Chloride (mg/L)	06/18/01 - 09/24/01	grab	11	28.730	75.350	58.413	14.317	Equal or less than 250 mg/L
Sulfate (mg/L)	07/16/01 - 07/16/01	grab	1			32.170		
Sodium (mg/L)	07/16/01 - 07/16/01	grab	2	34.598	35.641	35.119		
Potassium (mg/L)	07/16/01 - 07/16/01	grab	2	6.655	6.976	6.816		
Calcium (mg/L)	07/16/01 - 07/16/01	grab	2	79.198	80.018	79.608		
Magnesium (mg/L)	07/16/01 - 07/16/01	grab	2	9.811	10.414	10.112		
Trace Metals								
Total Arsenic (µg/L)	07/05/01 - 07/05/01	grab	1			2.2		Less than or equal to 50 µg/L
Total Cadmium (µg/L)	07/05/01 - 07/05/01	grab	1			<0.3		Less than or equal to calculated value
Total Copper (µg/L)	07/05/01 - 07/05/01	grab	1			1.5		Less than or equal to calculated value
Total Iron (µg/L)	07/05/01 - 07/05/01	grab	1			70.4		Less than or equal to 300 µg/L
Total Lead (µg/L)	07/05/01 - 07/05/01	grab	1			<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	07/05/01 - 07/05/01	grab	1			<4		Less than or equal to calculated value

Table 16. Water Quality Data Summary at S308 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/18/01 - 09/24/01	grab	11	26.8	30.8	29.0	1.2	
Specific Conductivity (µmhos/cm)	06/18/01 - 09/24/01	grab	11	516	849	686	114	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/18/01 - 09/24/01	grab	11	0.3	4.8	3.5	1.2	Not less than 5.0 mg/L
Water pH (units)	06/18/01 - 09/24/01	grab	11	6.9	7.6	7.2	0.2	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/18/01 - 09/24/01	grab	11	2.5	19.0	8.8	5.9	Less than or equal to 29 NTU above background
Color (PCU)	06/18/01 - 09/24/01	grab	11	40	218	111	51	
Total Suspended Solids (mg/L)	06/18/01 - 09/24/01	grab	11	1.2	23.6	10.7	8.2	
Total Dissolved Solids (mg/L)	07/16/01 - 08/28/01	grab	2	418.0	478.0	448.0		
Hardness (mg/L as CaCO3)	07/05/01 - 07/16/01	grab	2	250.0	265.2	257.6		
Alkalinity (mg/L as CaCO3)	06/18/01 - 09/24/01	grab	11	114.5	190.9	156.3	27.7	
Nutrients								
Total Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	15	1.4	4.3	1.9	0.7	
Total Kjeldahl Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	15	1.3	4.1	1.7	0.7	
Total Dissolved Kjeldahl Nitrogen (mg/L)	08/28/01 - 08/28/01	grab	1			1.2		
Nitrate+Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	15	0.074	0.405	0.215	0.086	
Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	11	0.008	0.052	0.031	0.014	
Nitrate as N(mg/L)	06/18/01 - 09/24/01	grab	11	0.059	0.353	0.180	0.082	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/18/01 - 09/24/01	grab	15	0.170	0.321	0.235	0.048	
Un-ionized Ammonia as NH_3 (mg/L)	06/18/01 - 09/24/01	grab	11	0.001	0.007	0.003	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/18/01 - 09/24/01	grab	15	0.196	0.740	0.325	0.136	
Orthophosphate as P (mg/L)	06/18/01 - 09/24/01	grab	11	0.119	0.406	0.219	0.078	
Total Dissolved Phosphorus (mg/L)	08/28/01 - 08/28/01	grab	1			0.259		
Silica (mg/L)	07/16/01 - 08/28/01	grab	2	10.654	11.515	11.085		
Major Ions								
Chloride (mg/L)	06/18/01 - 09/24/01	grab	11	60.430	104.860	82.132	14.488	Equal or less than 250 mg/L
Sulfate (mg/L)	07/16/01 - 08/28/01	grab	2	47.230	59.200	53.215		
Sodium (mg/L)	07/05/01 - 07/16/01	grab	2	50.912	61.473	56.192		
Potassium (mg/L)	07/05/01 - 07/16/01	grab	2	6.981	9.310	8.146		
Calcium (mg/L)	07/05/01 - 07/16/01	grab	2	81.290	86.101	83.695		
Magnesium (mg/L)	07/05/01 - 07/16/01	grab	2	11.424	12.192	11.808		
Trace Metals								
Total Arsenic (µg/L)	07/05/01 - 07/05/01	grab	1			1.9		Less than or equal to 50 µg/L
Total Cadmium (µg/L)	07/05/01 - 07/05/01	grab	1			<0.3		Less than or equal to calculated value
Total Copper (µg/L)	07/05/01 - 07/05/01	grab	1			4.6		Less than or equal to calculated value
Total Iron (µg/L)	07/05/01 - 07/05/01	grab	1			694.8		Less than or equal to 300 µg/L
Total Lead (µg/L)	07/05/01 - 07/05/01	grab	1			<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	07/05/01 - 07/05/01	grab	1			<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	08/28/01 - 08/28/01	grab	1			7.2		
Chlorophyll a2 (µg/L)	08/28/01 - 08/28/01	grab	1			5.8		
Chlorophyll b (µg/L)	08/28/01 - 08/28/01	grab	1			<1		
Chlorophyll c (µg/L)	08/28/01 - 08/28/01	grab	1			<1		
Pheophytin a (µg/L)	08/28/01 - 08/28/01	grab	1			2.2		
Carotenoid (µg/L)	08/28/01 - 08/28/01	grab	1			3.4		
Total Organic Carbon (mg/L)	08/28/01 - 08/28/01	grab	1			21.1		
Dissolved Organic Carbon (mg/L)	08/28/01 - 08/28/01	grab	1			21.6		

Table 17. Water Quality Data Summary at C-10A at L8 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/18/01 - 09/24/01	grab	10	27.7	30.6	29.3	1.0	
Specific Conductivity (µmhos/cm)	06/18/01 - 09/24/01	grab	10	510	968	680	142	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/18/01 - 09/24/01	grab	10	1.5	4.5	2.7	1.0	Not less than 5.0 mg/L
Water pH (units)	06/18/01 - 09/24/01	grab	10	7.0	7.6	7.2	0.2	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/18/01 - 09/24/01	grab	10	3.3	46.2	14.1	13.6	Less than or equal to 29 NTU above background
Color (PCU)	06/18/01 - 09/24/01	grab	10	38	255	127	80	
Total Suspended Solids (mg/L)	06/18/01 - 09/24/01	grab	10	4.6	97.0	27.5	29.0	
Total Dissolved Solids (mg/L)	07/16/01 - 07/16/01	grab	1			519.0		
Hardness (mg/L as CaCO3)	07/05/01 - 07/16/01	grab	2	199.5	275.3	237.4		
Alkalinity (mg/L as CaCO3)	06/18/01 - 09/24/01	grab	10	143.1	205.2	172.6	22.4	
Nutrients								
Total Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	14	1.0	3.6	2.0	0.7	
Total Kjeldahl Nitrogen (mg/L)	06/18/01 - 09/24/01	grab	14	0.9	2.7	1.9	0.6	
Nitrate+Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	14	0.010	0.881	0.151	0.227	
Nitrite as N (mg/L)	06/18/01 - 09/24/01	grab	10	<0.004	0.043	0.014	0.012	
Nitrate as N(mg/L)	07/02/01 - 09/24/01	grab	9	0.045	0.325	0.105	0.085	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/18/01 - 09/24/01	grab	14	0.041	0.415	0.144	0.100	
Un-ionized Ammonia as NH_3 (mg/L)	06/18/01 - 09/24/01	grab	10	0.001	0.003	0.002	0.001	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/18/01 - 09/24/01	grab	14	0.042	0.170	0.098	0.038	
Orthophosphate as P (mg/L)	06/18/01 - 09/24/01	grab	10	0.012	0.052	0.032	0.013	
Silica (mg/L)	07/16/01 - 07/16/01	grab	1			14.764		
Major Ions								
Chloride (mg/L)	06/18/01 - 09/24/01	grab	10	51.520	143.320	84.813	28.484	Equal or less than 250 mg/L
Sulfate (mg/L)	07/16/01 - 07/16/01	grab	1			43.360		
Sodium (mg/L)	07/05/01 - 07/16/01	grab	2	37.075	77.381	57.228		
Potassium (mg/L)	07/05/01 - 07/16/01	grab	2	1.729	4.687	3.208		
Calcium (mg/L)	07/05/01 - 07/16/01	grab	2	71.716	90.385	81.051		
Magnesium (mg/L)	07/05/01 - 07/16/01	grab	2	4.951	12.047	8.499		
Trace Metals								
Total Arsenic (µg/L)	07/05/01 - 07/05/01	grab	1			1.6		Less than or equal to 50 µg/L
Total Cadmium (µg/L)	07/05/01 - 07/05/01	grab	1			<0.3		Less than or equal to calculated value
Total Copper (µg/L)	07/05/01 - 07/05/01	grab	1			<1.2		Less than or equal to calculated value
Total Iron (µg/L)	07/05/01 - 07/05/01	grab	1			650.7		Less than or equal to 300 µg/L
Total Lead (µg/L)	07/05/01 - 07/05/01	grab	1			<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	07/05/01 - 07/05/01	grab	1			<4		Less than or equal to calculated value

Table 18. Water Quality Data Summary at S-352 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/05/01 - 09/24/01	grab	15	25.4	32.2	29.2	1.6	
Specific Conductivity (µmhos/cm)	06/05/01 - 09/24/01	grab	15	631	1851	946	436	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/05/01 - 09/24/01	grab	14	0.5	12.9	4.9	3.0	Not less than 5.0 mg/L
Water pH (units)	06/05/01 - 09/24/01	grab	15	6.8	8.3	7.7	0.4	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/05/01 - 09/24/01	grab	11	6.8	42.6	21.4	15.5	Less than or equal to 29 NTU above background
Color (PCU)	06/05/01 - 09/24/01	grab	11	23	145	63	44	
Total Suspended Solids (mg/L)	06/05/01 - 09/24/01	grab	11	7.2	53.0	26.8	16.7	
Total Dissolved Solids (mg/L)	06/05/01 - 07/31/01	grab	5	386.0	552.0	426.8	70.8	
Hardness (mg/L as CaCO3)	06/05/01 - 07/31/01	grab	5	186.9	244.9	203.9	23.7	
Alkalinity (mg/L as CaCO3)	06/05/01 - 09/24/01	grab	11	125.0	318.9	178.2	64.5	
Nutrients								
Total Nitrogen (mg/L)	06/05/01 - 09/24/01	grab	20	1.4	7.5	3.0	1.8	
Total Kjeldahl Nitrogen (mg/L)	06/05/01 - 09/24/01	grab	20	1.3	5.9	2.7	1.4	
Nitrate+Nitrite as N (mg/L)	06/05/01 - 09/24/01	grab	20	0.007	1.598	0.332	0.496	
Nitrite as N (mg/L)	06/05/01 - 09/24/01	grab	12	<0.004	0.303	0.055	0.093	
Nitrate as N(mg/L)	06/05/01 - 09/24/01	grab	8	0.006	1.295	0.371	0.463	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/05/01 - 09/24/01	grab	20	<0.009	2.000	0.371	0.642	
Un-ionized Ammonia as NH_3 (mg/L)	06/05/01 - 09/24/01	grab	16	0.001	0.042	0.007	0.011	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/05/01 - 09/24/01	grab	20	0.104	0.421	0.184	0.071	
Orthophosphate as P (mg/L)	06/05/01 - 09/24/01	grab	12	0.008	0.163	0.060	0.044	
Silica (mg/L)	06/05/01 - 09/24/01	grab	5	8.387	16.529	10.486	3.402	
Major Ions								
Chloride (mg/L)	06/05/01 - 09/24/01	grab	11	80.740	271.280	120.051	58.907	Equal or less than 250 mg/L
Sulfate (mg/L)	06/05/01 - 07/31/01	grab	5	47.350	79.170	57.298	12.679	
Sodium (mg/L)	06/05/01 - 07/31/01	grab	5	49.557	92.043	59.560	18.255	
Potassium (mg/L)	06/05/01 - 07/31/01	grab	5	6.442	8.233	7.048	0.699	
Calcium (mg/L)	06/05/01 - 07/31/01	grab	5	48.354	60.439	53.349	4.412	
Magnesium (mg/L)	06/05/01 - 07/31/01	grab	5	13.936	22.817	17.172	3.391	
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/05/01 - 06/19/01	grab	2	21.0	26.3	23.7		
Chlorophyll a2 (µg/L)	06/05/01 - 06/19/01	grab	2	16.0	22.3	19.2		
Chlorophyll b (µg/L)	06/05/01 - 06/19/01	grab	2	<1	1.1	<1		
Chlorophyll c (µg/L)	06/05/01 - 06/19/01	grab	2	<1	<1	<1		
Pheophytin a (µg/L)	06/05/01 - 06/19/01	grab	2	5.0	7.8	6.4		
Carotenoid (µg/L)	06/05/01 - 06/19/01	grab	2	11.4	12.0	11.7		
Total Organic Carbon (mg/L)	06/05/01 - 07/31/01	grab	3	15.7	18.0	16.7	1.2	
Dissolved Organic Carbon (mg/L)	06/05/01 - 07/31/01	grab	4	15.5	17.2	16.4	0.7	

Table 19. Water Quality Data Summary at S2DOWN for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/04/01 - 08/30/01	grab	11	25.5	31.0	28.3	1.7	
Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	786	1161	986	107	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	1.4	4.7	2.9	1.1	Not less than 5.0 mg/L
Water pH (units)	06/04/01 - 08/30/01	grab	11	7.0	7.5	7.1	0.2	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	3.2	17.3	10.1	3.8	Less than or equal to 29 NTU above background
Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	10	0.4	0.8	0.6	0.1	
Color (PCU)	06/04/01 - 08/30/01	grab	11	96	163	119	22	
Total Suspended Solids (mg/L)	06/04/01 - 08/30/01	grab	11	4.0	19.2	12.3	4.9	
Total Dissolved Solids (mg/L)	06/04/01 - 08/30/01	grab	11	491.0	759.0	628.7	78.0	
Hardness (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	13	297.6	432.1	366.2	37.2	
Alkalinity (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	11	207.4	330.5	275.1	40.6	
Nutrients								
Total Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	2.0	5.0	3.5	1.0	
Total Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	2.0	3.5	2.7	0.4	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.8	3.2	2.3	0.4	
Nitrate+Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.054	1.650	0.876	0.598	
Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.008	0.095	0.060	0.033	
Nitrate as N(mg/L)	06/04/01 - 08/30/01	grab	11	0.046	1.563	0.816	0.567	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.024	0.620	0.255	0.187	
Un-ionized Ammonia as NH_3 (mg/L)	06/04/01 - 08/30/01	grab	11	0.001	0.005	0.003	0.001	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.039	0.120	0.090	0.027	
Orthophosphate as P (mg/L)	06/04/01 - 08/30/01	grab	11	0.006	0.065	0.042	0.021	
Total Dissolved Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.012	0.074	0.047	0.022	
Silica (mg/L)	06/04/01 - 08/30/01	grab	11	9.509	21.283	14.805	3.866	
Major Ions								
Chloride (mg/L)	06/04/01 - 08/30/01	grab	11	92.740	127.460	103.497	9.546	Equal or less than 250 mg/L
Sulfate (mg/L)	06/04/01 - 08/30/01	grab	11	20.700	105.410	65.976	24.214	
Sodium (mg/L)	06/04/01 - 08/30/01	grab	13	51.280	85.757	64.597	9.610	
Potassium (mg/L)	06/04/01 - 08/30/01	grab	13	6.778	9.196	7.785	0.793	
Calcium (mg/L)	06/04/01 - 08/30/01	grab	13	79.252	115.018	101.100	9.421	
Magnesium (mg/L)	06/04/01 - 08/30/01	grab	13	20.648	35.175	28.281	3.912	
Trace Metals								
Total Arsenic (µg/L)	07/18/01 - 08/02/01	grab	5	4.4	5.4	4.9	0.4	Less than or equal to 50 µg/L
Total Cadmium (µg/L)	07/18/01 - 08/02/01	grab	5	<0.3	<0.3	<0.3		Less than or equal to calculated value
Total Copper (µg/L)	07/18/01 - 08/02/01	grab	5	2.0	3.1	2.7	0.4	Less than or equal to calculated value
Total Iron (µg/L)	07/18/01 - 08/02/01	grab	5	149.5	322.1	225.5	81.3	Less than or equal to 300 µg/L
Total Lead (µg/L)	07/18/01 - 08/02/01	grab	5	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	07/18/01 - 08/02/01	grab	5	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/04/01 - 08/30/01	grab	11	4.8	139.2	31.1	37.9	
Chlorophyll a2 (µg/L)	06/04/01 - 08/30/01	grab	10	3.5	125.4	25.0	36.7	
Chlorophyll b (µg/L)	06/04/01 - 08/30/01	grab	11	<1	3.7	1.1	1.0	
Chlorophyll c (µg/L)	06/04/01 - 08/30/01	grab	11	<1	10.2	2.7	3.0	
Pheophytin a (µg/L)	06/04/01 - 08/30/01	grab	11	2.0	14.3	8.0	4.0	
Carotenoid (µg/L)	06/04/01 - 08/30/01	grab	11	2.3	44.0	12.1	11.4	
Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	29.5	40.7	34.9	4.2	
Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	30.1	42.6	35.3	4.9	

Table 20. Water Quality Data Summary at S3DOWN for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/04/01 - 08/30/01	grab	11	26.1	33.2	29.3	2.0	
Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	668	981	867	103	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	2.4	8.8	4.2	1.8	Not less than 5.0 mg/L
Water pH (units)	06/04/01 - 08/30/01	grab	11	7.0	8.0	7.3	0.3	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	5.3	10.7	7.1	1.6	Less than or equal to 29 NTU above background
Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	10	0.6	0.9	0.7	0.1	
Color (PCU)	06/04/01 - 08/30/01	grab	11	31	148	115	34	
Total Suspended Solids (mg/L)	06/04/01 - 08/30/01	grab	10	4.8	14.8	9.2	2.9	
Total Dissolved Solids (mg/L)	06/04/01 - 08/30/01	grab	11	408.0	663.0	560.4	75.8	
Hardness (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	12	186.3	374.8	320.7	52.8	
Alkalinity (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	11	124.5	274.2	231.7	42.5	
Nutrients								
Total Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.8	5.1	3.3	1.0	
Total Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.7	3.3	2.5	0.4	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.3	2.8	2.1	0.4	
Nitrate+Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.091	1.918	0.751	0.700	
Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.018	0.085	0.043	0.023	
Nitrate as N(mg/L)	06/04/01 - 08/30/01	grab	11	0.052	1.833	0.708	0.680	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.031	0.318	0.132	0.097	
Un-ionized Ammonia as NH_3 (mg/L)	06/04/01 - 08/30/01	grab	11	0.000	0.004	0.002	0.001	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.042	0.121	0.066	0.022	
Orthophosphate as P (mg/L)	06/04/01 - 08/30/01	grab	10	0.006	0.043	0.021	0.015	
Total Dissolved Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.012	0.050	0.026	0.015	
Silica (mg/L)	06/04/01 - 08/30/01	grab	11	6.773	12.559	9.598	1.871	
Major Ions								
Chloride (mg/L)	06/04/01 - 08/30/01	grab	11	74.760	110.540	94.734	9.969	Equal or less than 250 mg/L
Sulfate (mg/L)	06/04/01 - 08/30/01	grab	11	27.770	77.380	58.221	14.480	
Sodium (mg/L)	06/04/01 - 08/30/01	grab	12	48.690	64.542	56.653	5.343	
Potassium (mg/L)	06/04/01 - 08/30/01	grab	12	5.069	7.442	6.687	0.744	
Calcium (mg/L)	06/04/01 - 08/30/01	grab	12	46.598	112.413	97.916	18.213	
Magnesium (mg/L)	06/04/01 - 08/30/01	grab	12	12.915	22.890	18.746	3.098	
Trace Metals								
Total Arsenic (µg/L)	06/04/01 - 08/30/01	grab	4	3.3	5.0	4.3	0.8	Less than or equal to 50 µg/L
Total Cadmium (µg/L)	06/04/01 - 08/30/01	grab	4	<0.3	<0.3	<0.3		Less than or equal to calculated value
Total Copper (µg/L)	06/04/01 - 08/30/01	grab	4	2.5	3.4	2.9	0.4	Less than or equal to calculated value
Total Iron (µg/L)	06/04/01 - 08/30/01	grab	4	175.6	476.3	287.2	137.4	Less than or equal to 300 µg/L
Total Lead (µg/L)	06/04/01 - 08/30/01	grab	4	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	06/04/01 - 08/30/01	grab	4	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/04/01 - 08/30/01	grab	11	7.8	133.4	35.2	37.8	
Chlorophyll a2 (µg/L)	06/04/01 - 08/30/01	grab	11	5.3	116.3	29.8	34.0	
Chlorophyll b (µg/L)	06/04/01 - 08/30/01	grab	11	<1	4.8	1.2	1.3	
Chlorophyll c (µg/L)	06/04/01 - 08/30/01	grab	11	<1	13.8	3.4	3.8	
Pheophytin a (µg/L)	06/04/01 - 08/30/01	grab	11	3.4	21.7	7.1	5.1	
Carotenoid (µg/L)	06/04/01 - 08/30/01	grab	11	4.4	48.2	14.0	12.9	
Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	21.9	42.1	34.4	5.3	
Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	18.3	41.6	33.9	6.3	

Table 21a. Water Quality Data Summary at CUT1 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/04/01 - 08/30/01	grab	11	27.1	33.1	29.6	1.7	
Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	657	1112	864	137	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	3.0	8.4	5.2	1.8	Not less than 5.0 mg/L
Water pH (units)	06/04/01 - 08/30/01	grab	11	7.2	8.2	7.4	0.3	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	2.8	11.1	6.4	2.6	Less than or equal to 29 NTU above background
Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	9	0.4	1.0	0.6	0.2	
Color (PCU)	06/04/01 - 08/30/01	grab	11	32	177	107	42	
Total Suspended Solids (mg/L)	06/04/01 - 08/30/01	grab	11	4.4	18.4	8.4	4.3	
Total Dissolved Solids (mg/L)	06/04/01 - 08/30/01	grab	11	425.0	704.0	552.5	88.4	
Hardness (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	12	194.3	381.3	302.6	56.1	
Alkalinity (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	11	125.6	274.6	220.0	48.5	
Nutrients								
Total Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.8	4.3	2.9	0.7	
Total Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.7	3.0	2.4	0.4	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.3	2.9	2.0	0.4	
Nitrate+Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.028	1.282	0.516	0.432	
Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.007	0.108	0.043	0.029	
Nitrate as N(mg/L)	06/04/01 - 08/30/01	grab	11	0.021	1.174	0.474	0.407	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.011	0.405	0.167	0.124	
Un-ionized Ammonia as NH_3 (mg/L)	06/04/01 - 08/30/01	grab	11	0.001	0.014	0.004	0.004	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.045	0.196	0.083	0.043	
Orthophosphate as P (mg/L)	06/04/01 - 08/30/01	grab	10	0.005	0.040	0.019	0.013	
Total Dissolved Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.013	0.051	0.027	0.012	
Silica (mg/L)	06/04/01 - 08/30/01	grab	11	6.395	14.979	10.809	2.857	
Major Ions								
Chloride (mg/L)	06/04/01 - 08/30/01	grab	11	69.590	122.810	98.039	13.881	Equal or less than 250 mg/L
Sulfate (mg/L)	06/04/01 - 08/30/01	grab	11	41.270	92.910	60.647	15.599	
Sodium (mg/L)	06/04/01 - 08/30/01	grab	12	39.017	83.865	61.289	11.664	
Potassium (mg/L)	06/04/01 - 08/30/01	grab	12	5.490	8.507	7.054	0.967	
Calcium (mg/L)	06/04/01 - 08/30/01	grab	12	48.495	113.773	91.276	18.833	
Magnesium (mg/L)	06/04/01 - 08/30/01	grab	12	12.064	24.551	18.247	3.822	
Trace Metals								
Total Arsenic (µg/L)	06/04/01 - 08/30/01	grab	4	3.1	5.7	4.2	1.1	Less than or equal to 50 µg/L
Total Cadmium (µg/L)	06/04/01 - 08/30/01	grab	4	<0.3	<0.3	<0.3		Less than or equal to calculated value
Total Copper (µg/L)	06/04/01 - 08/30/01	grab	4	1.9	2.7	2.3	0.3	Less than or equal to calculated value
Total Iron (µg/L)	06/04/01 - 08/30/01	grab	4	76.3	216.6	144.6	57.3	Less than or equal to 300 µg/L
Total Lead (µg/L)	06/04/01 - 08/30/01	grab	4	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	06/04/01 - 08/30/01	grab	4	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/04/01 - 08/30/01	grab	11	11.8	167.7	44.2	44.1	
Chlorophyll a2 (µg/L)	06/04/01 - 08/30/01	grab	11	10.2	149.6	36.9	39.9	
Chlorophyll b (µg/L)	06/04/01 - 08/30/01	grab	11	<1	4.4	1.6	1.4	
Chlorophyll c (µg/L)	06/04/01 - 08/30/01	grab	11	<1	13.6	3.6	3.7	
Pheophytin a (µg/L)	06/04/01 - 08/30/01	grab	11	2.1	20.2	9.9	5.6	
Carotenoid (µg/L)	06/04/01 - 08/30/01	grab	11	5.0	56.8	16.4	14.3	
Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	21.1	39.4	32.8	6.5	
Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	19.7	39.6	32.3	6.9	

Table 21b. Water Quality Data Summary at CUT2 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	07/28/01 - 08/30/01	grab	3	31.8	33.6	32.6	0.9	
Specific Conductivity (µmhos/cm)	07/28/01 - 08/30/01	grab	3	805	1082	920	145	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	07/28/01 - 08/30/01	grab	3	0.3	6.2	3.7	3.1	Not less than 5.0 mg/L
Water pH (units)	07/28/01 - 08/30/01	grab	3	7.1	7.9	7.4	0.4	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	07/28/01 - 08/30/01	grab	3	3.5	6.7	5.3	1.7	Less than or equal to 29 NTU above background
Secchi Disk Depth, meters	08/17/01 - 08/30/01	grab	2	0.6	0.7	0.7		
Color (PCU)	07/28/01 - 08/30/01	grab	3	118	149	138	17	
Total Suspended Solids (mg/L)	07/28/01 - 08/30/01	grab	3	4.0	7.4	5.6	1.7	
Total Dissolved Solids (mg/L)	07/28/01 - 08/30/01	grab	3	527.0	676.0	594.3	75.5	
Hardness (mg/L as CaCO3)	07/28/01 - 07/28/01	grab	1			310.9		
Alkalinity (mg/L as CaCO3)	07/28/01 - 08/30/01	grab	3	217.7	303.6	251.0	46.1	
Nutrients								
Total Nitrogen (mg/L)	07/28/01 - 08/30/01	grab	3	2.6	3.2	2.8	0.4	
Total Kjeldahl Nitrogen (mg/L)	07/28/01 - 08/30/01	grab	3	2.3	2.5	2.5	0.1	
Total Dissolved Kjeldahl Nitrogen (mg/L)	07/28/01 - 08/30/01	grab	3	1.9	2.2	2.1	0.2	
Nitrate+Nitrite as N (mg/L)	07/28/01 - 08/30/01	grab	3	0.077	0.910	0.380	0.461	
Nitrite as N (mg/L)	07/28/01 - 08/30/01	grab	3	0.017	0.043	0.030	0.013	
Nitrate as N(mg/L)	07/28/01 - 08/30/01	grab	3	0.060	0.867	0.350	0.449	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	07/28/01 - 08/30/01	grab	3	0.018	0.082	0.047	0.032	
Un-ionized Ammonia as NH_3 (mg/L)	07/28/01 - 08/30/01	grab	3	0.000	0.004	0.002	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	07/28/01 - 08/30/01	grab	3	0.057	0.102	0.077	0.023	
Orthophosphate as P (mg/L)	07/28/01 - 08/30/01	grab	3	0.016	0.023	0.020	0.004	
Total Dissolved Phosphorus (mg/L)	07/28/01 - 08/30/01	grab	3	0.025	0.036	0.031	0.006	
Silica (mg/L)	07/28/01 - 08/30/01	grab	3	8.374	17.172	12.693	4.401	
Major Ions								
Chloride (mg/L)	07/28/01 - 08/30/01	grab	3	92.400	131.320	107.323	20.987	Equal or less than 250 mg/L
Sulfate (mg/L)	07/28/01 - 08/30/01	grab	3	47.770	48.680	48.370	0.520	
Sodium (mg/L)	07/28/01 - 07/28/01	grab	1			59.852		
Potassium (mg/L)	07/28/01 - 07/28/01	grab	1			6.110		
Calcium (mg/L)	07/28/01 - 07/28/01	grab	1			99.425		
Magnesium (mg/L)	07/28/01 - 07/28/01	grab	1			15.222		
Phytoplankton Indicators								
Chlorophyll a (µg/L)	07/28/01 - 08/30/01	grab	3	14.1	55.0	37.4	21.0	
Chlorophyll a2 (µg/L)	07/28/01 - 08/30/01	grab	3	8.3	45.3	29.8	19.2	
Chlorophyll b (µg/L)	07/28/01 - 08/30/01	grab	3	1.7	3.8	2.7	1.1	
Chlorophyll c (µg/L)	07/28/01 - 08/30/01	grab	3	1.4	5.1	2.9	1.9	
Pheophytin a (µg/L)	07/28/01 - 08/30/01	grab	3	9.2	13.5	11.0	2.2	
Carotenoid (µg/L)	07/28/01 - 08/30/01	grab	3	5.9	21.0	14.5	7.8	
Total Organic Carbon (mg/L)	07/28/01 - 08/30/01	grab	3	35.4	42.1	38.3	3.5	
Dissolved Organic Carbon (mg/L)	07/28/01 - 08/30/01	grab	3	34.7	42.8	38.5	4.1	

Table 21c. Water Quality Data Summary at CUT3 for June 1, 2001 through September 21, 2001 .

Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
Physical								
Temperature (°C)	06/04/01 - 08/30/01	grab	11	25.8	32.0	29.7	1.7	
Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	780	1157	960	103	Not greater than 50% above background or 1,275 µmhos/cm
Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	1.4	9.5	5.0	2.6	Not less than 5.0 mg/L
Water pH (units)	06/04/01 - 08/30/01	grab	11	7.0	8.1	7.4	0.4	Not less than 6.0 or greater than 8.5 units
Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	2.9	24.3	14.1	7.0	Less than or equal to 29 NTU above background
Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	10	0.3	0.9	0.5	0.2	
Color (PCU)	06/04/01 - 08/30/01	grab	11	80	144	110	21	
Total Suspended Solids (mg/L)	06/04/01 - 08/30/01	grab	11	2.8	45.0	19.9	13.9	
Total Dissolved Solids (mg/L)	06/04/01 - 08/30/01	grab	11	494.0	776.0	613.8	80.0	
Hardness (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	12	281.7	431.9	344.5	41.7	
Alkalinity (mg/L as CaCO3)	06/04/01 - 08/30/01	grab	11	198.2	318.4	258.7	39.3	
Nutrients								
Total Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	2.0	5.7	3.7	1.1	
Total Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	2.0	3.9	2.9	0.7	
Total Dissolved Kjeldahl Nitrogen (mg/L)	06/04/01 - 08/30/01	grab	11	1.6	2.7	2.2	0.3	
Nitrate+Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.041	1.843	0.788	0.603	
Nitrite as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.011	0.135	0.066	0.044	
Nitrate as N(mg/L)	06/04/01 - 08/30/01	grab	11	0.029	1.747	0.721	0.566	Equal or less than 10 mg/L as N
Ammonium as N (mg/L)	06/04/01 - 08/30/01	grab	11	0.012	0.626	0.181	0.168	
Un-ionized Ammonia as NH_3 (mg/L)	06/04/01 - 08/30/01	grab	11	0.001	0.009	0.003	0.002	Equal or less than 0.02 mg/L as NH_3
Total Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.052	0.366	0.122	0.092	
Orthophosphate as P (mg/L)	06/04/01 - 08/30/01	grab	11	0.006	0.059	0.025	0.018	
Total Dissolved Phosphorus (mg/L)	06/04/01 - 08/30/01	grab	11	0.013	0.067	0.032	0.018	
Silica (mg/L)	06/04/01 - 08/30/01	grab	11	8.730	22.064	13.657	3.875	
Major Ions								
Chloride (mg/L)	06/04/01 - 08/30/01	grab	11	94.040	128.850	104.712	9.659	Equal or less than 250 mg/L
Sulfate (mg/L)	06/04/01 - 08/30/01	grab	11	24.810	108.510	65.387	20.962	
Sodium (mg/L)	06/04/01 - 08/30/01	grab	12	54.029	73.595	63.886	6.087	
Potassium (mg/L)	06/04/01 - 08/30/01	grab	12	6.681	8.494	7.240	0.619	
Calcium (mg/L)	06/04/01 - 08/30/01	grab	12	74.272	114.961	97.111	11.737	
Magnesium (mg/L)	06/04/01 - 08/30/01	grab	12	20.514	35.174	24.831	4.513	
Trace Metals								
Total Arsenic (µg/L)	07/18/01 - 07/30/01	grab	4	4.5	4.9	4.7	0.2	Less than or equal to 50 µg/L
Total Cadmium (µg/L)	07/18/01 - 07/30/01	grab	4	<0.3	<0.3	<0.3		Less than or equal to calculated value
Total Copper (µg/L)	07/18/01 - 07/30/01	grab	4	2.6	3.5	2.9	0.4	Less than or equal to calculated value
Total Iron (µg/L)	07/18/01 - 07/30/01	grab	4	96.3	507.8	236.0	184.5	Less than or equal to 300 µg/L
Total Lead (µg/L)	07/18/01 - 07/30/01	grab	4	<0.8	<0.8	<0.8		Less than or equal to calculated value
Total Zinc (µg/L)	07/18/01 - 07/30/01	grab	4	<4	<4	<4		Less than or equal to calculated value
Phytoplankton Indicators								
Chlorophyll a (µg/L)	06/04/01 - 08/30/01	grab	11	6.9	332.3	83.5	109.9	
Chlorophyll a2 (µg/L)	06/04/01 - 08/30/01	grab	11	5.9	286.8	72.8	98.6	
Chlorophyll b (µg/L)	06/04/01 - 08/30/01	grab	11	<1	5.3	1.9	2.0	
Chlorophyll c (µg/L)	06/04/01 - 08/30/01	grab	11	<1	22.5	6.9	7.5	
Pheophytin a (µg/L)	06/04/01 - 08/30/01	grab	11	1.4	55.0	13.1	14.4	
Carotenoid (µg/L)	06/04/01 - 08/30/01	grab	11	2.8	128.9	32.4	40.4	
Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	28.6	42.0	35.1	4.6	
Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	27.3	42.9	34.4	4.9	

Table 22. Water Quality Data Summary at INT for June 1, 2001 through September 21, 2001 .

Station	Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
BGINT	***Physical***								
	Temperature (°C)	06/04/01 - 08/30/01	grab	11	25.6	31.8	28.5	1.8	
	Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	775	1168	1005	112	Not greater than 50% above background or 1,275 µmhos/cm
	Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	1.3	5.4	3.1	1.2	Not less than 5.0 mg/L
	Water pH (units)	06/04/01 - 08/30/01	grab	11	7.0	7.3	7.1	0.1	Not less than 6.0 or greater than 8.5 units
	Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	10	0.3	0.9	0.6	0.2	
	Color (PCU)	06/04/01 - 08/03/01	grab	9	96	165	125	21	
	Total Dissolved Solids (mg/L)	08/17/01 - 08/30/01	grab	2	492.0	657.0	574.5		
	Major Ions								
	Chloride (mg/L)	08/17/01 - 08/30/01	grab	2	99.010	124.790	111.900		Equal or less than 250 mg/L
	Phytoplankton Indicators								
	Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	30.3	43.5	36.6	4.4	
	Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	30.7	44.2	36.8	4.9	
SBINT	***Physical***								
	Temperature (°C)	06/04/01 - 08/30/01	grab	11	27.3	32.5	29.8	1.4	
	Specific Conductivity (µmhos/cm)	06/04/01 - 08/30/01	grab	11	704	1035	891	110	Not greater than 50% above background or 1,275 µmhos/cm
	Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	1.8	9.0	5.9	2.2	Not less than 5.0 mg/L
	Water pH (units)	06/04/01 - 08/30/01	grab	11	7.1	8.0	7.5	0.3	Not less than 6.0 or greater than 8.5 units
	Secchi Disk Depth	06/10/01 - 08/30/01	grab	10	0.3	0.9	0.6	0.2	
	Color (PCU)	06/04/01 - 08/30/01	grab	9	40	117	94	25	
	Total Dissolved Solids (mg/L)	08/17/01 - 08/30/01	grab	2	492.0	642.0	567.0		
	Major Ions								
	Chloride (mg/L)	08/17/01 - 08/30/01	grab	2	83.370	126.270	104.820		Equal or less than 250 mg/L
	Phytoplankton Indicators								
	Total Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	21.5	40.4	33.6	5.4	
	Dissolved Organic Carbon (mg/L)	06/04/01 - 08/30/01	grab	11	20.5	42.8	33.4	6.5	
PHINT	***Physical***								
	Temperature (°C)	06/10/01 - 08/30/01	grab	10	25.6	33.6	29.5	2.3	
	Specific Conductivity (µmhos/cm)	06/10/01 - 08/30/01	grab	10	602	988	745	110	Not greater than 50% above background or 1,275 µmhos/cm
	Dissolved Oxygen (mg/L)	06/10/01 - 08/30/01	grab	10	4.1	8.3	6.0	1.4	Not less than 5.0 mg/L
	Water pH (units)	06/10/01 - 08/30/01	grab	10	7.5	8.3	7.9	0.3	Not less than 6.0 or greater than 8.5 units
	Color (PCU)	06/10/01 - 08/03/01	grab	8	21	100	45	28	
	Total Dissolved Solids (mg/L)	06/17/08 - 08/30/01	grab	2	418.0	490.0	454.0		
	Major Ions								
	Chloride (mg/L)	06/17/08 - 08/30/01	grab	2	92.260	97.750	95.005		Equal or less than 250 mg/L
	Phytoplankton Indicators								
	Total Organic Carbon (mg/L)	06/10/01 - 08/30/01	grab	10	14.6	33.9	22.0	5.5	
	Dissolved Organic Carbon (mg/L)	06/10/01 - 08/30/01	grab	10	13.8	33.0	21.6	5.6	

Table 23. Water Quality Data Summary at Rim Canals for June 1, 2001 through September 21, 2001 .

Station	Parameters	Period	Sample Type	n	min	max	avg	S.D.	FAC 62-302 Class I Criteria
RC1	*Physical*								
	Temperature (°C)	06/04/01 - 08/30/01	grab	11	26.5	32.2	29.0	1.8	
	Specific Conductivity (μmhos/cm)	06/04/01 - 08/30/01	grab	11	705	1186	994	146	Not greater than 50% above background or 1,275 μmhos/cm
	Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	1.9	6.4	3.9	1.5	Not less than 5.0 mg/L
	Water pH (units)	06/04/01 - 08/30/01	grab	11	7.1	7.8	7.3	0.2	Not less than 6.0 or greater than 8.5 units
	Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	5.6	18.0	10.5	3.1	Less than or equal to 29 NTU above background
	Secchi Disk Depth, meters	06/10/01 - 08/30/01	grab	10	0.4	0.9	0.6	0.2	
	Color (PCU)	06/04/01 - 08/30/01	grab	10	56	154	106	29	
RC3	*Physical*								
	Temperature (°C)	06/04/01 - 08/30/01	grab	11	27.0	31.5	29.6	1.4	
	Specific Conductivity (μmhos/cm)	06/04/01 - 08/30/01	grab	11	708	1062	889	119	Not greater than 50% above background or 1,275 μmhos/cm
	Dissolved Oxygen (mg/L)	06/04/01 - 08/30/01	grab	11	2.9	8.9	6.1	2.3	Not less than 5.0 mg/L
	Water pH (units)	06/04/01 - 08/30/01	grab	11	7.2	8.0	7.5	0.3	Not less than 6.0 or greater than 8.5 units
	Turbidity (NTU)	06/04/01 - 08/30/01	grab	11	5.0	25.1	9.9	6.1	Less than or equal to 29 NTU above background
	Secchi Disk Depth	06/10/01 - 08/30/01	grab	10	0.3	0.8	0.5	0.1	
	Color (PCU)	06/04/01 - 08/30/01	grab	11	42	144	102	32	
RC6	*Physical*								
	Temperature (°C)	06/10/01 - 08/30/01	grab	9	26.8	32.3	29.5	1.9	
	Specific Conductivity (μmhos/cm)	06/10/01 - 08/30/01	grab	9	349	824	613	148	Not greater than 50% above background or 1,275 μmhos/cm
	Dissolved Oxygen (mg/L)	06/10/01 - 08/30/01	grab	9	0.3	7.0	3.1	2.1	Not less than 5.0 mg/L
	Water pH (units)	06/10/01 - 08/30/01	grab	9	6.7	7.4	7.1	0.2	Not less than 6.0 or greater than 8.5 units
	Turbidity (NTU)	06/10/01 - 08/30/01	grab	9	1.6	10.2	6.9	2.7	Less than or equal to 29 NTU above background
	Secchi Disk Depth	06/10/01 - 08/17/01	grab	7	0.2	0.8	0.5	0.2	
	Color (PCU)	06/10/01 - 08/30/01	grab	9	82	556	209	178	
RC29	*Physical*								
	Temperature (°C)	0604/01 - 08/30/01	grab	11	26.0	32.3	28.6	1.8	
	Specific Conductivity (μmhos/cm)	0604/01 - 08/30/01	grab	11	790	1145	1019	108	Not greater than 50% above background or 1,275 μmhos/cm
	Dissolved Oxygen (mg/L)	0604/01 - 08/30/01	grab	11	2.2	6.6	3.4	1.3	Not less than 5.0 mg/L
	Water pH (units)	0604/01 - 08/30/01	grab	11	7.0	7.6	7.2	0.2	Not less than 6.0 or greater than 8.5 units
	Turbidity (NTU)	0604/01 - 08/30/01	grab	11	4.0	16.4	8.5	3.2	Less than or equal to 29 NTU above background
	Secchi Disk Depth	06/10/01 - 08/30/01	grab	10	0.3	0.8	0.6	0.1	
	Color (PCU)	0604/01 - 08/30/01	grab	11	92	160	123	21	

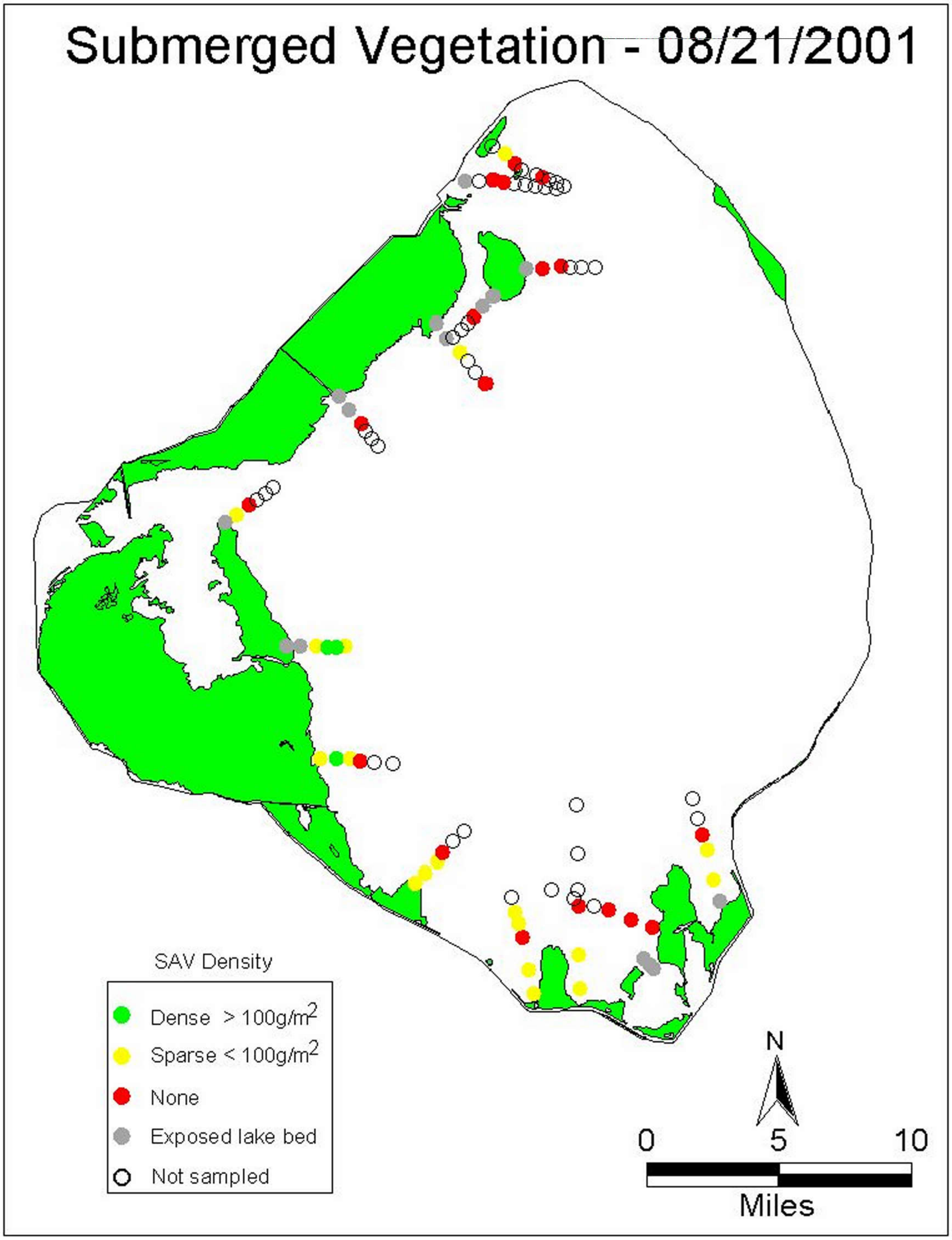

Submerged Vegetation - 08/21/2001
SAV Density
Dense > 100g/m2
Sparse < 100g/m2
None
Exposed lake bed
Not sampled
N
0 5 10
Miles

Figure B1.

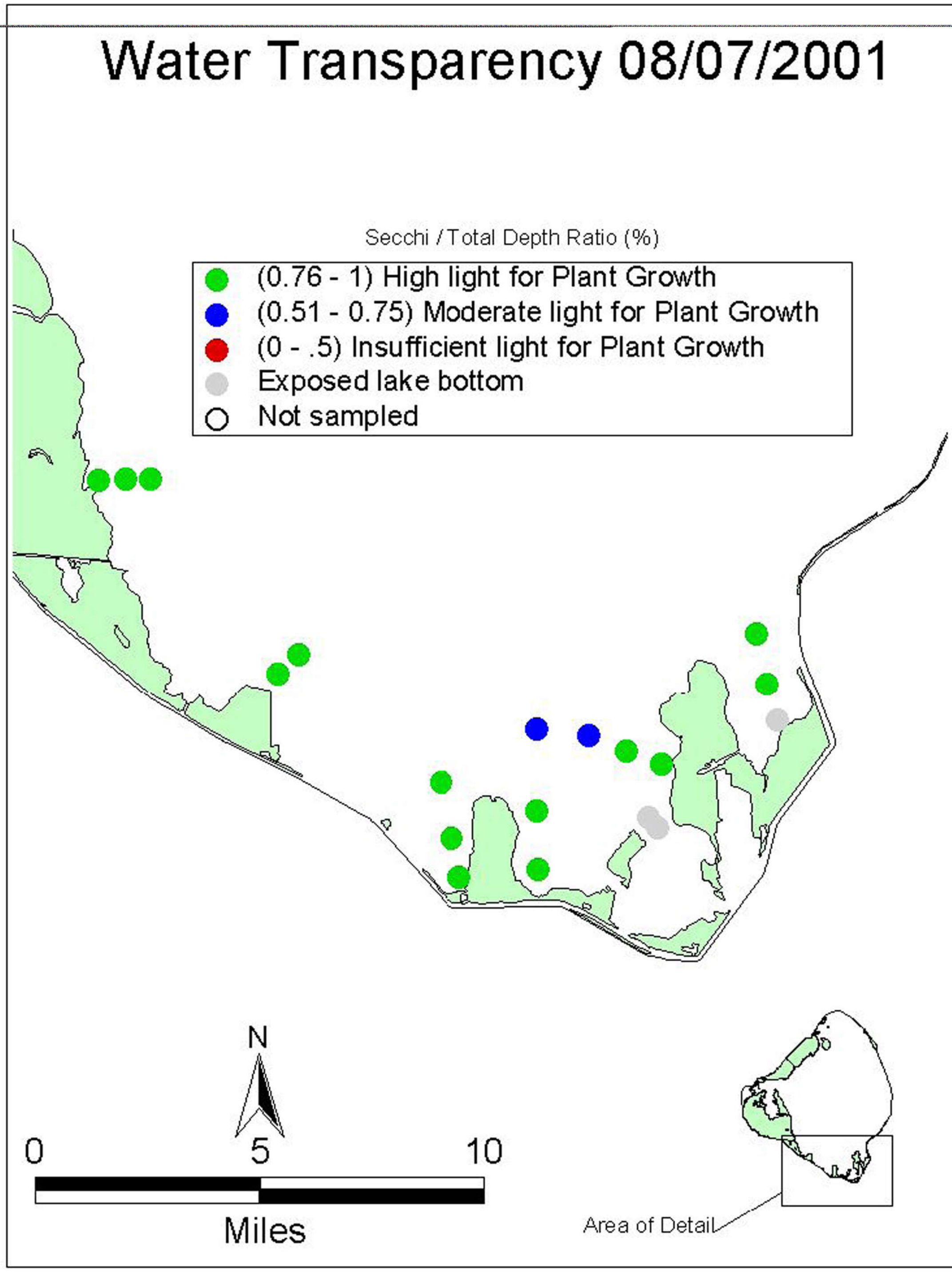

Water Transparency 08/07/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B2.

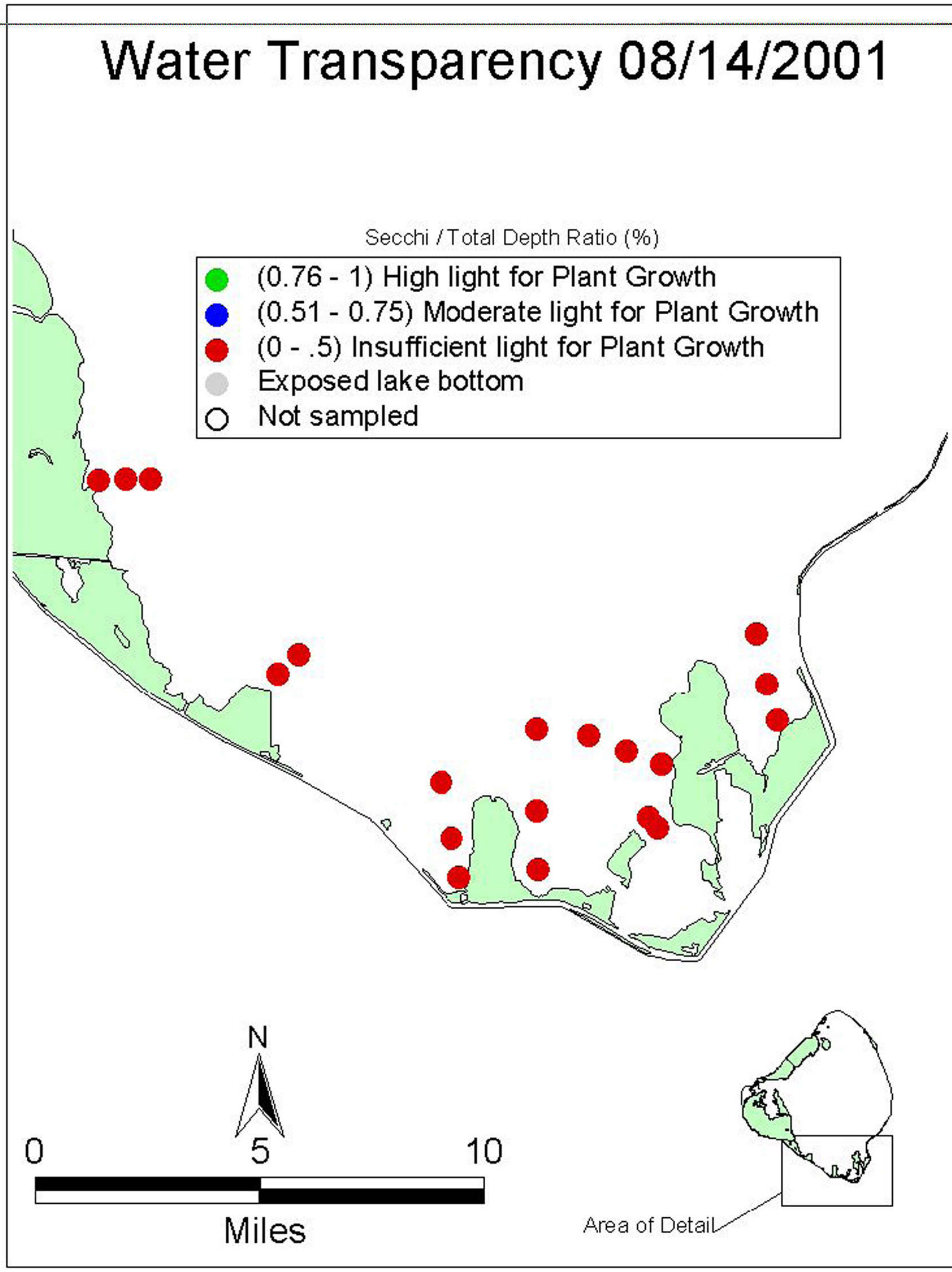

Water Transparency 08/14/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B3.

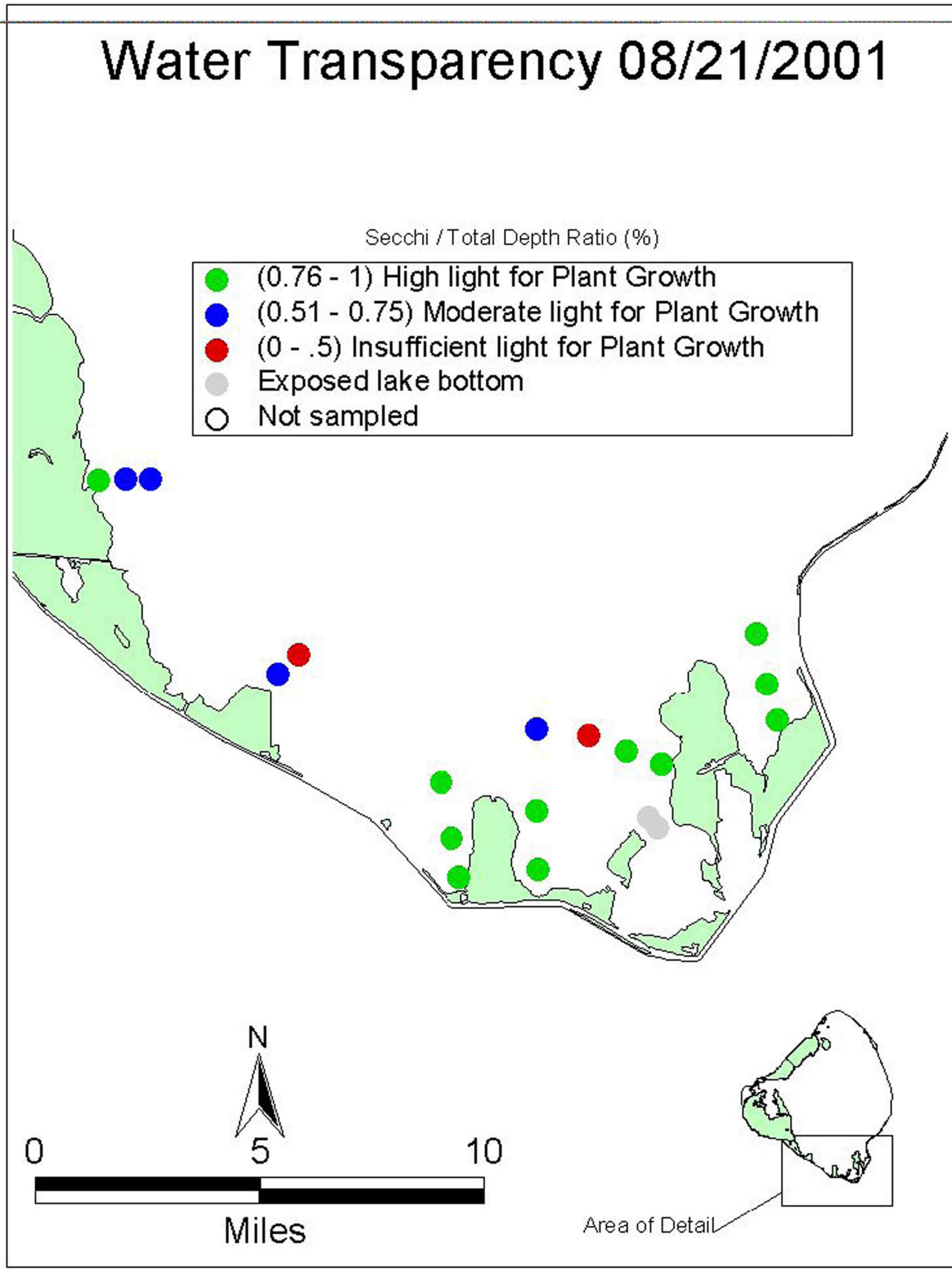

Water Transparency 08/21/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B4.

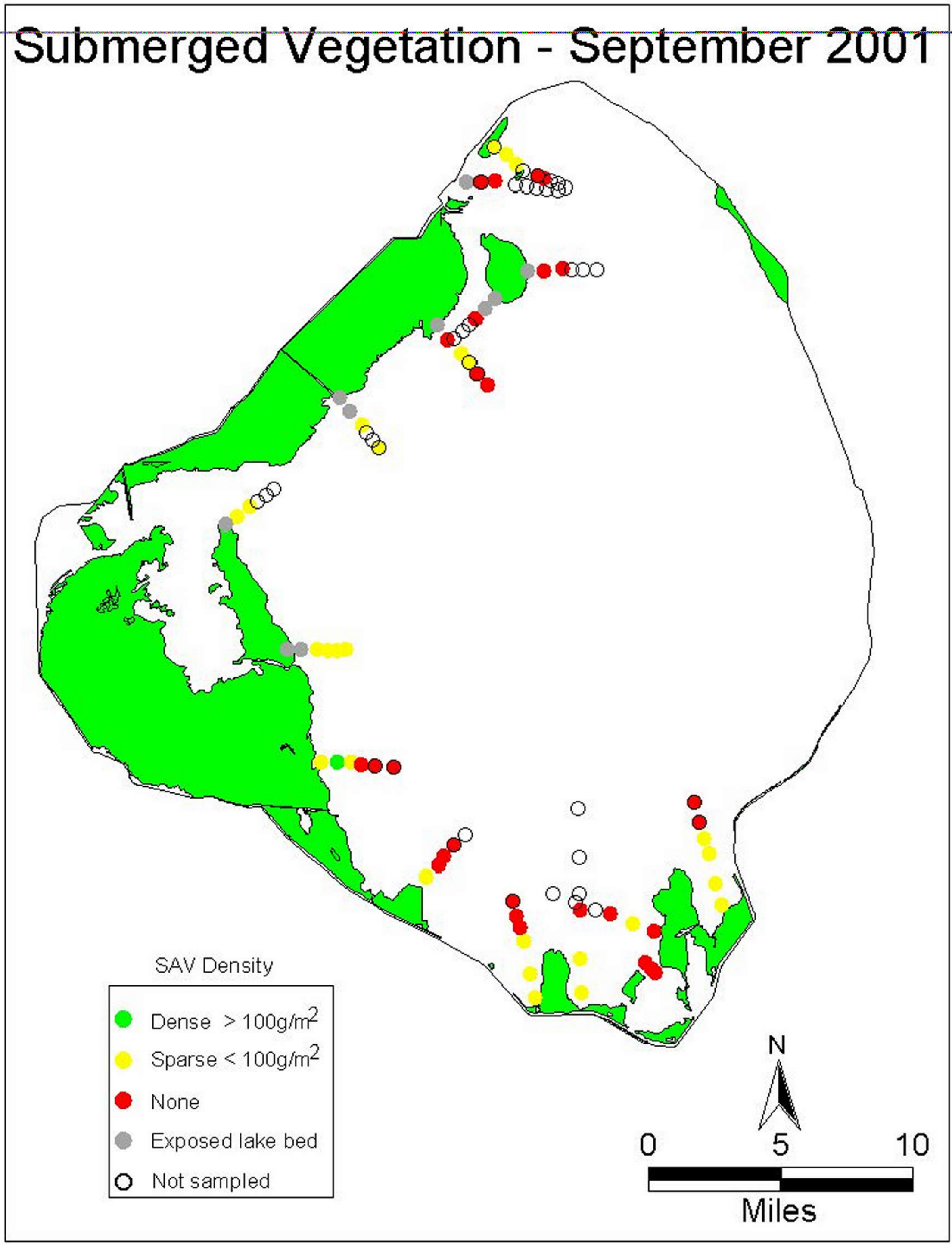

Submerged Vegetation - September 2001
SAV Density
Dense > 100g/m2
Sparse < 100g/m2
None
Exposed lake bed
Not sampled
N
0
5
10
Miles

Figure B5.

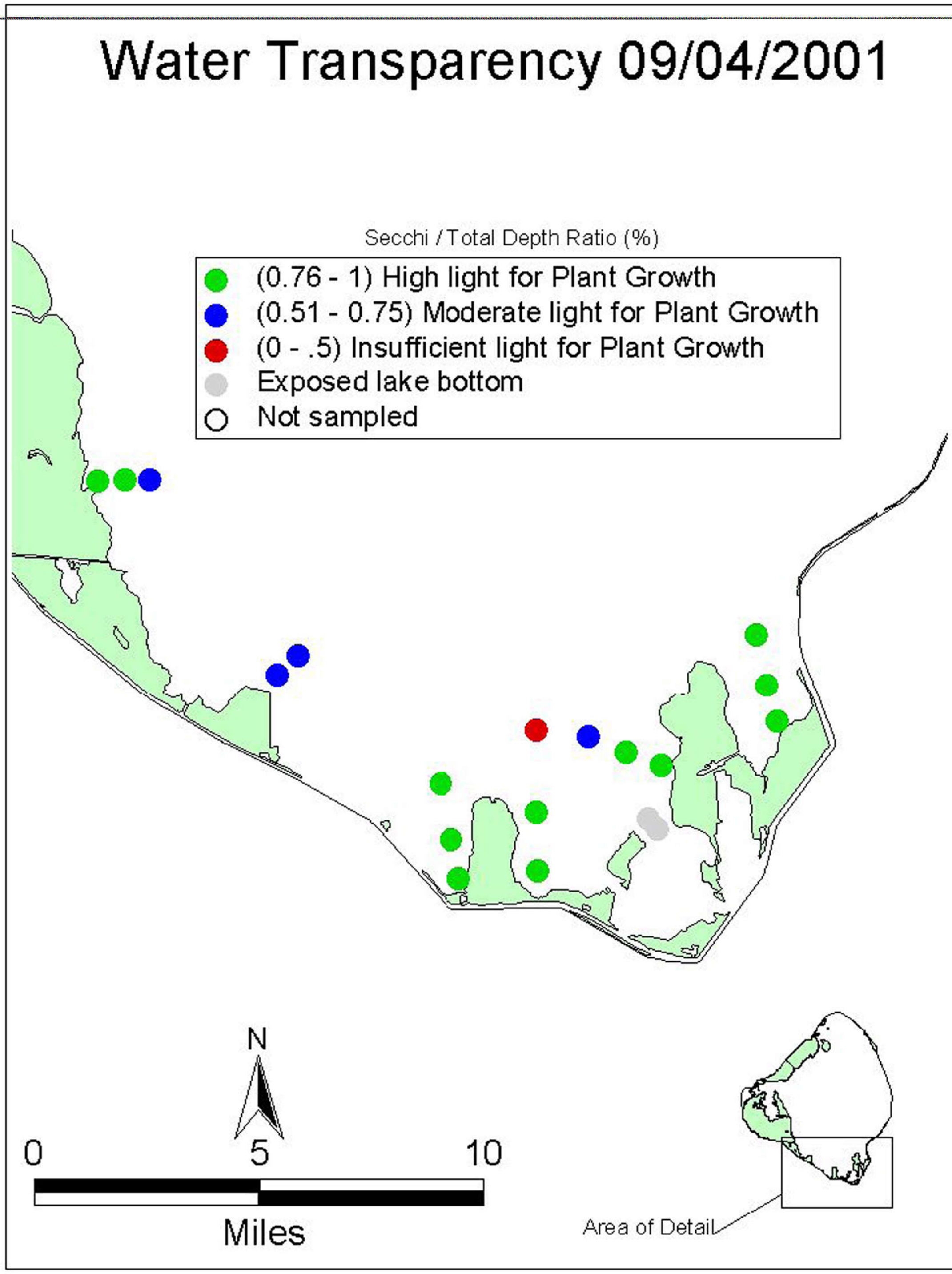

Water Transparency 09/04/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B6.

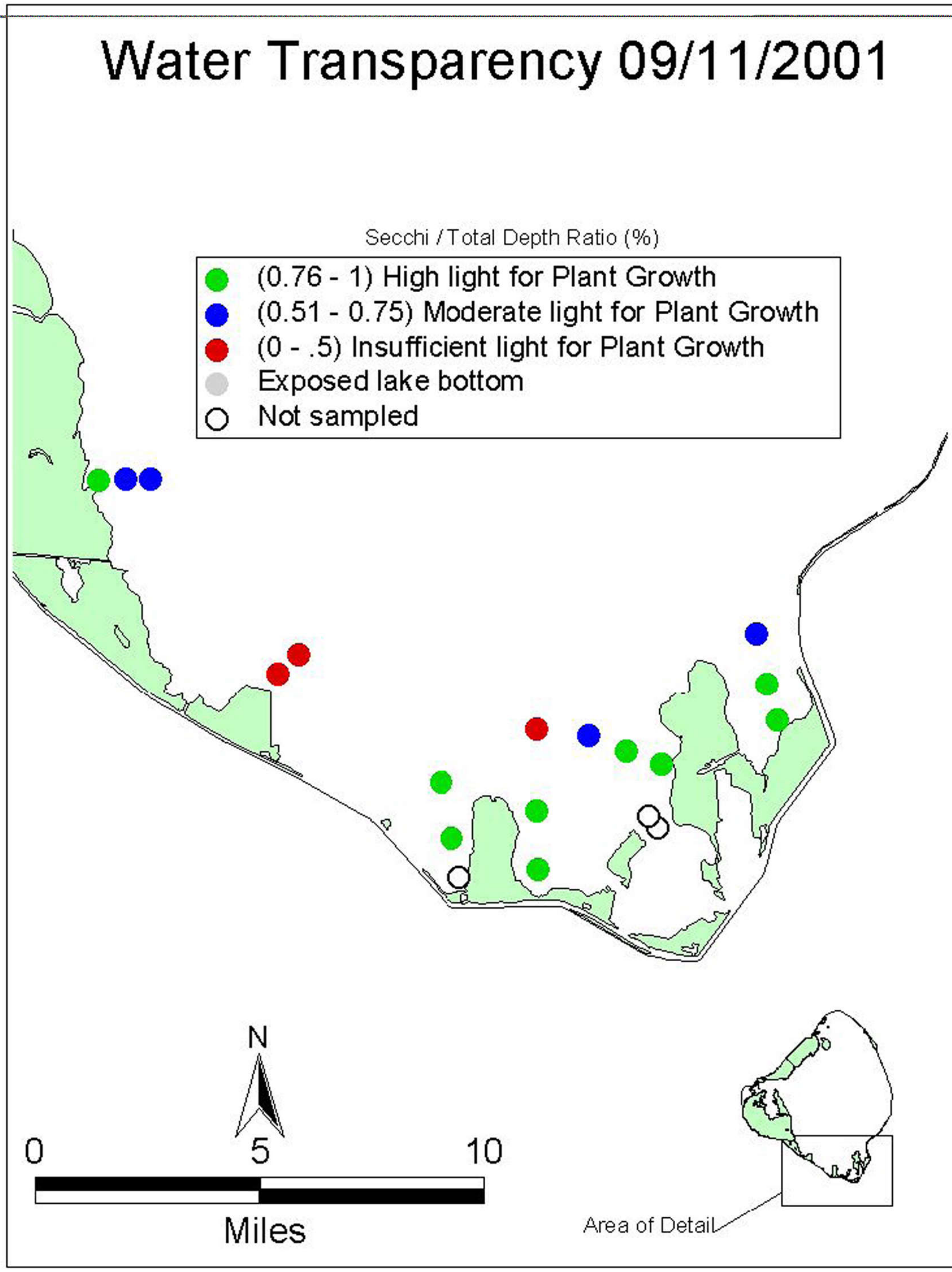

Water Transparency 09/11/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B7.

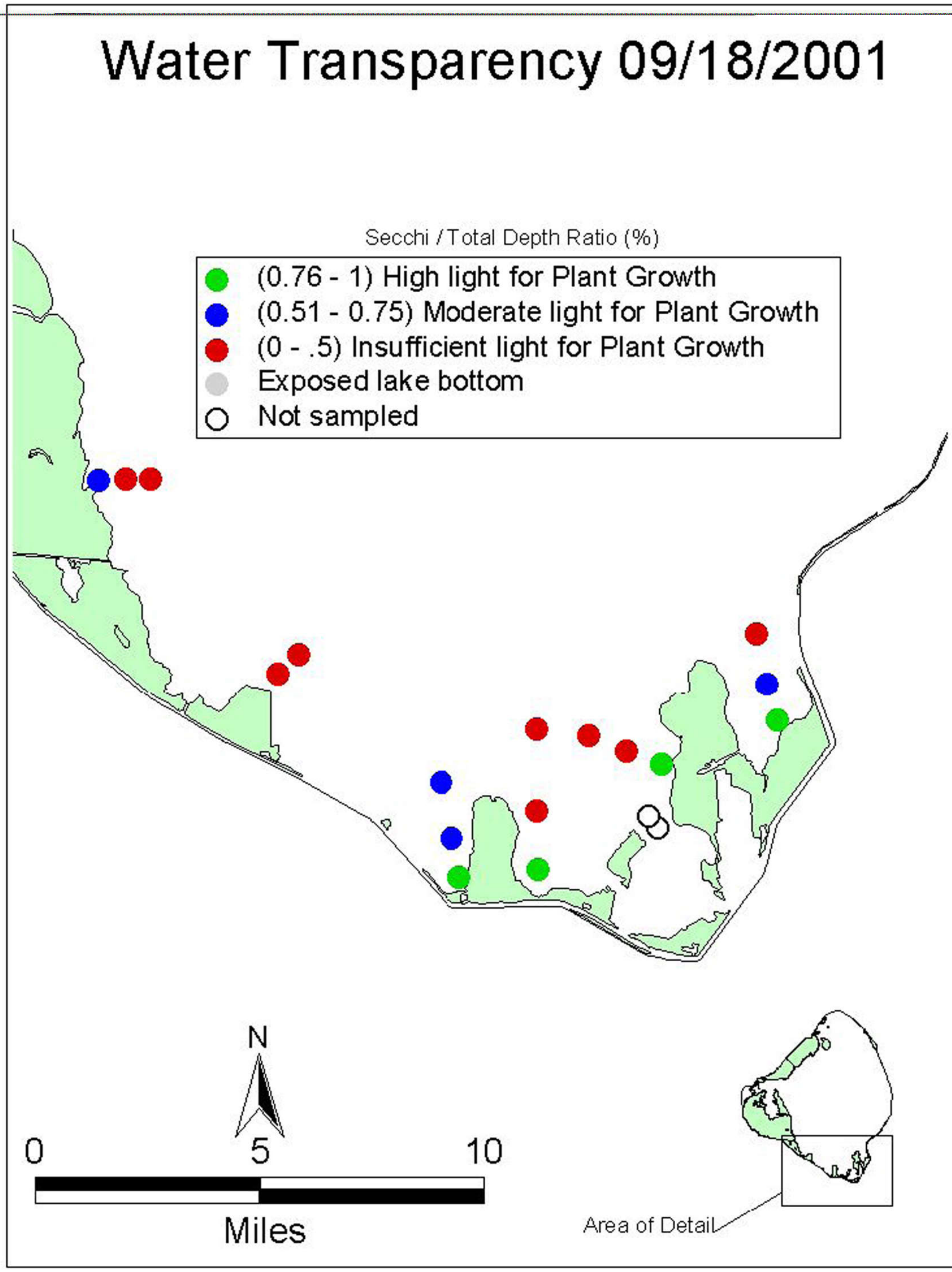

Water Transparency 09/18/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B8.

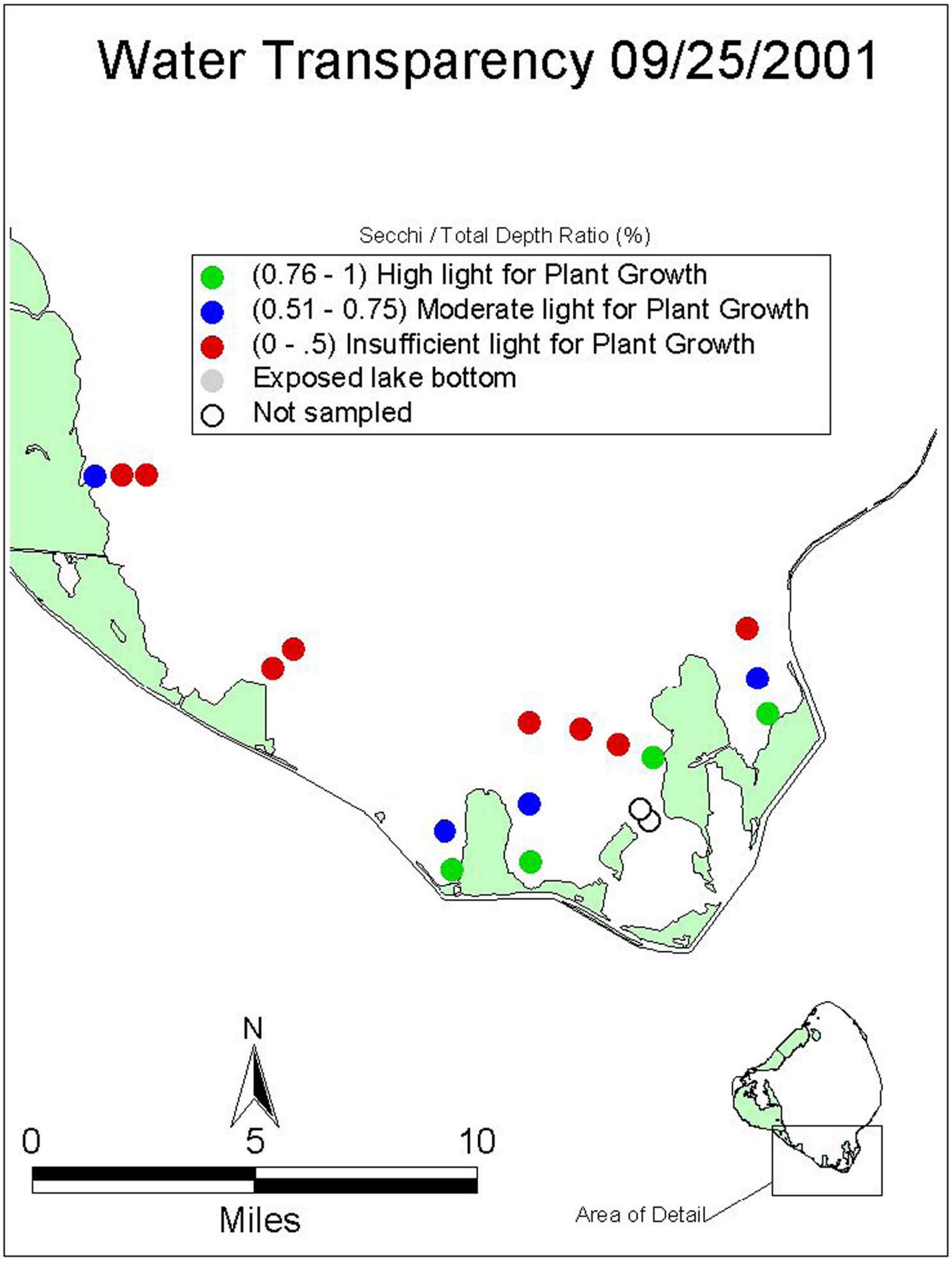

Water Transparency 09/25/2001
Secchi / Total Depth Ratio (%)
(0.76 - 1) High light for Plant Growth
(0.51 - 0.75) Moderate light for Plant Growth
(0 - .5) Insufficient light for Plant Growth
Exposed lake bottom
Not sampled
N
0
5
10
Miles
Area of Detail

Figure B9.

Table 24: Lake Recess Period (April 25, 2000 - June 30, 2000)
Outflow Volume and Total Phosphorus Load

note: TP load is calculated using interpolated values of grab measurements.

STRUCTURE	FLOW		TP LOAD	
	sum of cfs-days	acre-feet	kg	metric tons
S308	69142	137142	25802	**26**
L8 (at CULV10A)	5363	10638	1961	**2**
S352	38486	76336	12160	**12**
S351 (at S2)	80057	158791	20084	**20**
S354 (at S3)	50284	99737	12581	**13**
INDUSTRIAL CANAL	12702	25193	3420	**3**
S77	139420	276536	73792	**74**
total	**395455**	**784373**	**149800**	**150**

Gross flow-weighted-mean concentration (ppb) for the period : 155 ppb.

Appendix 4A-1: Tools for Monitoring Enforcement of Water Use Restrictions during the Drought

Robert M. Brown

EXHIBIT 1: PLAN FOR IMPLEMENTING WATER SHORTAGE ENFORCEMENT IN AGRICULTURAL AND URBAN AREAS

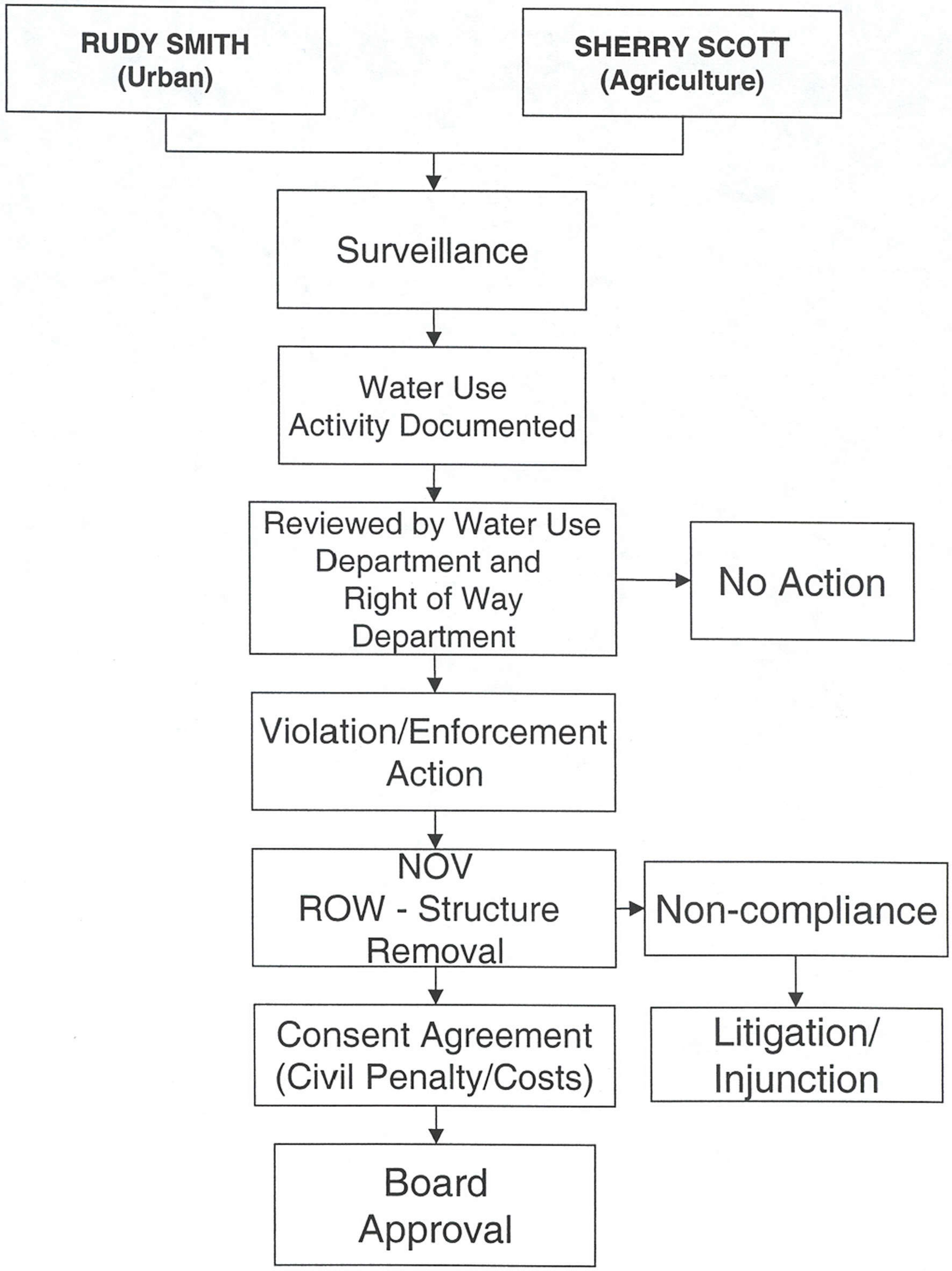

RUDY SMITH
(Urban)
SHERRY SCOTT
(Agriculture)
Surveillance
Water Use
Activity Documented
Reviewed by Water Use
Department and
Right of Way
Department
No Action
Violation/Enforcement
Action
NOV
ROW - Structure
Removal
Non-compliance
Consent Agreement
(Civil Penalty/Costs)
Litigation/
Injunction
Board
Approval

EXHIBIT 1

EXHIBIT 2: WATER SHORTAGE VIOLATION FIELD REPORT FORM

Water Shortage Violation Field Report

Date ____________________ Day ____________________ Time ___________ AM/PM

Property Name ____

Property Address ____
Street City County

Contacted Name ____

Contacted Address ____
Street City State Zip

Check only one box
☐NE – ☐NW – ☐SE – ☐SW Corner of Cross-Street ______________________________ *or*

Check only one box
☐N – ☐S – ☐E – ☐W Side of Street Near Intersection of ______________________________

Section ____________________ Twp ______________ Range _______________

Type: ☐ PUD ☐ Apartments ☐ Business ☐ Golf Course ☐ Dewatering
☐ Municipal Park ☐ Municipal Property/Medians ☐ Nursery
☐ Agricultural ☐ Other ____

Violation:
☐ 40E-21.531 (3)(c): Landscape irrigation outside of restricted odd/even days or times
☐ 40E-21.531 (3)(a): Nursery irrigation outside of restricted odd/even days or times
☐ 40E-21.531 (2)(a) Agricultural irrigation outside of restricted odd/even days or times
☐ 40E-21.531 (__)(__) Other ____
☐ 40E-2.041 (1): Lack of valid water use permit

Field Inspector (print) ____ Initials: ____________

FOR WATER USE REGULATION STAFF

Property Owner ____________________________________ Phone No. ______________________

Owner Address ____
Street City State Zip

WU Permit No. ________________________________ ☐ No WU Permit ☐ City Water

Variance No. ____________________ ☐ No Variance Board Order No. __________________

Category: ☐ <100,000 GPD ☐ 100,000 to 1,000,000 GPD ☐ > 1,000,000 GPD

Offense: ☐ First ☐ Second ☐ Third ☐ ____________________________

Water Use Compliance Reviewer (print) ________________________________ Initials __________

Water Use Compliance Supervisor (signature) ____

EXHIBIT 2

Disposition: ____

ATTACH PHOTO DOCUMENTATION WITH DATE & TIME STAMP TO THIS REPORT.

LOCATION MAP

Comments:

EXHIBIT 3: PENALTY ASSESSMENT MATRIX FOR VIOLATIONS OF WATER SHORTAGE RESTRICTIONS

PENALTY ASSESSMENT MATRIX

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

Extent of Deviation

Potential for Harm	Major	Moderate	Minor
Major	$10,000 to $8,000	$7,999 to $6,000	$5,999 to $4,600
Moderate	$4,600 to $3,200	$3,199 to $2,000	$1,999 to $1,200
Minor	$1,199 to $600	$599 to $200	$199 to $100

EXHIBIT 3

ERC Division 1999

EXHIBIT 4: TABLE OF WATER RESTRICTION PENALTIES PER DAY, PER OFFENSE

WATER RESTRICTION PENALTIES

	100,000 GPD or Less *	100,000 to 1,000,000 GPD*	1,000,000 GPD or more*
1st Offense**	$ 200	$ 500	$ 1,000
2nd Offense**	$ 1,500	$ 2,500	$ 5,000
3rd Offense***	$ 5,000	$ 7,500	$ 10,000

* Permitted Allocation

** Per Day, Per Offense

*** Revocation of Permit and Injunctive Relief

EXHIBIT 4

EXHIBIT 5: NOTICE OF VIOLATION/CONSENT AGREEMENT FOR MODIFIED PHASE II RESTRICTIONS

CON 24-06-04

Date:

VIA CERTIFIED MAIL

Dear Sir or Madam:

NOTICE OF VIOLATION/CONSENT AGREEMENT

Subject: **Violation of Water Restrictions**
Project:
Permit No. :
County
Order No. ________________

The purpose of this correspondence is to advise you that you are in violation **of Modified Phase II Water Restrictions as described in Water Shortage Order Number 2001-48** (copy attached). District staff documented this violation **at________a.m. on __________ 2001**. The violation consisted of _________**irrigation** and occurred outside of the designated day and time specified for irrigation.

As a result of this violation the District will seek a civil penalty/costs in the amount of ________________**Dollars ($0.00).** The District is authorized to seek civil penalties up to Ten Thousand Dollars ($10,000.00) per day, per offense and to recover staff investigative time and attorney fee's under Section 373.129 **Florida Statutes**. The penalty/costs amount referenced above was generated from a penalty matrix specifically designed for water restriction violations and is based upon the matrix used by the United States Environmental Protection Agency (EPA). This penalty/costs amount represents a first time offense. Be advised that should the District document further violations of the **Modified Phase II Water Restriction Order Number 2001-48,** civil penalties/costs will increase substantially and may include revocation of permit no. _______________ and injunctive relief by the court.

EXHIBIT 5

Project:
Order No. ________________
Date:
Page 2

Your execution of this short form consent agreement constitutes your acknowledgement to the terms to resolve this violation. This agreement will then be presented to the District's Governing Board with a staff recommendation for approval. The terms and conditions of which may be enforced in a court of competent jurisdiction pursuant to Sections 120.69, 373.129 and 373.136, Florida Statutes.

Without admitting liability, you have provided assurances of good faith compliance with all agreements entered into between yourselves and the District in consideration for the District not taking action to seek judicial imposition of damages, or civil penalties/costs for the violation described above. If you do not sign and return this letter to the South Florida Water Management District, at the address given above, within seven (7) days of receipt it will be assumed that you do not intend settling this matter according to the terms described herein. Subsequently, this matter would then be referred to the District's Office of Counsel with a recommendation that formal enforcement action be taken against you.

The civil penalty/District costs amount of ____________**($0.00)** is to be paid by certified check or money order to the South Florida Water Management District, 3301 Gun Club Road, Post Office Box 24680, West Palm Beach, Florida 33416-4680, to the attention of Rudy Smith, Senior Regulatory Supervisor, Environmental Resource Compliance Department. This payment is due within fourteen (14) days of execution of this agreement by the District's Governing Board.

Should you have any questions or require additional information, please contact me at (561) 682-6599. Your attention and cooperation in this matter is important to avoid further action.

Sincerely,

Rudy Smith
Sr. Regulatory Supervisor
Environmental Resource Compliance Department
South Florida Water Management District

RS
Attachment(s)

Project:
Order No. ________________
Date:
Page 3

DONE AND SO ORDERED at West Palm Beach, Palm Beach County, Florida, this _____ day of ___________ 2001.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
BY ITS GOVERNING BOARD

BY: ____________________________
Deputy Executive Director

RESPONDENT

BY: ____________________________

ATTEST:

BY: ____________________________
Assistant Secretary

c: John Fumero, SFWMD, Office of Counsel

EXHIBITS 6 AND 7: NOTICE OF VIOLATION/CONSENT AGREEMENT FOR PHASE II RESTRICTIONS

CON 24-06-04

Date:

VIA CERTIFIED MAIL

Dear Sir or Madam:

NOTICE OF VIOLATION/CONSENT AGREEMENT

Subject: Violation of Water Restrictions
Project:
County
Sec./Twp. S/Rge. E
Order No. ________________

The purpose of this correspondence is to advise you that you are in violation **of Phase II Water Restrictions** as described in **Water Shortage Order Number 2001-04** (copy attached) and consumptive use of water without a permit. District staff documented this violation **at ________a.m. on________, 2001.** The violation consisted of ________ irrigation and occurred outside of the designated day specified for irrigation.

As a result of this violation of **Phase II Water Restriction Order Number 2001-04** the District will seek a civil penalty and recovery of costs in the amount of **________Dollars ($00.00).** The District is authorized to seek civil penalties up to Ten Thousand Dollars ($10,000.00) per day, per offense and to recover staff investigative time and attorney fee's under Section 373.129 **Florida Statutes**. The penalty amount referenced above was generated from a penalty matrix specifically designed for water restriction violations and is based upon the matrix used by the United States Environmental Protection Agency (EPA). This penalty amount represents a first time offense. Be advised that should the District document further violations of the Phase II Water Restrictions, civil penalties will increase substantially.

EXHIBIT 6

Project:
Order No. _______________
Date:
Page 2

Furthermore, you are directed to submit a permit application for the consumptive use of water within 30 days of receipt of this correspondence and to obtain District authorization in a timely manner. You are required to obtain a permit authorization for the consumptive use of water under Section 373.219, **Florida Statutes** and Rules 40E-2 or 40E-20, **Florida Administrative Code**. Accordingly, you are directed to cease all unauthorized use of water in violation of state law until a permit is issued. Failure to submit and complete this permit application will result in the District taking additional enforcement action to mandate compliance. You may contact Mr. Jeffrey Rosenfeld of the District's Water Use Permitting Department at (561) 682-6922 for further information.

Your execution of this short form consent agreement constitutes your acknowledgement to the terms to resolve this violation. This agreement will then be presented to the District's Governing Board with a staff recommendation for approval. The terms and conditions of which may be enforced in a court of competent jurisdiction pursuant to Sections 120.69, 373.129 and 373.136, **Florida Statutes**.

Without admitting liability, you have provided assurances of good faith compliance with all agreements entered into between yourselves and the District in consideration for the District not taking action to seek judicial imposition of damages, or civil penalties for the violation described above. If you do not sign and return this letter to the South Florida Water Management District, at the address given above, within seven (7) days of receipt, it will be assumed that you do not intend settling this matter according to the terms described herein. Subsequently, this matter would then be referred to the District's Office of Counsel with a recommendation that formal enforcement action be taken against you.

The civil penalty/District costs amount of ________ **Dollars ($00.00)** is to be paid by certified check or money order to the South Florida Water Management District, 3301 Gun Club Road, Post Office Box 24680, West Palm Beach, Florida 33416-4680, to the attention of Rudy Smith, Sr. Regulatory Supervisor, Environmental Resource Regulation Department. This payment is due within fourteen (14) days of execution of this agreement by the District's Governing Board.

Project:
Order No. ________________
Date:
Page 3

Should you have any questions or require additional information, please contact me at (561) 682-6599. Your attention and cooperation in this matter is important to avoid further action.

Sincerely,

Rudy Smith
Sr. Regulatory Supervisor
Environmental Resource Compliance Department
South Florida Water Management District

RS
Attachment(s)