# Appendix 4-1: Water Year 2011 Supplemental Evaluations for Regulatory Source Control Programs in the Lake Okeechobee Watershed

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## INTRODUCTION

The South Florida Water Management District (SFWMD or District) is required under the Northern Everglades and Estuaries Protection Program [Subsection 373.4595(6), Florida Statutes] to provide an annual progress report on water quality and other conditions. Annual reporting on the progress and effectiveness of the source control programs for the Northern Everglades watersheds is a component of the overall strategy for meeting water quality requirements. Other source control reporting requirements are presented in Chapter 4 of this volume. The three-year updates to the Caloosahatchee and St. Lucie River Watershed Protection Plans, Construction Projects, and Research and Water Quality Monitoring Program are provided in Appendices 10-1 and 10-2 of this volume, respectively.

The Lake Okeechobee Watershed Phosphorus Source Control Program consists of a combination of distinct and coordinated efforts, including the SFWMD Works of the District Phosphorus Control Program, SFWMD Environmental Resource Permitting/Surface Water Management Permitting, and Florida Department of Agriculture and Consumer Services (FDACS) Notice of Intent Best Management Practices Program. The Works of the District Program is a mandated nonpoint source control program focusing on nutrient discharges from new and existing rule-specified agricultural and non-agricultural land uses in portions of the watershed. The Environmental Resource Permitting/Surface Water permits apply to agricultural and non-agricultural projects (new or modifications to existing) that alter surface water flows and have the potential to affect water management and resource protection. The FDACS program is an incentive-based best management practice program targeting pollutants from agricultural land uses.

As source control programs continue to be developed and implemented in the Northern Everglades watersheds, it is essential to accurately track their progress to full implementation. These implementation rates are key to evaluating the effectiveness of the collective source control programs with regard to improving downstream water quality. Once performance measure methodologies are developed and adopted, it is anticipated that they will be used in conjunction with implementation rates to evaluate progress toward achieving water quality goals.

Performance Measures are anticipated to be developed in 2012. The District will then request approval from the Office of Fiscal Accountability and Regulatory Reform to amend Chapter 40E-61, Florida Administrative Code. Rule amendment efforts will be subject to the directives provided under executive orders and any further requirements from the Office of Fiscal Accountability and Regulatory Reform. The implementation of source control programs in the St. Lucie and Caloosahatchee watersheds is provided in Chapter 4 of this volume (see the *South Florida Water Management District Nutrient Source Control Programs* section), while this appendix is specific to the Lake Okeechobee Watershed. The following pages provide geospatial coverage of these source control programs in the each sub-watershed (**Figures 1** through **9**) in the Lake Okeechobee Watershed, including lands that have SFWMD Works of the District and Environmental Resource Permitting/Surface Water permits, and agricultural lands that are enrolled in an FDACS best management practice program based on an Notice of Intent to Implement documentation as of March 2011.

This appendix also provides (1) total phosphorus (TP) data collected at all Lake Okeechobee summary basin structures, (2) Lake Okeechobee Watershed Assessment monitoring stations for Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011), and (3) graphical representations of TP concentrations in relation to land area. In the future, it is expected that TP loads will be used to compare sub-watershed performance with the performance metrics currently under development (see Chapter 4 of this volume). It should also be noted that while the performance metrics are being finalized, the data presented will consist of the current water year TP loads along with the historical period from WY1991–WY2005. Important considerations regarding these data are the many factors affecting phosphorus in runoff, including sub-watershed characteristics and rainfall conditions for a given year. It is also important to note that for the source control program, loads include all discharges from the sub-watershed discharge structures, regardless of the ultimate receiving body, and loads are reported in this section accordingly. This differs from other loading reporting, such as in the Research and Water Quality Monitoring Programs in the watershed protection plans, which have the broader objective of assessing the conditions of the hydrology and water quality of the watershed as a whole and loading to a specific receiving water body. This difference in reporting is due to the fact that source control performance will be based on phosphorus in landowner runoff and how those levels are affected by best management practices implemented on-site. It is expected that future reports on performance measures will exclude sub-watershed discharges that are not sub-watershed landowner runoff. For example, discharges from the Upper Kissimmee sub-watershed that flow through the S-65 structure and ultimately reach Lake Okeechobee through the S-65E structure will be excluded from loads attributed to the Lower Kissimmee Sub-watershed.

There are also relatively minor differences in the boundaries of the source control sub-watersheds from those listed in the 2011 Lake Okeechobee Protection Plan Update (SFWMD et al., 2011[1]) and Chapter 8 of this volume, which may lead to variations in reported loads. A review of the hydrology of each sub-watershed was conducted in concert with the data analysis for the development of the performance metrics. When the results of that review indicated that water flowed in a different direction, the source control load calculations were revised accordingly. In the future, it is anticipated that data reported in this appendix will be used to evaluate source control performance from each sub-watershed, which differs from the water quality data analyses in Chapter 8 that assess the water quality of the watershed as a whole.

[1] SFWMD, FDEP and FDACS. 2011. Lake Okeechobee Protection Plan Update. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Tallahassee, FL; and Florida Department of Agriculture and Consumer Services, Tallahassee, FL.

# LAKE OKEECHOBEE WATERSHED TOTAL PHOSPHORUS LOADS

Consistent with the Lake Okeechobee Watershed Construction Project Phase II Technical Plan (SFWMD et al., 2008[2]), the Lake Okeechobee Watershed is divided into nine sub-watersheds. The sub-watershed boundaries have been revised based on recent hydrologic studies previously mentioned. In Chapter 4 of this volume, the data presented for the Lake Okeechobee Watershed are based on a sub-watershed approach. Of the nine sub-watersheds within the Lake Okeechobee Watershed, four sub-watersheds — Taylor Creek/Nubbin Slough, Fisheating Creek/Nicodemus Slough, South Lake Okeechobee, and East Lake Okeechobee — have intermediate areas within their boundaries where the annual TP load is measured. These areas are known as summary basins. **Table 1** presents observed annual TP loads for each of the 18 summary basins in the Lake Okeechobee Watershed for WY2011. TP loads measured from all land areas located within the watershed are reported in this section, regardless of where the flow is discharged. This includes discharges into the St. Lucie and Caloosahatchee river watersheds. For example, for the West and East Lake Okeechobee sub-watersheds, the total load is reported although some portion of this load is discharged to the lake whereas the remaining load flows to the downstream estuaries. Load estimates concerned solely with the discharges to Lake Okeechobee are presented in Chapter 8 of this volume. **Figures 10** through **18** show the observed annual TP loads for each sub-watershed since WY1991.

## UPPER KISSIMMEE SUB-WATERSHED

The observed annual TP loads for the Upper Kissimmee Sub-Watershed are based on samples collected and flows measured at the S-65 structure. The observed annual TP loads and flow-weighted mean (FWM) concentrations for the Upper Kissimmee Sub-Watershed since WY1991 are provided in **Figure 10**. The WY2011 TP load was 36.0 metric tons (mt), with a FWM concentration of 63 parts per billion (ppb).

## LOWER KISSIMMEE SUB-WATERSHED

The observed annual TP loads for the Lower Kissimmee Sub-watershed are based on the difference in loads and flows measured at the S-65E and S-65 structures. The observed annual TP loads and FWM concentrations for the Lower Kissimmee Sub-watershed are presented in **Figure 11**. The WY2011 TP load was 13.0 mt, with a FWM concentration of 460 ppb.

## TAYLOR CREEK/NUBBIN SLOUGH SUB-WATERSHED

The observed annual TP loads and FWM concentrations for the Taylor Creek/Nubbin Slough Sub-watershed are based on samples and flows measured at the S-133, S-135, S-154, S-154C, and S-191 structures (**Figure 12**). The WY2011 TP load was 30.6 mt, with a FWM concentration of 408 ppb.

## LAKE ISTOKPOGA SUB-WATERSHED

The observed annual TP loads and FWM concentrations for the Lake Istokpoga Sub-watershed are based on samples and flows measured at the S-68 structure. Data since WY1991 are provided in **Figure 13**. The WY2011 TP load was 7.2 mt, with a FWM concentration of 48 ppb.

[2] SFWMD, FDEP and FDACS. 2008. Lake Okeechobee Watershed Construction Project Phase II Technical Plan. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection, Tallahassee, FL; and Florida Department of Agriculture and Consumer Services, Tallahassee, FL.

**Table 1.** Water Year 2011 (May 1, 2010–April 30, 2011) total phosphorus (TP) loads and TP flow-weighted mean concentrations.

| Summary Basin | WY2011 Observed TP Load (mt)[1] | WY2011 TP FWM Concentration (ppb) |
|---|---|---|
| **Upper Kissimmee Sub-watershed** | | |
| No Summary Basins | N/A | |
| *Sub-watershed Total* | ***36.0*** | ***63*** |
| **Lower Kissimmee Sub-watershed** | | |
| No Summary Basins | N/A | |
| *Sub-watershed Total* | ***13.0*** | ***460*** |
| **Taylor Creek/Nubbin Slough Sub-watershed** | | |
| S-191 | 19.21 | 460 |
| S-133 | 1.83 | 191 |
| S-135 | 0.36 | 54 |
| S-154 | 7.35 | 497 |
| S-154C | 1.88 | 836 |
| *Sub-watershed Total* | ***30.6*** | ***421*** |
| **Lake Istokpoga Sub-watershed** | | |
| No Summary Basins | N/A | |
| *Sub-watershed Total* | ***7.2*** | ***48*** |
| **Indian Prairie Sub-watershed** | | |
| No Summary Basins | N/A | |
| *Sub-watershed Total* | ***25.4*** | ***411*** |
| **Fisheating Creek Sub-watershed** | | |
| Fisheating Creek | 13.91 | 181 |
| Nicodemus Slough (Culvert 5) | 0.08 | 130 |
| *Sub-watershed Total* | ***14.0*** | ***181*** |
| **West Lake Okeechobee Sub-watershed** | | |
| No Summary Basins | N/A | N/A |
| *Sub-watershed Total* | ***26.2*** | ***131*** |
| **South Lake Okeechobee Sub-watershed** | | |
| 715 Farms (Culvert 12A) (to Lake Okeechobee) | 0.00 | N/A |
| East Beach Drainage District (Culvert 10) (to Lake Okeechobee) | 0.00 | N/A |
| East Shore Drainage District (Culvert 12) (to Lake Okeechobee) | 0.00 | N/A |
| S-2 (to Lake Okeechobee) | 0.08 | 132 |
| S-3 (to Lake Okeechobee) | 0.03 | 103 |
| S-4/Industrial Canal[2] (to Lake Okeechobee) | 4.06 | 135 |
| South Florida Conservancy Drainage District (S-236) (to Lake Okeechobee) | 0.00 | N/A |
| South Shore/South Bay Drainage District (Culvert 4A) (to Lake Okeechobee) | 0.00 | N/A |
| S5A Basin (S-352-West Palm Beach Canal) (to Lake Okeechobee) | 0.00 | N/A |
| *Sub-watershed Total* | ***4.2*** | ***134*** |
| **East Lake Okeechobee Sub-watershed** | | |
| S-308C (St. Lucie Canal-C-44 Canal) | 18.78 | 393 |
| L-8 Basin (Culvert 10A) | 0.41 | 126 |
| *Sub-watershed Total* | ***19.2*** | ***376*** |

[1] This differs from loads presented in Chapter 8 of this volume, as that chapter focuses solely on TP loads entering Lake Okeechobee, and also due to sub-watershed boundary differences; N/A = not applicable.
[2] The S-4/Industrial Canal (C-310) Summary Basin is not part of the Everglades Agricultural Area as defined in the Everglades Forever Act.

## INDIAN PRAIRIE SUB-WATERSHED

The observed annual TP loads for the Indian Prairie Sub-watershed are based on samples collected and flows measured at the G-33, G-34, G-74, G-75, G-76, S-71, S-72, S-84, S-127, S-129, and S-131 structures. It should be noted that prior to WY2011 reporting, the L-61W area was also considered to be within the Indian Prairie Sub-watershed. However, changes in the location of where flow is monitored for the Fisheating Creek/Nicodemus Slough Sub-watershed revealed that the L-61W area was hydraulically part of the Fisheating Creek/Nicodemus Slough Sub-watershed, and therefore this boundary has been updated. This area was a minor contributor to total loads from these sub-watersheds, but the historical loads have been transferred from Indian Prairie to Fisheating Creek. The observed annual TP loads and FWM concentrations for the Indian Prairie Sub-watershed (since WY1991) are provided in **Figure 14**. The WY2011 TP load was 25.4 mt, with a FWM concentration of 411 ppb.

## FISHEATING CREEK/NICODEMUS SLOUGH SUB-WATERSHED

The observed annual TP loads for the Fisheating Creek/Nicodemus Slough Sub-watershed are based on samples and flows measured in Fisheating Creek at State Road 78 in Lakeport and in the C-5 canal and at its structure. This is a change from previous years in which the flows and loads at the Culvert 5A (C-5A) structure were also included in the Fisheating Creek/Nicodemus Slough Sub-watershed calculations. However, a hydrologic review of this area indicates flows and loads from this structure better represented the West Lake Okeechobee Sub-watershed and such information is now included in that sub-watershed's reporting. Historical loads from Culvert 5A have been transferred from the Fisheating Creek/Nicodemus Slough Sub-watershed to the West Lake Okeechobee Sub-watershed.

Additionally, in the past, the TP loading monitoring for Fisheating Creek was conducted upstream of L-61W at State Road 27 in Palmdale. The L-61W area was measured at its discharge point and was included in the Indian Prairie Sub-watershed loads. In 2001, a monitoring station was added in Lakeport, downstream of the monitoring station in Palmdale, and downstream of the L-61W discharge point. Once this data was reviewed, it was discovered that the Lakeport monitoring station was also capturing loads being contributed from the L-61W area, leading to the move of the L-61W area from the Indian Prairie to the Fisheating Creek/Nicodemus Slough Sub-watershed. Due to its geographical location, data from the monitoring station at Lakeport is a better representation of total TP load from the Fisheating Creek/Nicodemus Slough Sub-watershed. The data presented from WY2001 to present represents TP loads and flows collected at Lakeport. The TP load prior to WY2001 from L-61W have been transferred from the Indian Prairie Sub-watershed to the Fisheating Creek/Nicodemus Slough Sub-watershed. The observed TP loads and FWM concentrations for the Fisheating Creek/Nicodemus Slough Sub-watershed since WY1991 are provided in **Figure 15**. The WY2011 TP load was 14.0 mt, with a FWM concentration of 181 ppb.

## WEST LAKE OKEECHOBEE SUB-WATERSHED

In the West Lake Okeechobee Sub-watershed, the observed TP loads are based on samples and flows measured at the S-77 (to Lake Okeechobee) and S-78 (through the Caloosahatchee River) structures. Additionally, this year the Culvert 5A structure flows and loads are included in the West Lake Okeechobee Sub-watershed, as water from Lake Okeechobee can be released through Culvert 5A and discharged to Lake Hicpochee through S-47B to provide irrigation water to landowners in this area. In previous reporting, the flows and loads from this structure were included in the Fisheating Creek/Nicodemus Slough Sub-watershed. This change is consistent with the Caloosahatchee River Watershed Source Control Program's boundaries, which include Culvert 5A in the East Caloosahatchee Summary Basin, and the Lake Okeechobee Operating Permit's Western Region. Historical loads from Culvert 5A have been transferred from the

Fisheating Creek/Nicodemus Slough Sub-watershed to the West Lake Okeechobee Sub-watershed. The observed annual TP loads and FWM concentrations for the West Lake Okeechobee Sub-watershed are provided in **Figure 16**. The WY2011 TP load was 26.2 mt, with a FWM concentration of 131 ppb.

### EAST LAKE OKEECHOBEE SUB-WATERSHED

East Lake Okeechobee Sub-watershed observed annual TP loads are based on samples and flows measured at S-308C (to Lake Okeechobee), C-10A, and S-80 (to the St. Lucie River). **Figure 17** provides TP loads and FWM concentrations for the East Lake Okeechobee Sub-watershed. The WY2011 TP load was 19.2 mt, with a FWM concentration of 376 ppb.

### SOUTH LAKE OKEECHOBEE SUB-WATERSHED

The observed annual TP loads from the South Lake Okeechobee Sub-watershed to Lake Okeechobee are based on samples and flows measured at the C-12A, C-10, C-12, S-2, S-3, S-4, S-236, C-310, C-4A, and S352 structures. [Note: The S-4 structure and the Industrial Canal (C-310) are within the South Lake Okeechobee Sub-watershed, but are not part of the Everglades Agricultural Area.] The observed annual TP loads and FWM concentrations for the South Lake Okeechobee Sub-watershed (based on water year) are provided in **Figure 18**. The TP loading data presented for this sub-watershed consider only discharges into Lake Okeechobee. The WY2011 TP load was 4.2 mt, with a FWM concentration of 134 ppb.

## LAKE OKEECHOBEE WATERSHED ASSESSMENT MONITORING NETWORK DATA

In addition to the water quality monitoring that takes place at the Lake Okeechobee Watershed sub-watershed and summary basin-level structures, monitoring is conducted within each sub-watershed and summary basin under several different projects. The District's ambient monitoring network and the United States Geological Survey monitoring network are described in Chapter 8 of this volume. Lake Okeechobee Watershed Assessment monitoring, along with other ambient monitoring network data (TP concentration only) are used by coordinating agencies to direct resources to areas of water quality concern. Site data collected under the program, along with data collected from the District's ambient monitoring network and Lake Okeechobee inflow sites, are used to identify, prioritize, and direct resources to areas of water quality concern within the sub-watershed. The SFWMD, FDACS and Florida Department of Environmental Protection meet routinely to discuss areas with water quality concerns.

An overview of TP concentrations from the Lake Okeechobee Watershed Assessment monitoring network and ambient TP sites from other monitoring projects is presented in **Figures 19** through **24.** These sites include WY2011 mean TP for all samples taken during a flow event. Note, the TP mean for stations flowing into and out of Lake Okeechobee includes flow both into and out of the lake. Also note that these means are not flow-weighted where flow is measured.

## SUB-WATERSHED OBSERVED ANNUAL TOTAL PHOSPHORUS LOAD BREAKDOWN

**Figure 25** depicts the observed WY2011 TP load distribution for Lake Okeechobee Watershed sub-watersheds. **Figure 26** summarizes the same percentages for WY2011 observed TP load, along with the percentages of total land area represented by each sub-watershed**.** Also in this section, **Figure 27** provides a box-and-whisker plot for the nine sub-watersheds. The data used to construct this figure included loading information based on water year from WY1991 to WY2011. **Figure 28** describes the details of this figure.

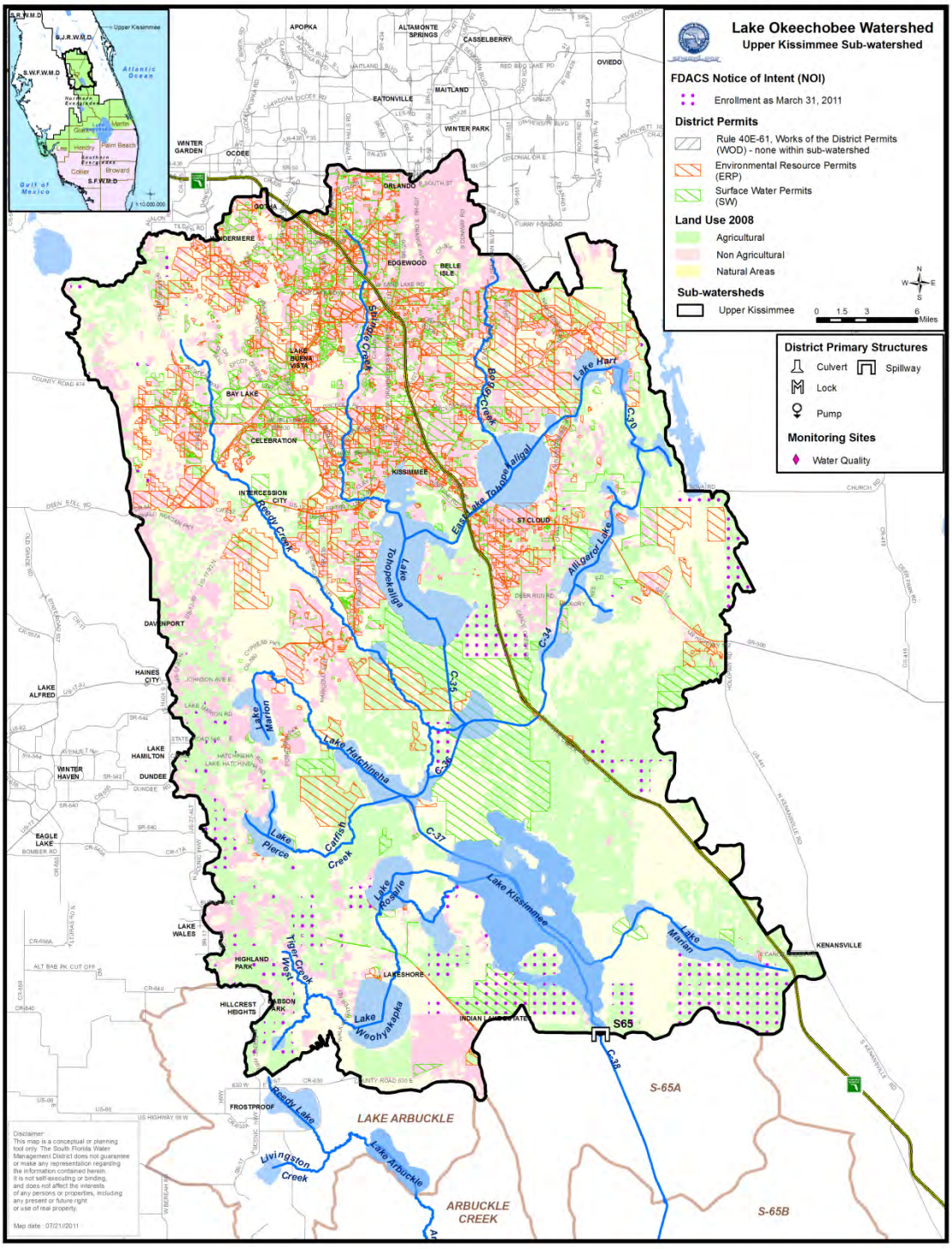


**Figure 1.** Source Control Program coverage in the Upper Kissimmee Sub-watershed.

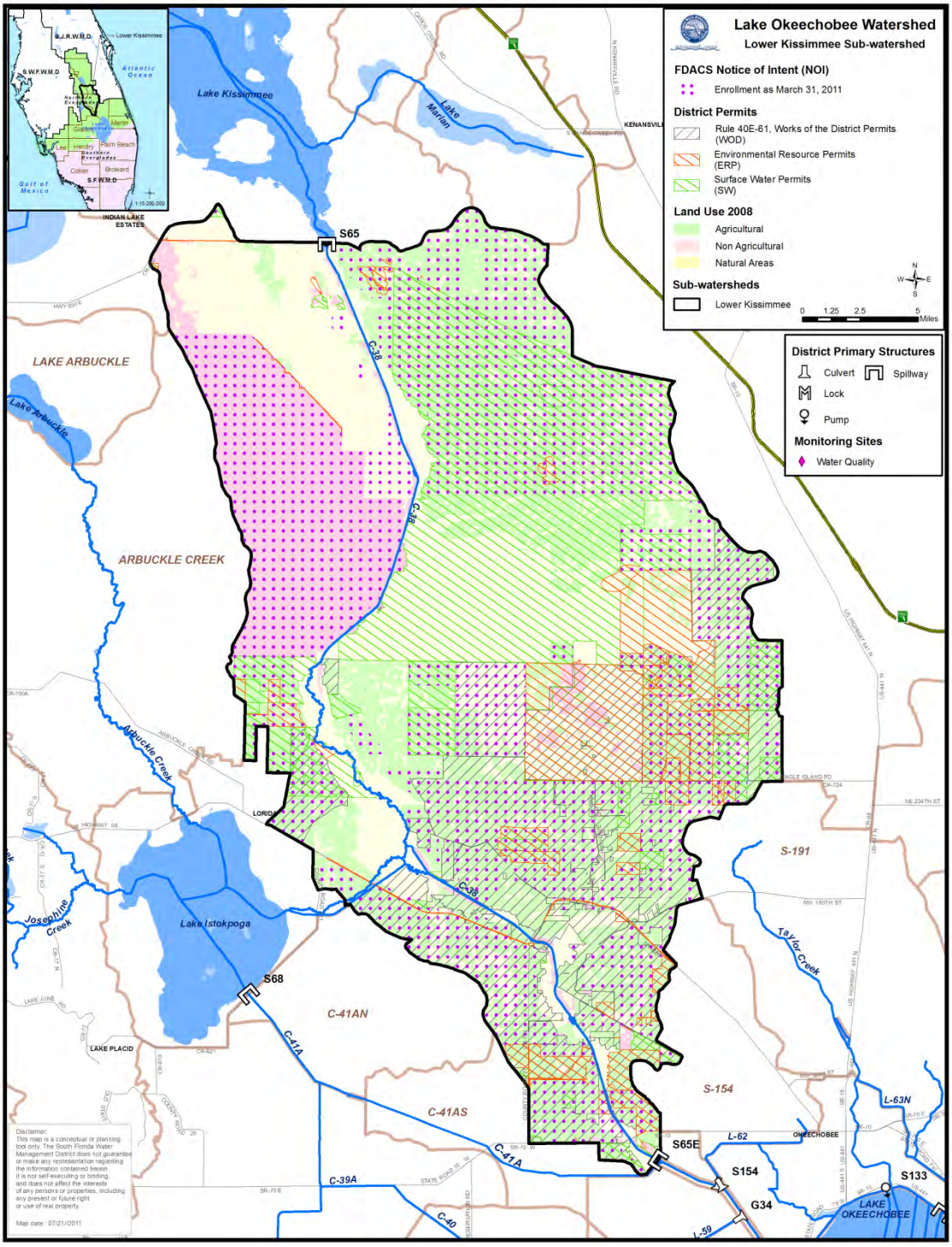


**Figure 2.** Source Control Program coverage in the Lower Kissimmee Sub-watershed.

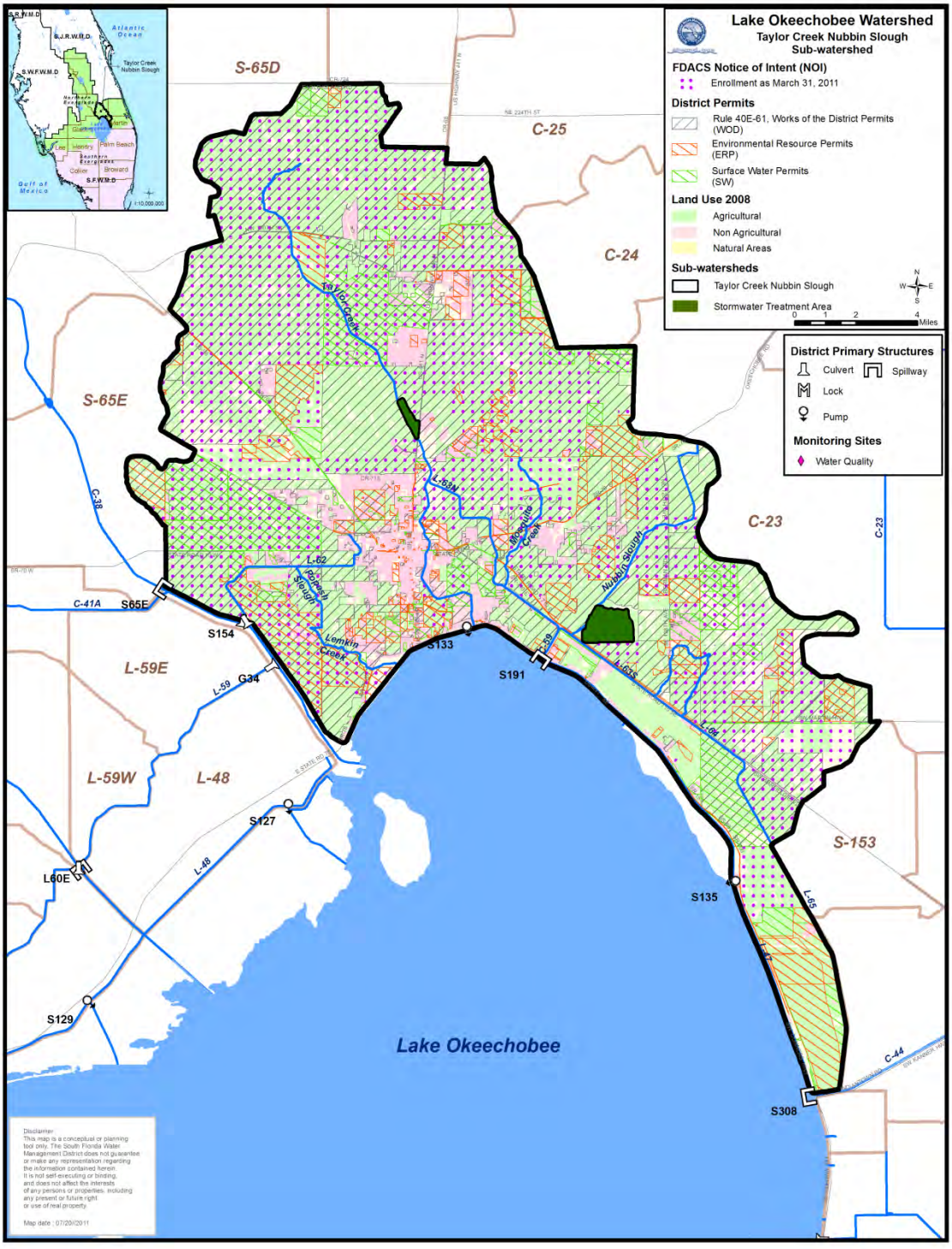


**Figure 3.** Source Control Program coverage in the Taylor Creek/Nubbin Slough Sub-watershed.

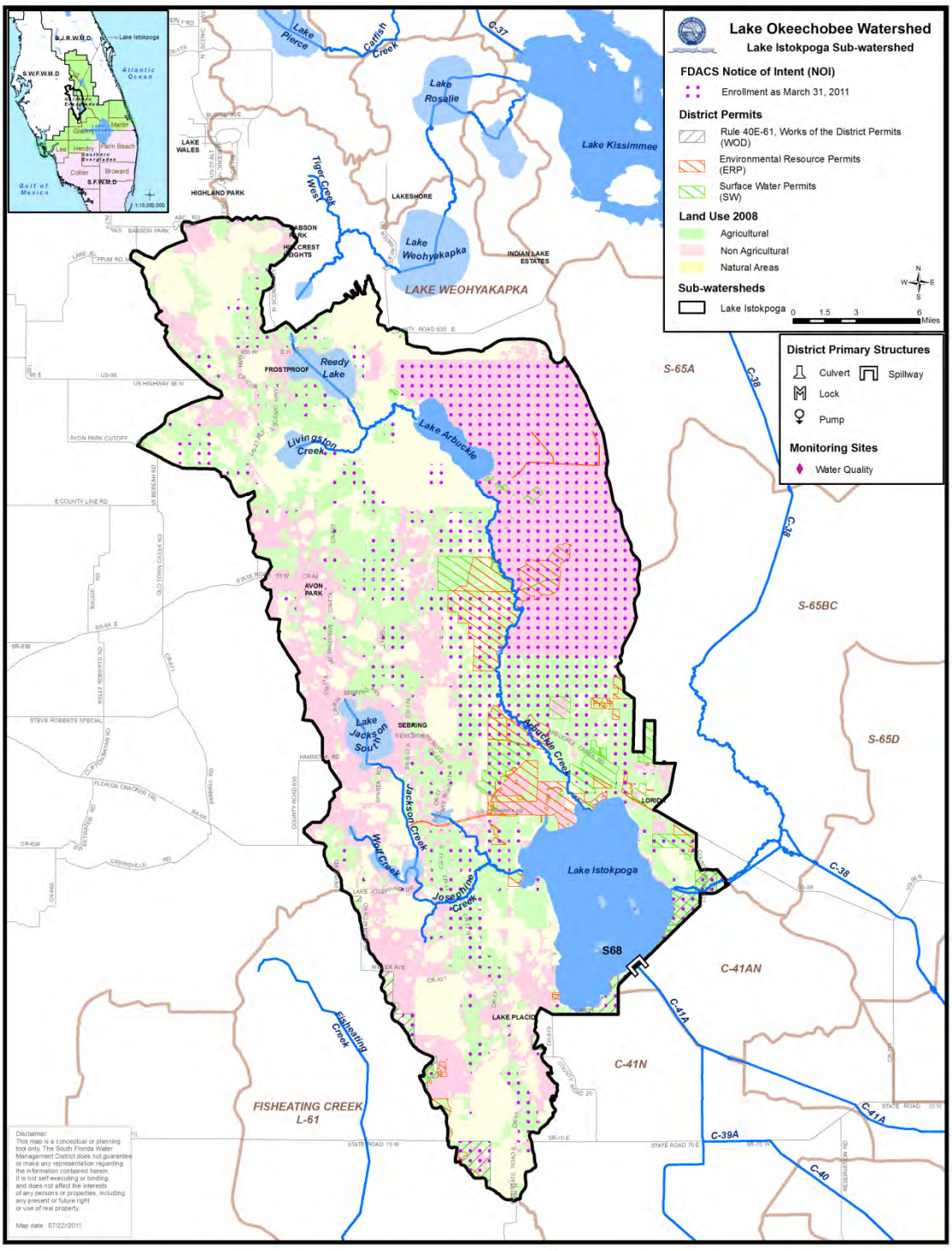


**Figure 4.** Source Control Program coverage in the Lake Istokpoga Sub-watershed.

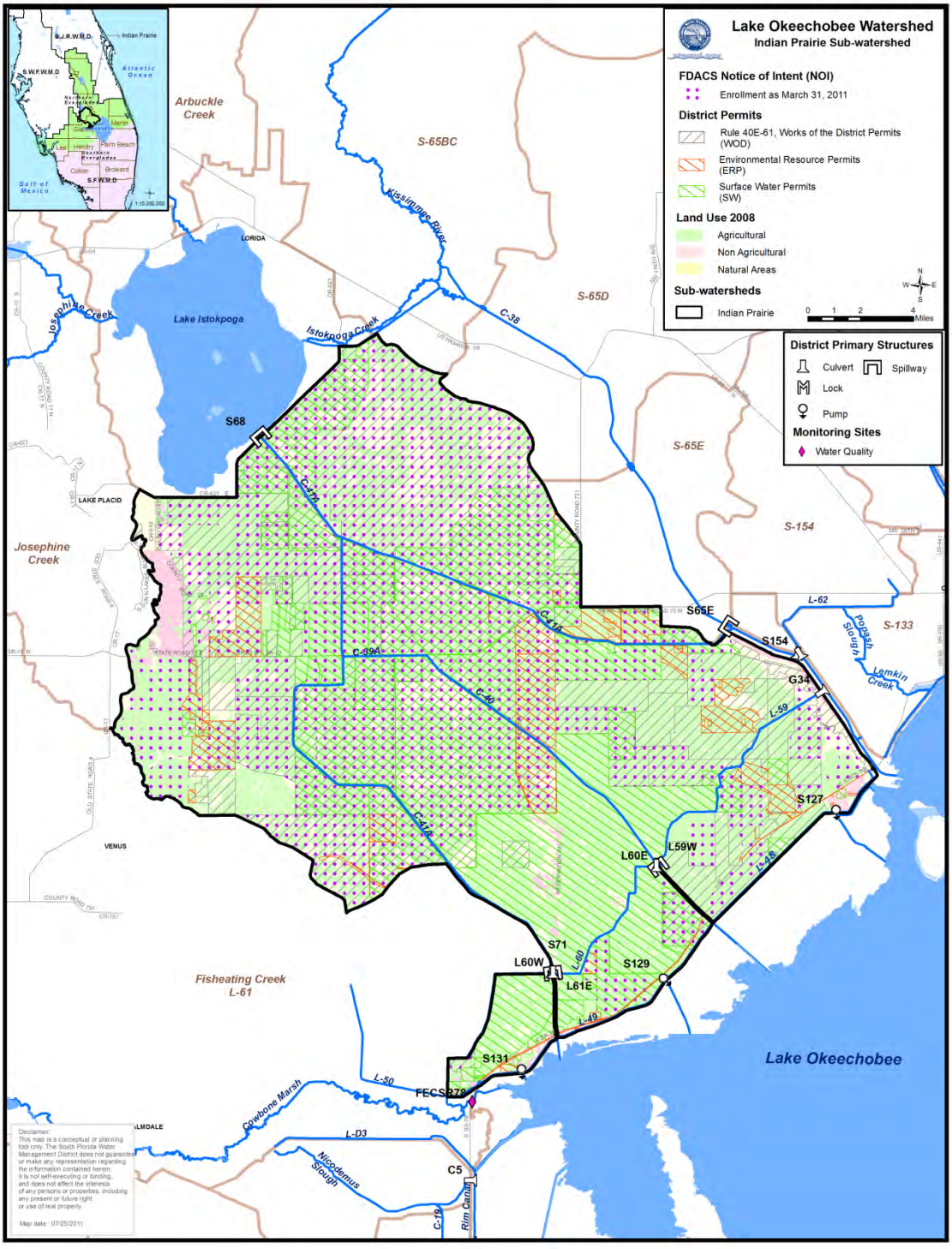


**Figure 5.** Source Control Program coverage in the Indian Prairie Sub-watershed.

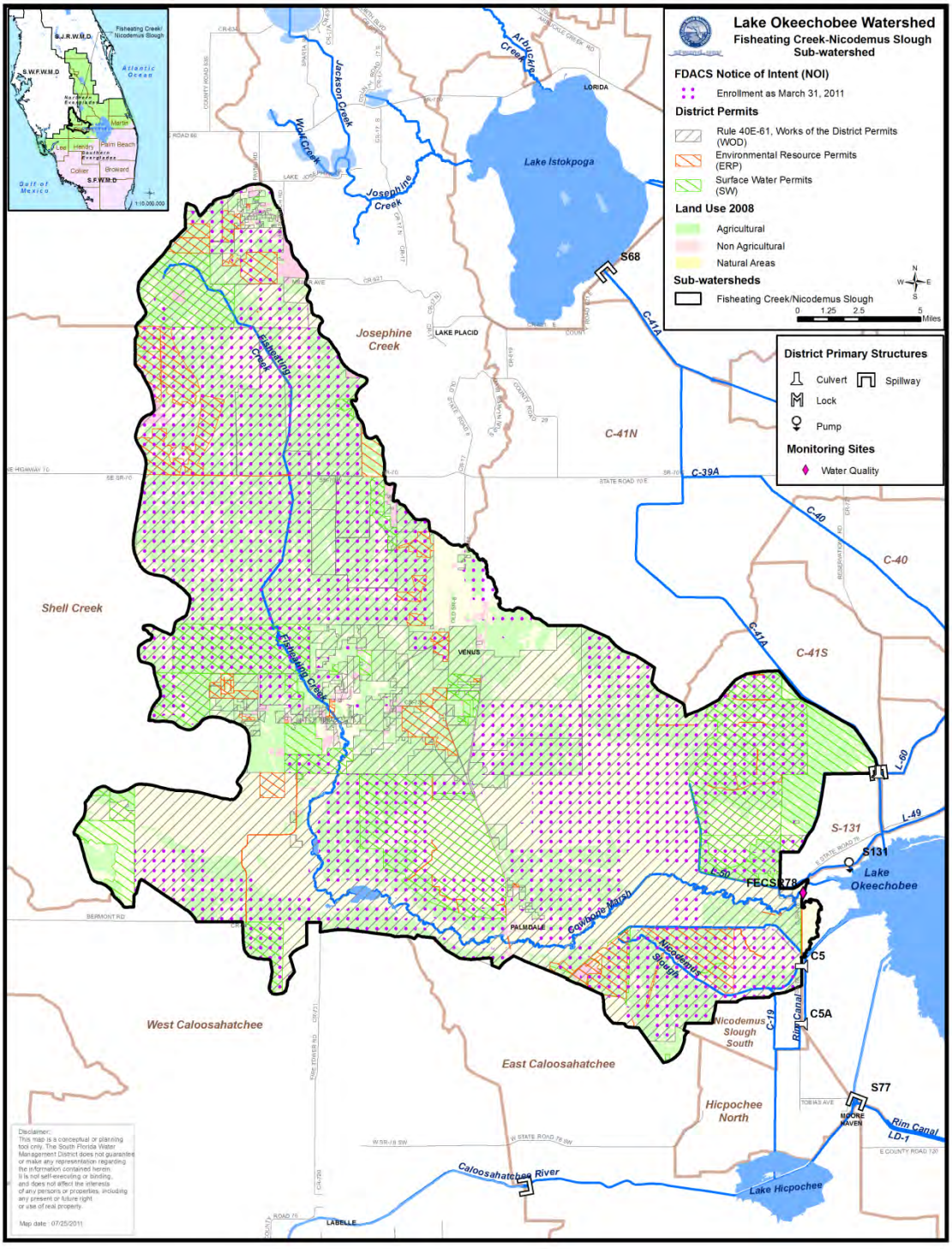


**Figure 6.** Source Control Program coverage in the Fisheating Creek Sub-watershed.

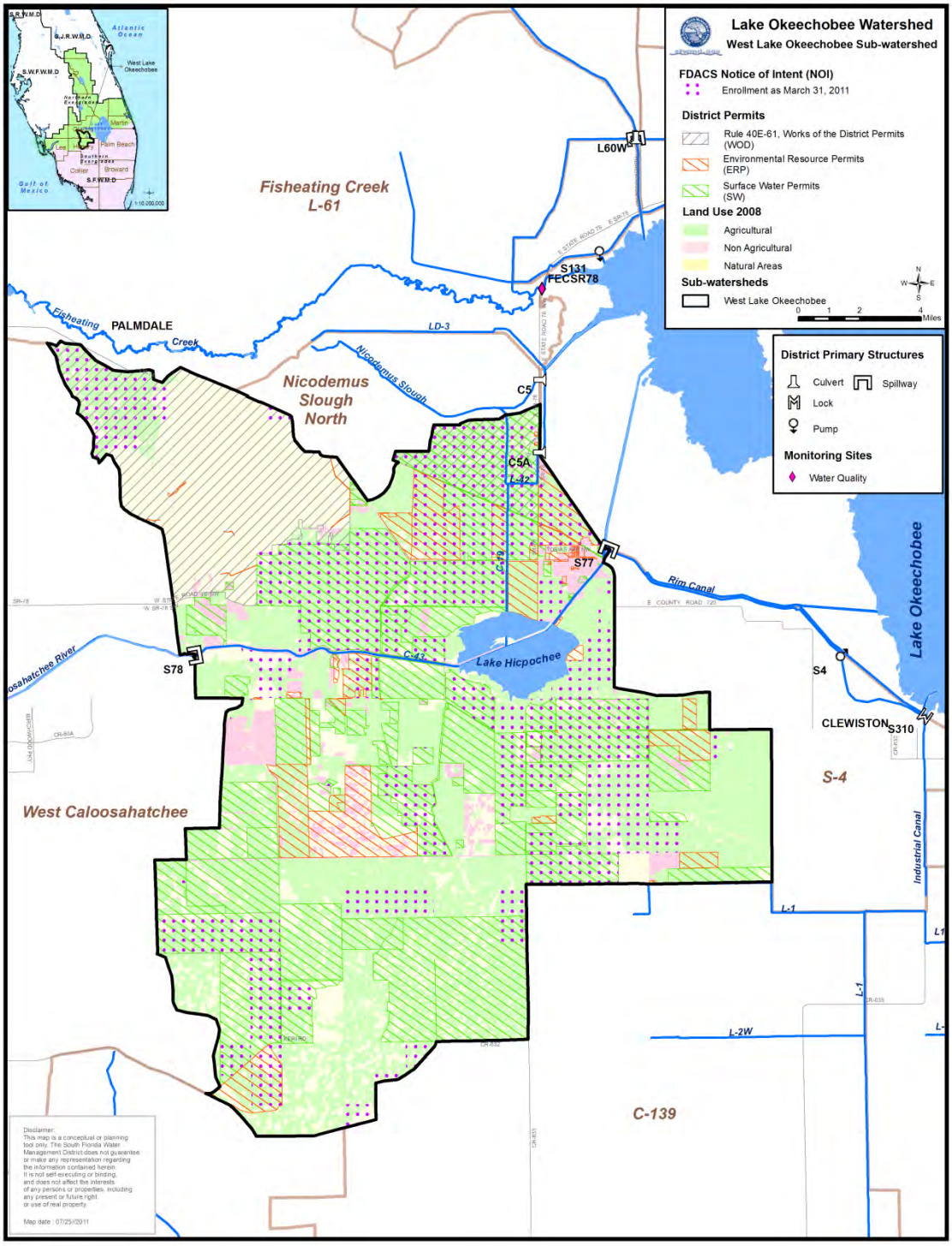


**Figure 7.** Source Control Program coverage in the West Lake Okeechobee Sub-watershed.

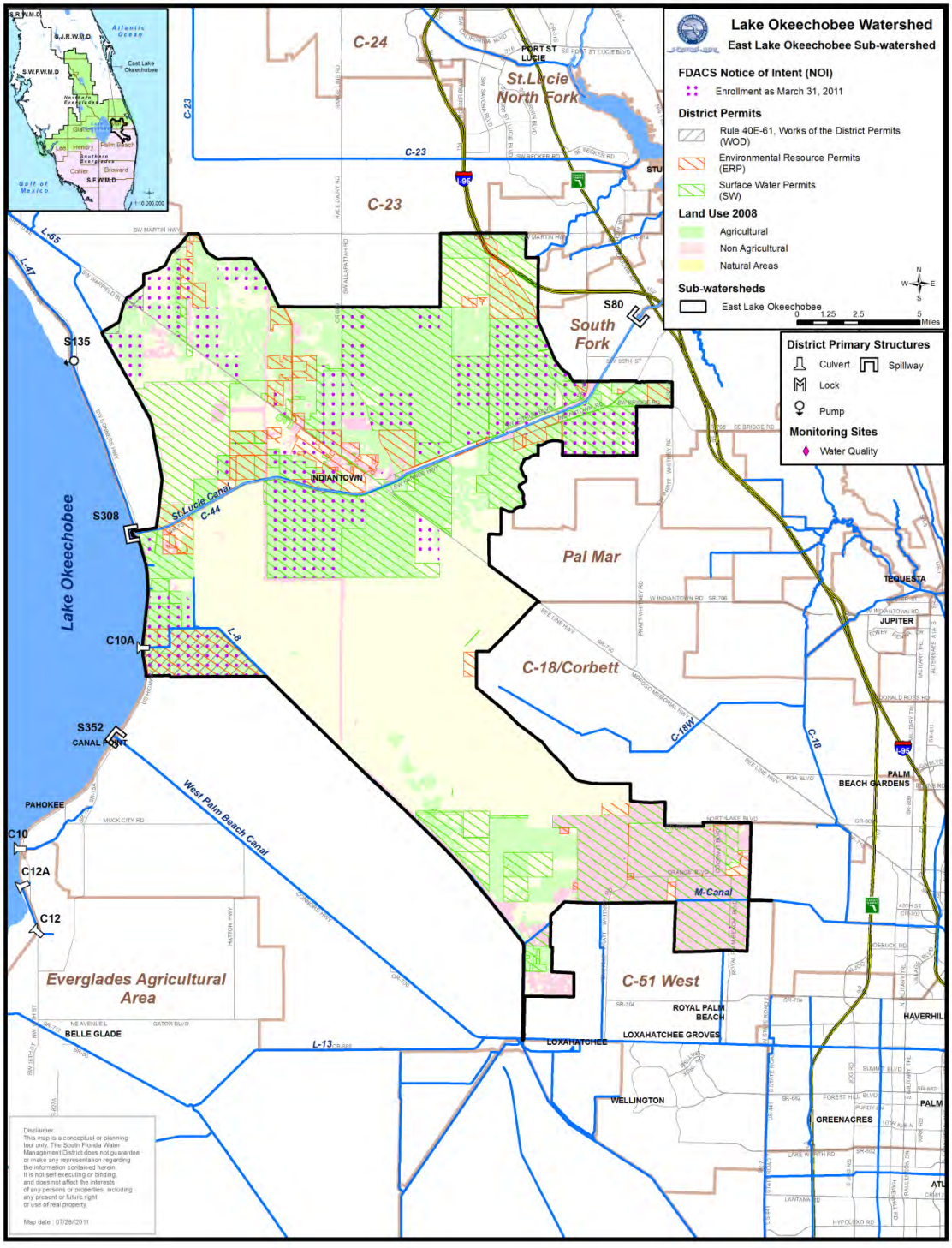


**Figure 8.** Source Control Program coverage in the East Lake Okeechobee Sub-watershed.

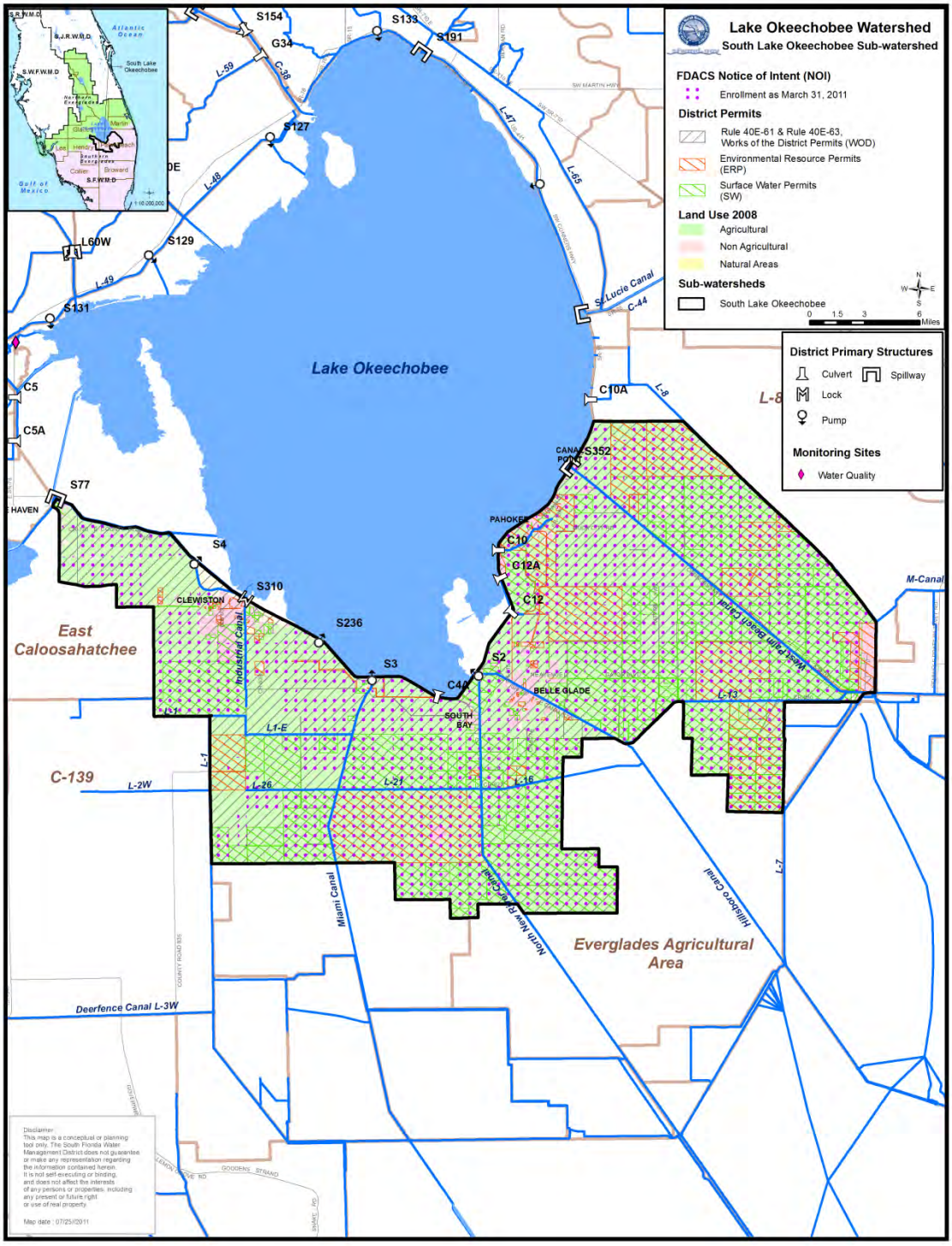


**Figure 9.** Source Control Program coverage in the South Lake Okeechobee Sub-watershed.

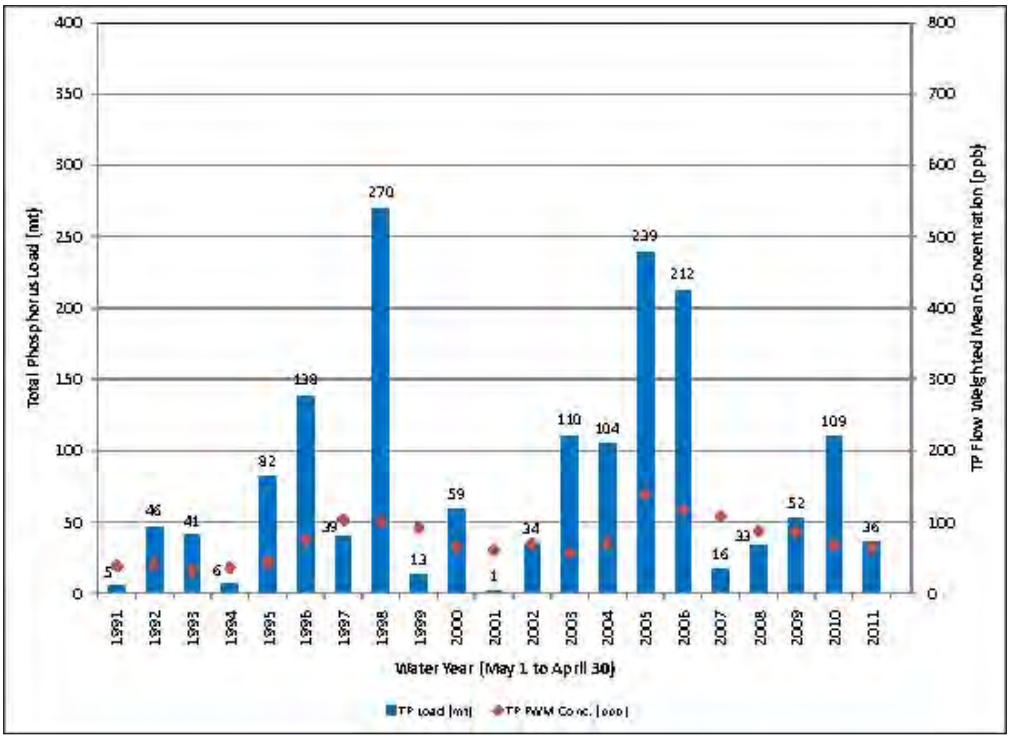


**Figure 10.** Upper Kissimmee Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

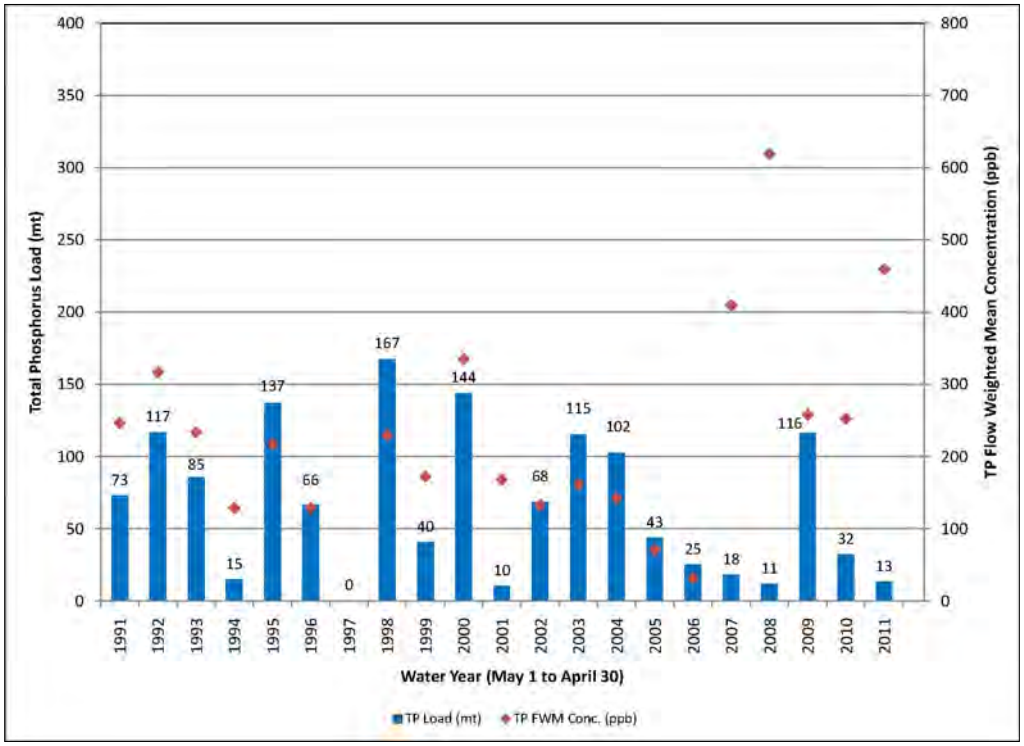


**Figure 11.** Lower Kissimmee Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

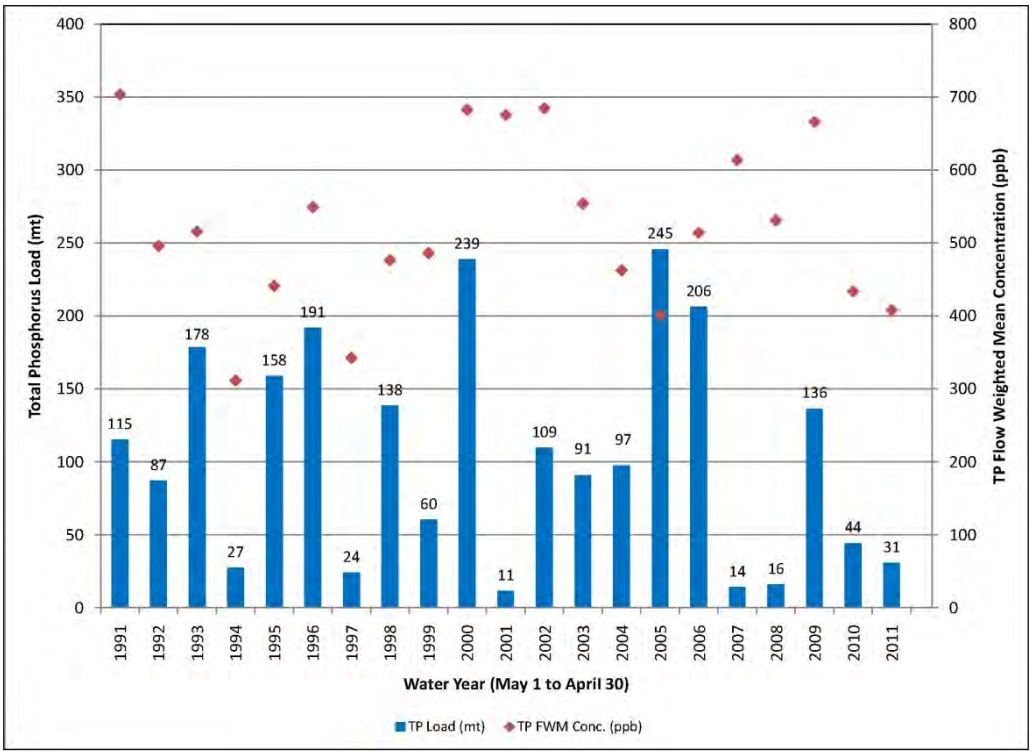


**Figure 12.** Taylor Creek/Nubbin Slough Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

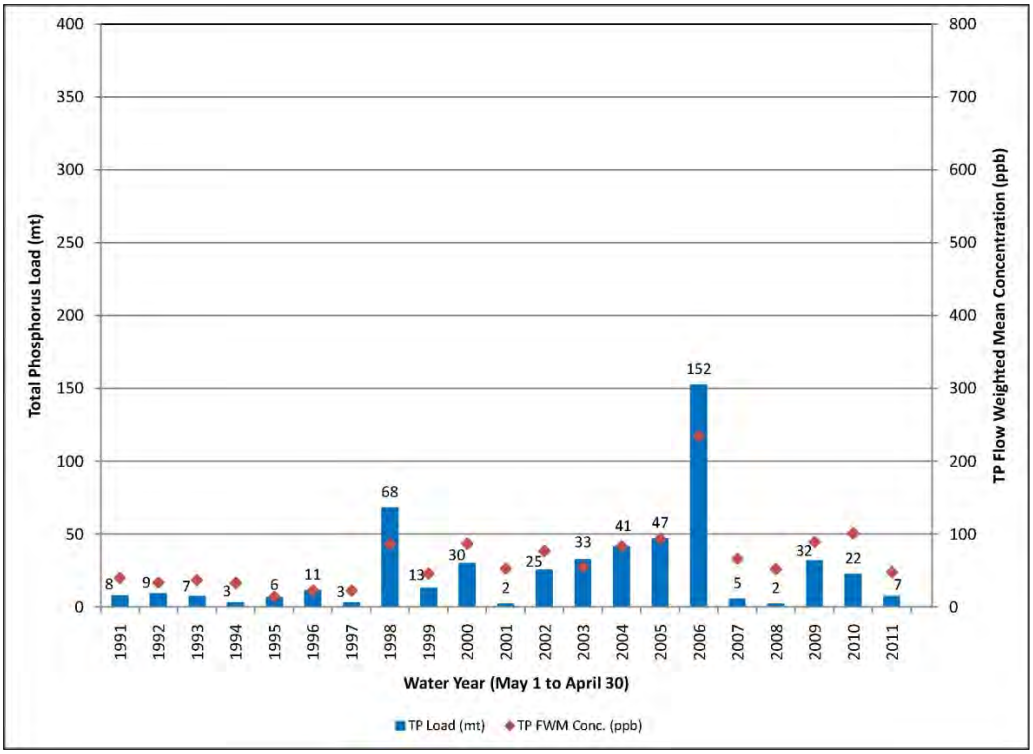


**Figure 13.** Lake Istokpoga Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

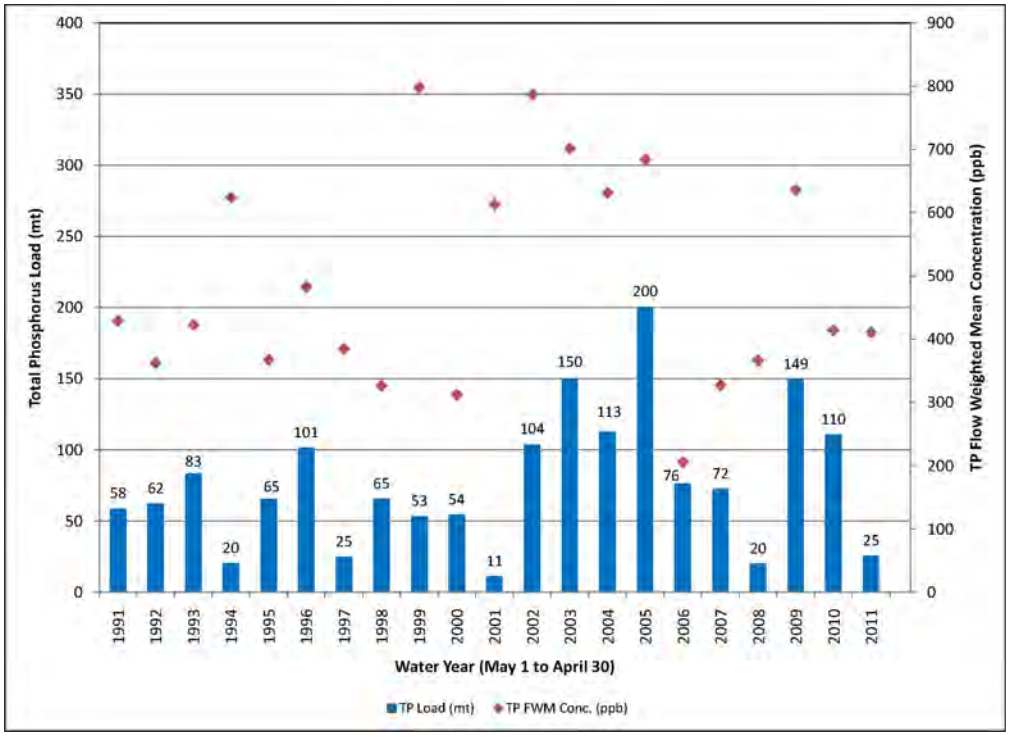


**Figure 14.** Indian Prairie Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

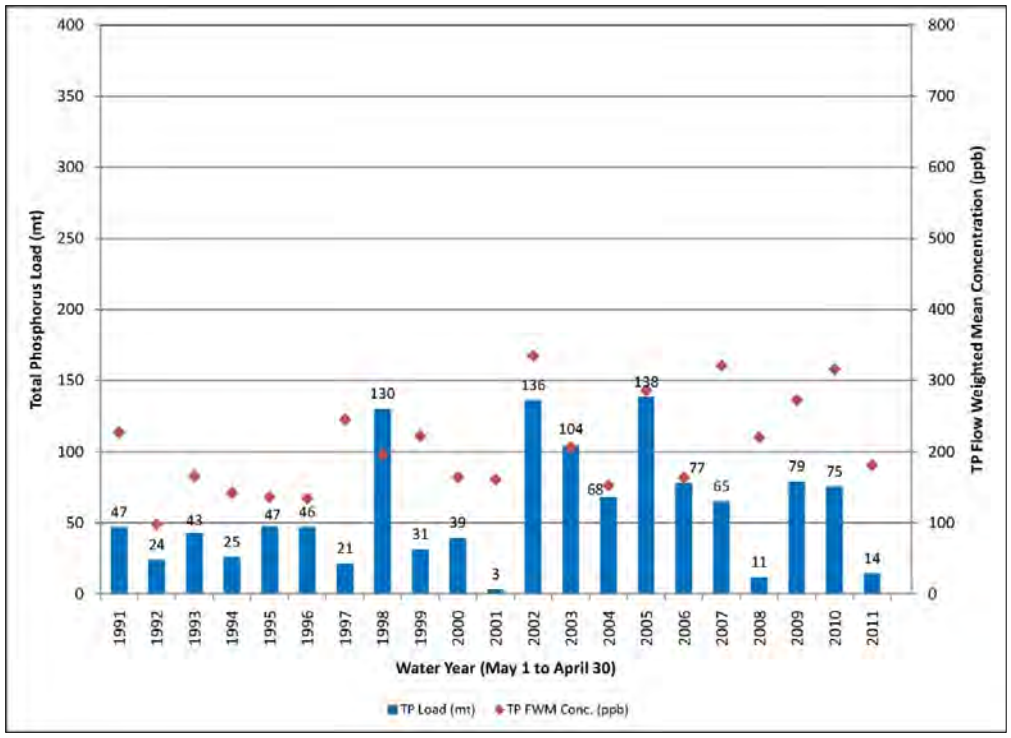


**Figure 15.** Fisheating Creek/Nicodemus Slough Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

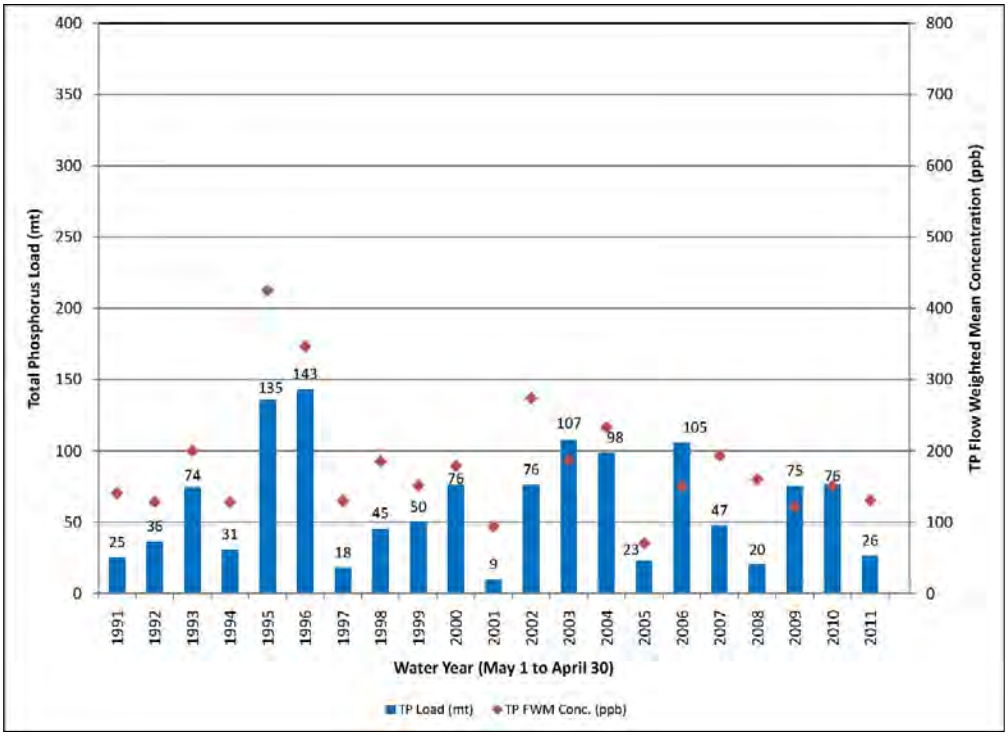


**Figure 16.** West Lake Okeechobee Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

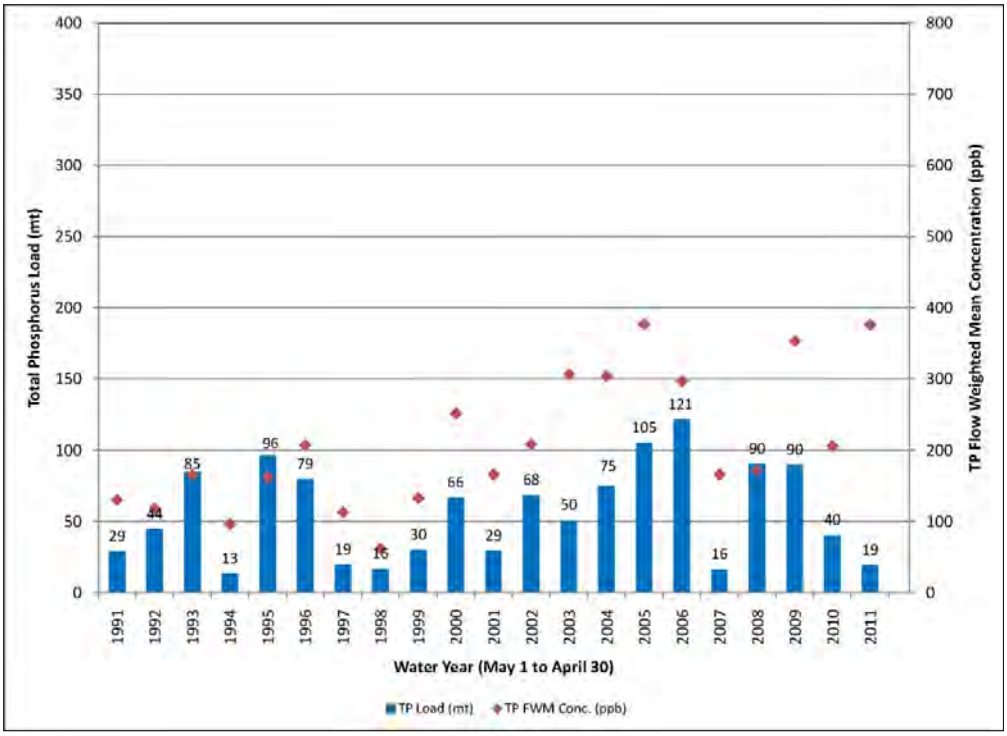


**Figure 17.** East Lake Okeechobee Sub-watershed observed TP loads and FWM concentrations (WY1991–WY2011).

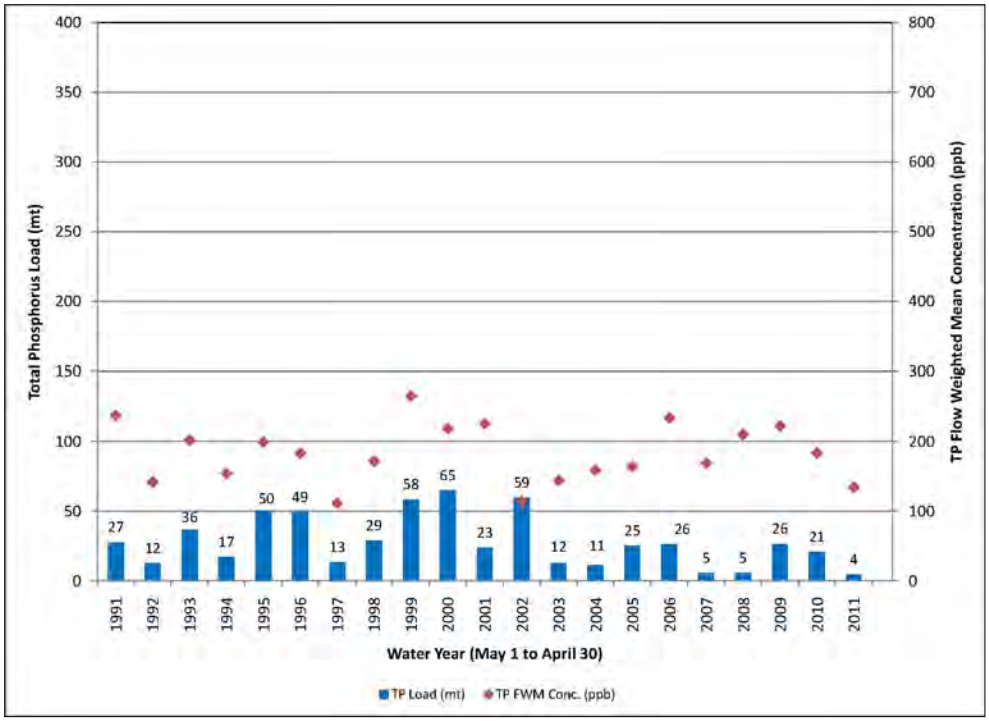


**Figure 18.** South Lake Okeechobee Sub-watershed observed TP loads (into Lake Okeechobee only) and FWM concentrations (WY1991–WY2011).

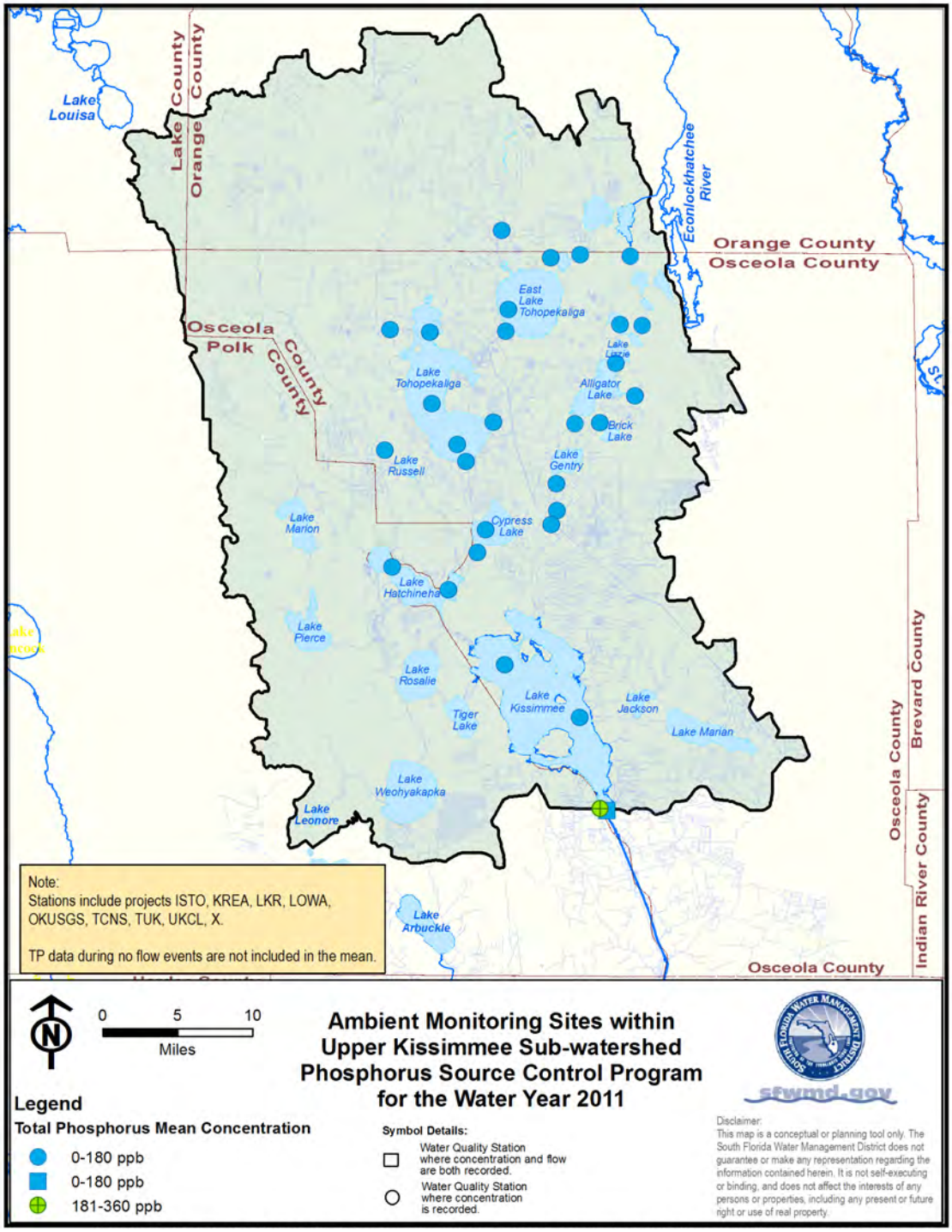


**Figure 19.** Upper Kissimmee Sub-watershed average TP concentrations (in parts per billion, or ppb) for WY2011.

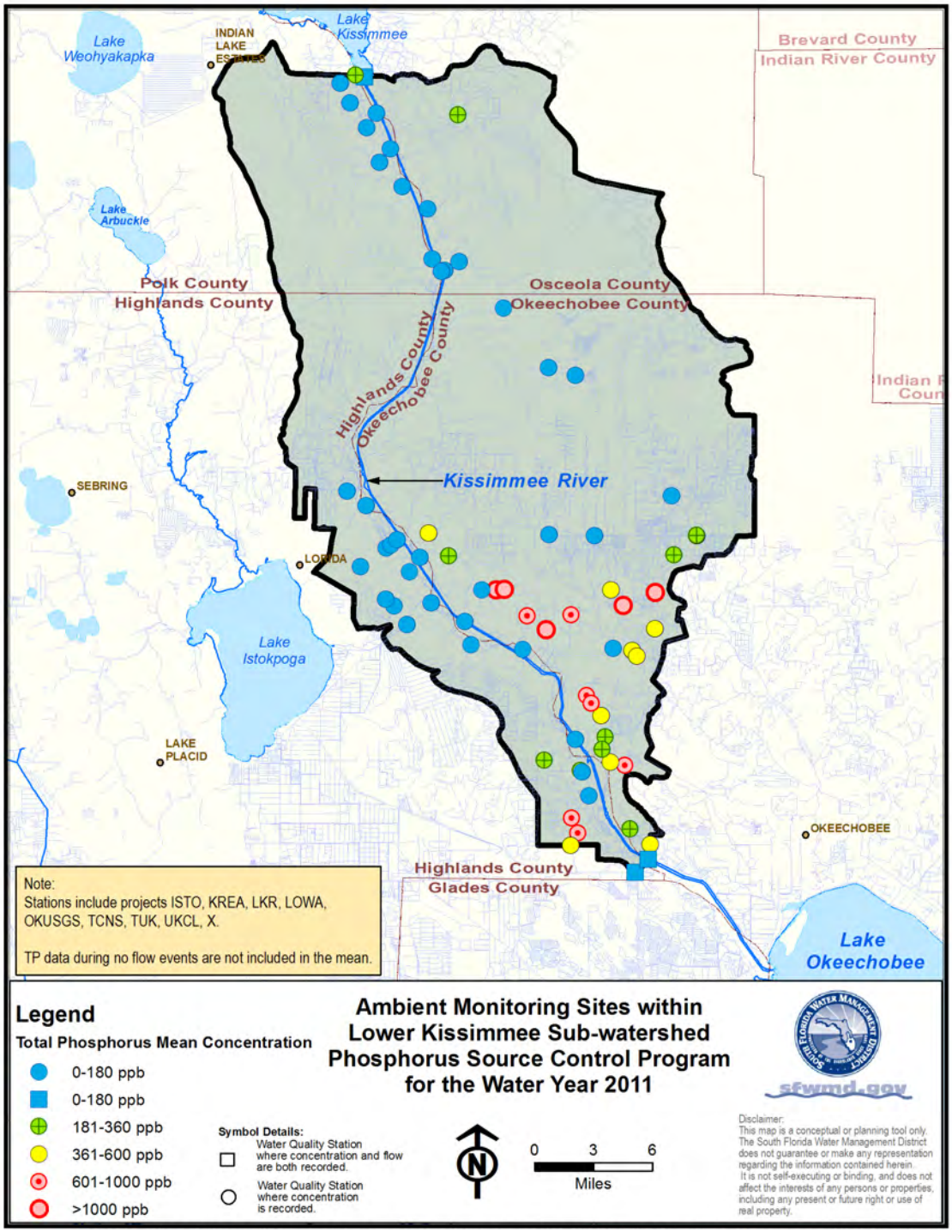


**Figure 20.** Lower Kissimmee Sub-watershed average TP concentrations (in ppb) for WY2011.

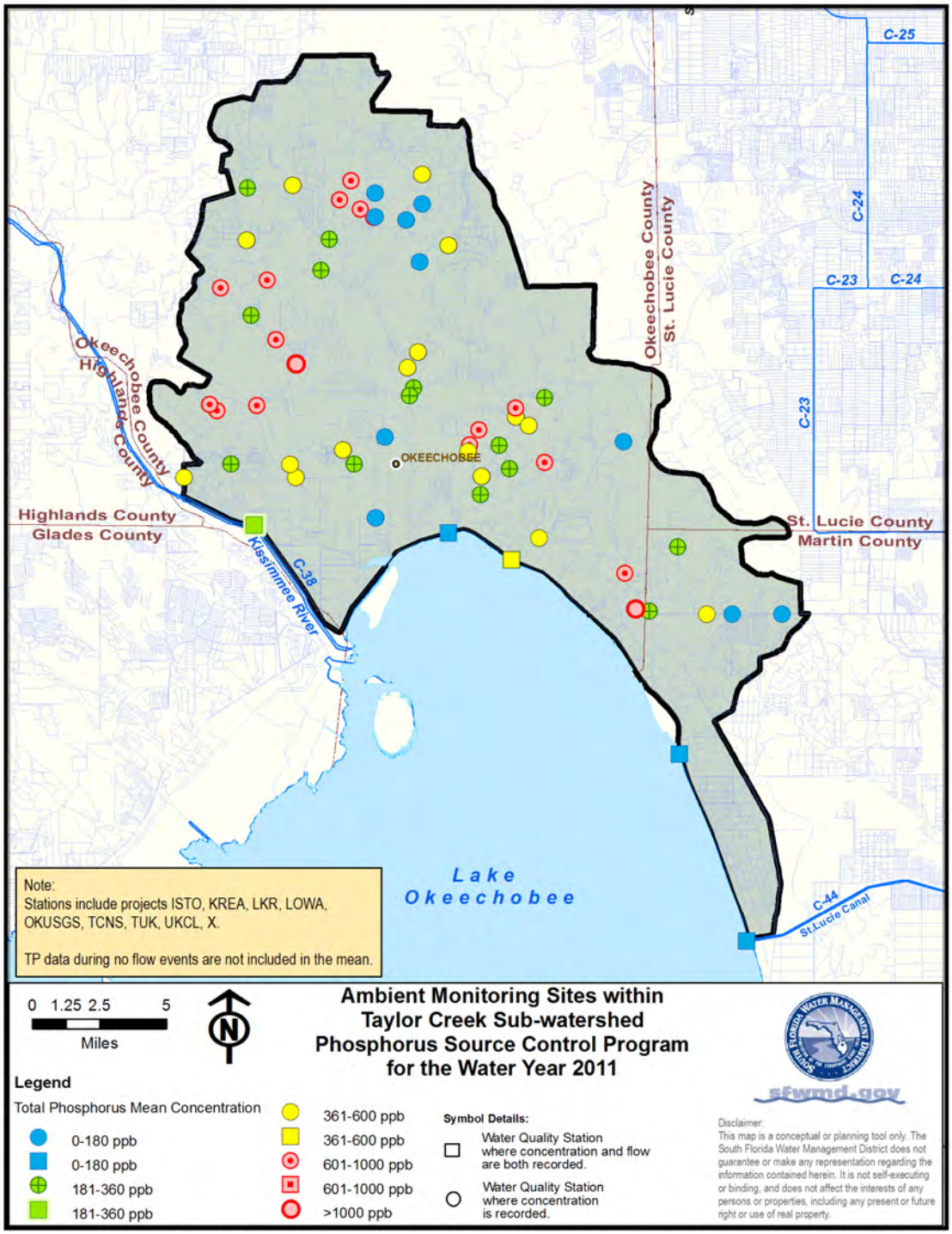


**Figure 21.** Taylor Creek/Nubbin Slough Sub-watershed average TP concentrations (in ppb) for WY2011.

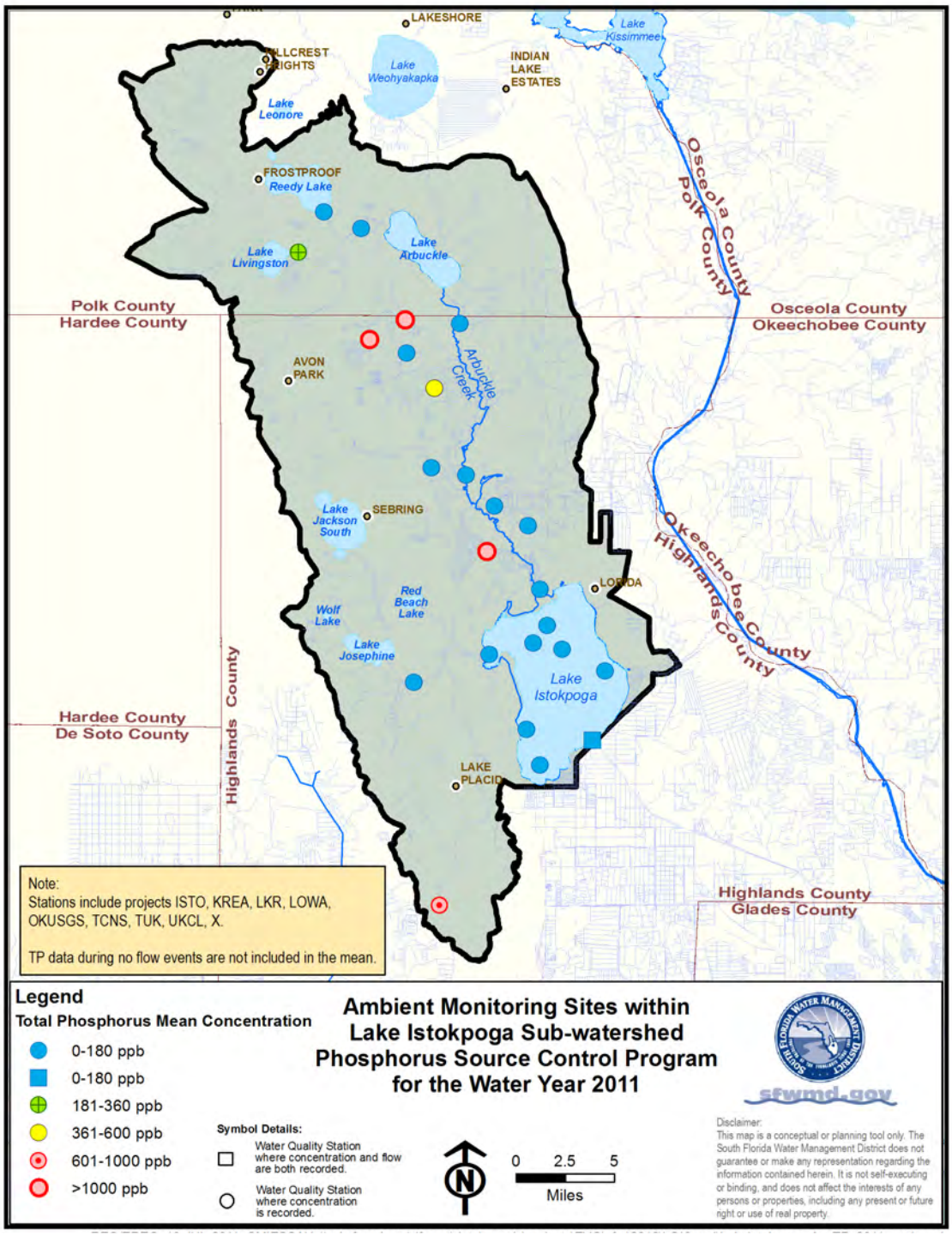


**Figure 22.** Lake Istokpoga Sub-watershed average TP concentrations (in ppb) for WY2011.

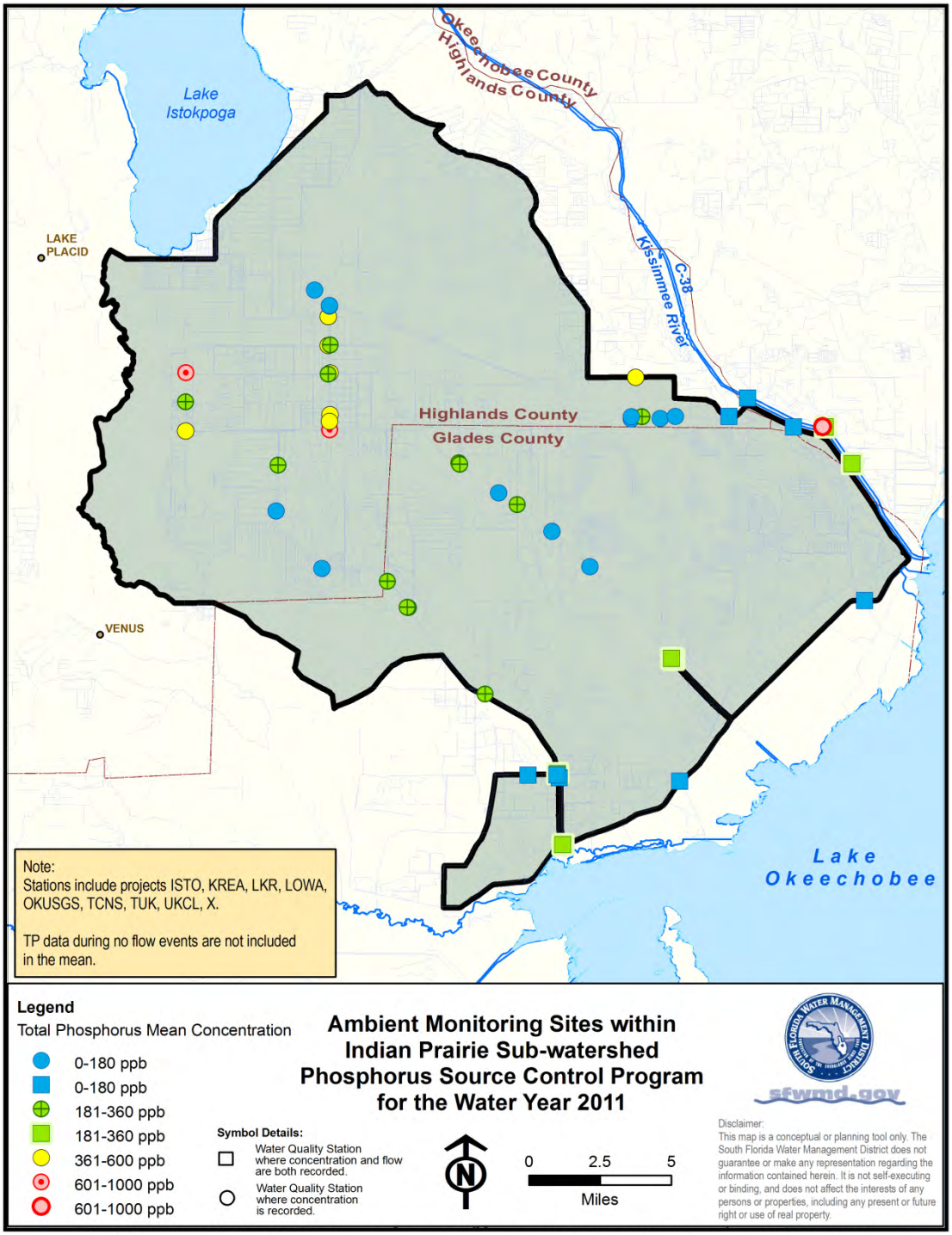


**Figure 23.** Indian Prairie Sub-watershed average TP concentrations (in ppb) for WY2011.

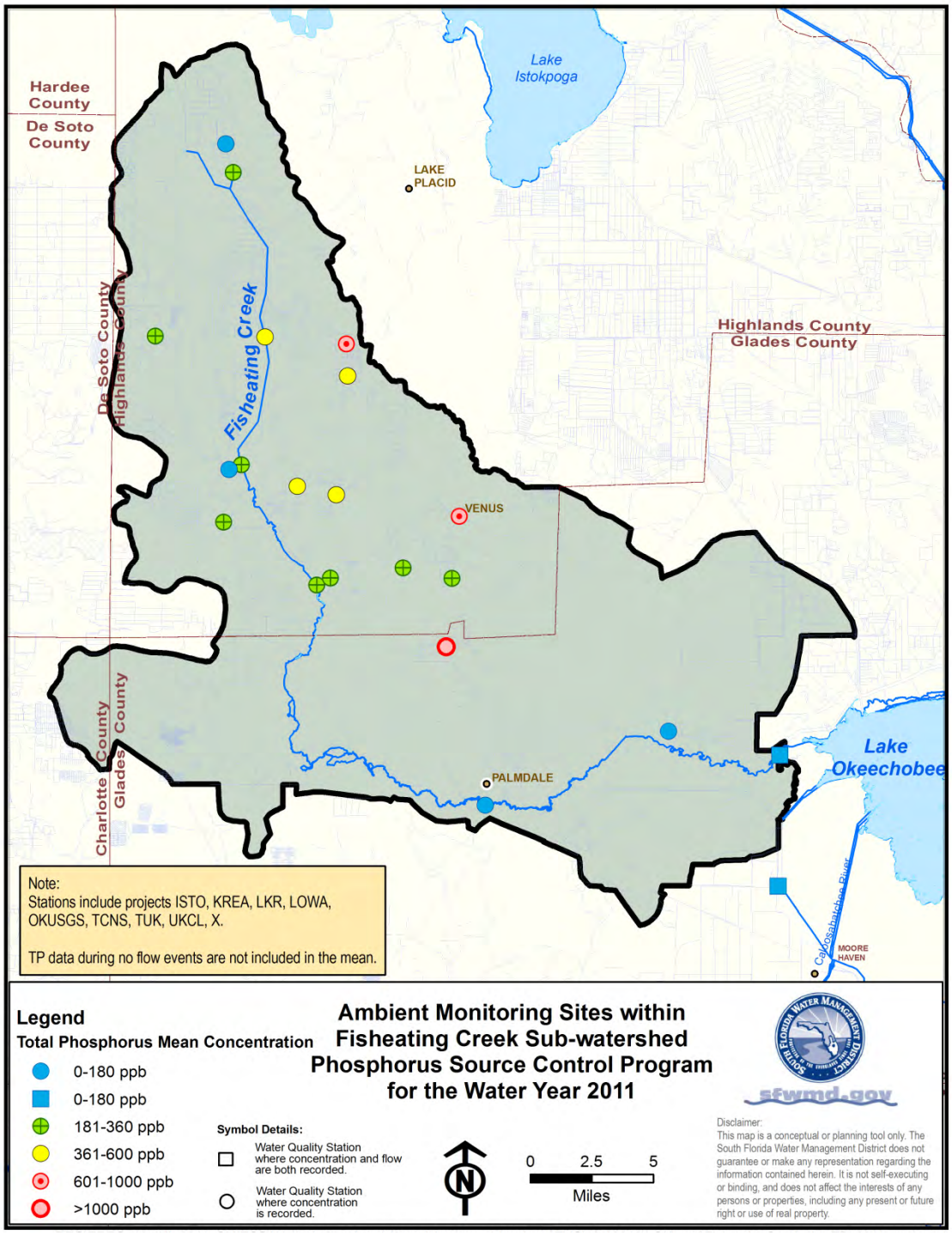


**Figure 24.** Fisheating Creek Sub-watershed average TP concentrations (in ppb) for WY2011.

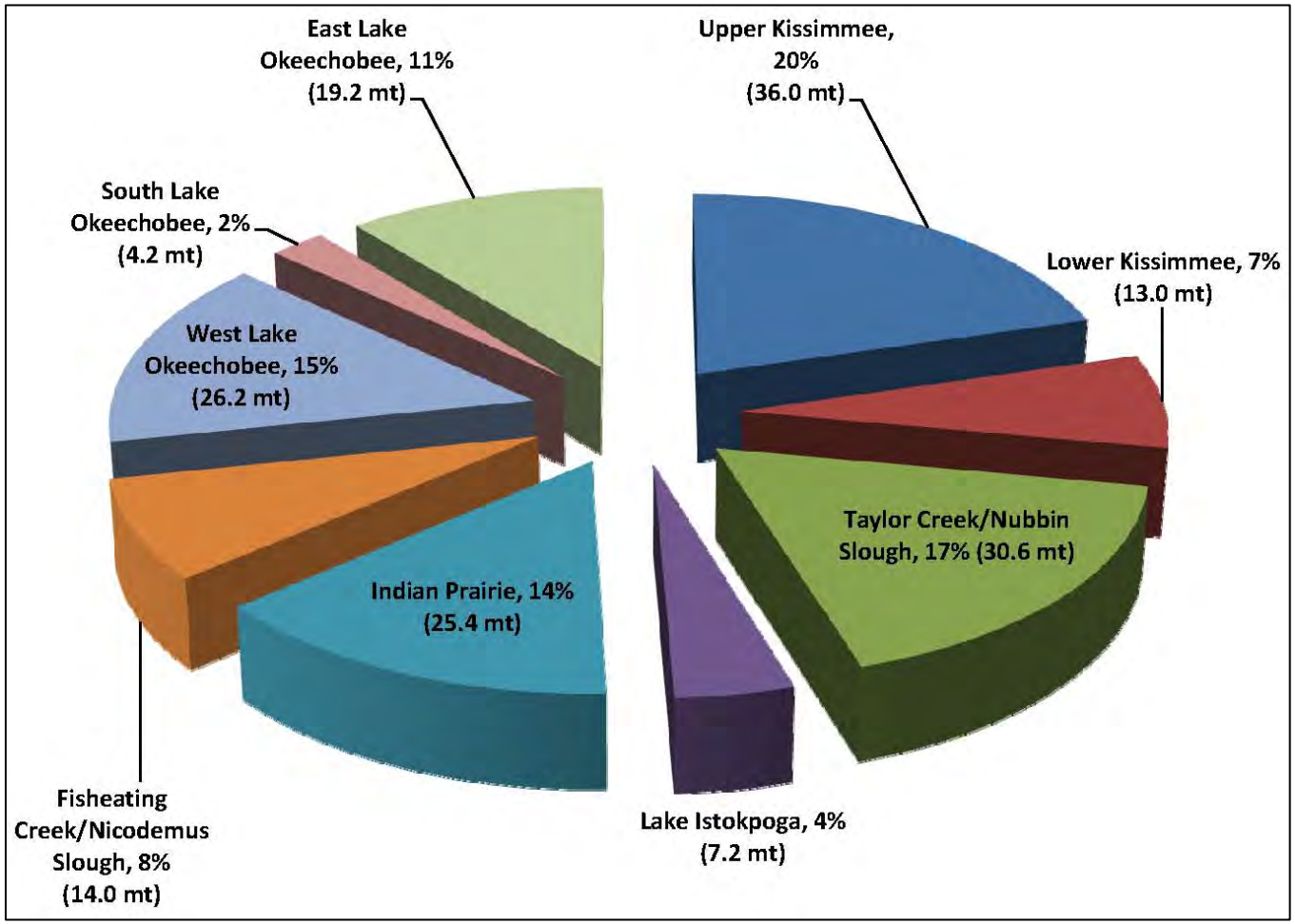


**Figure 25.** Distribution of WY2011 annual observed TP loads (in mt) within the Lake Okeechobee Watershed.

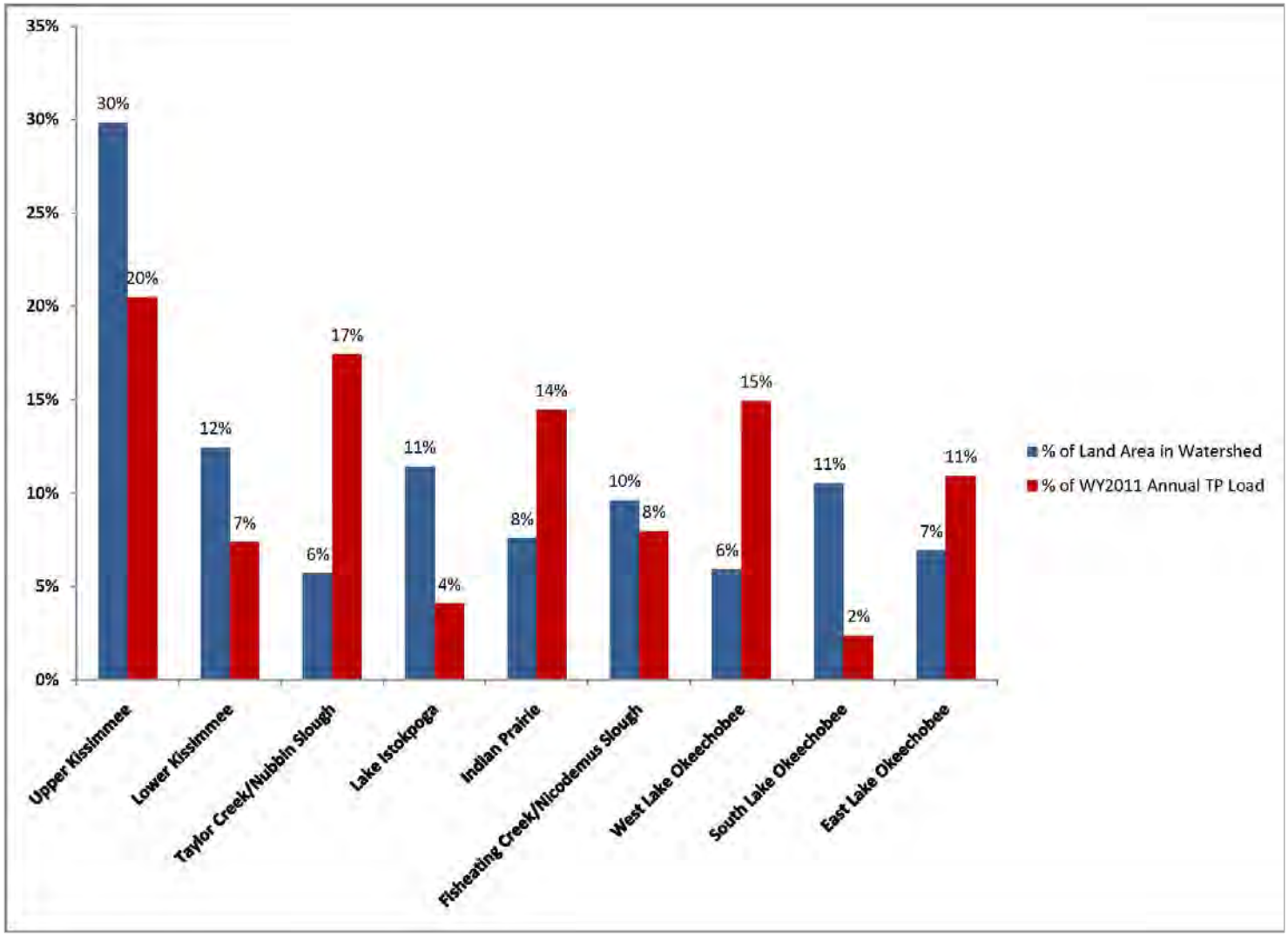


**Figure 26.** Distribution of WY2011 annual observed TP loads (in mt) and land areas for sub-watersheds within the Lake Okeechobee Watershed.

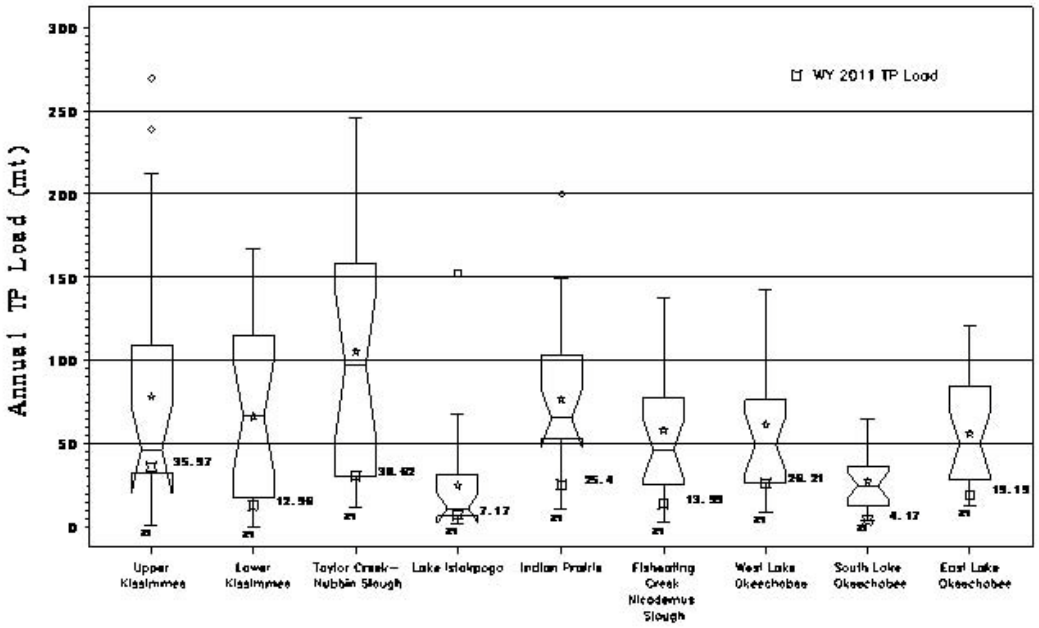


**Figure 27.** Comparison of TP loads (in mt) for each sub-watershed within the Lake Okeechobee Watershed as a box-and-whisker plot.

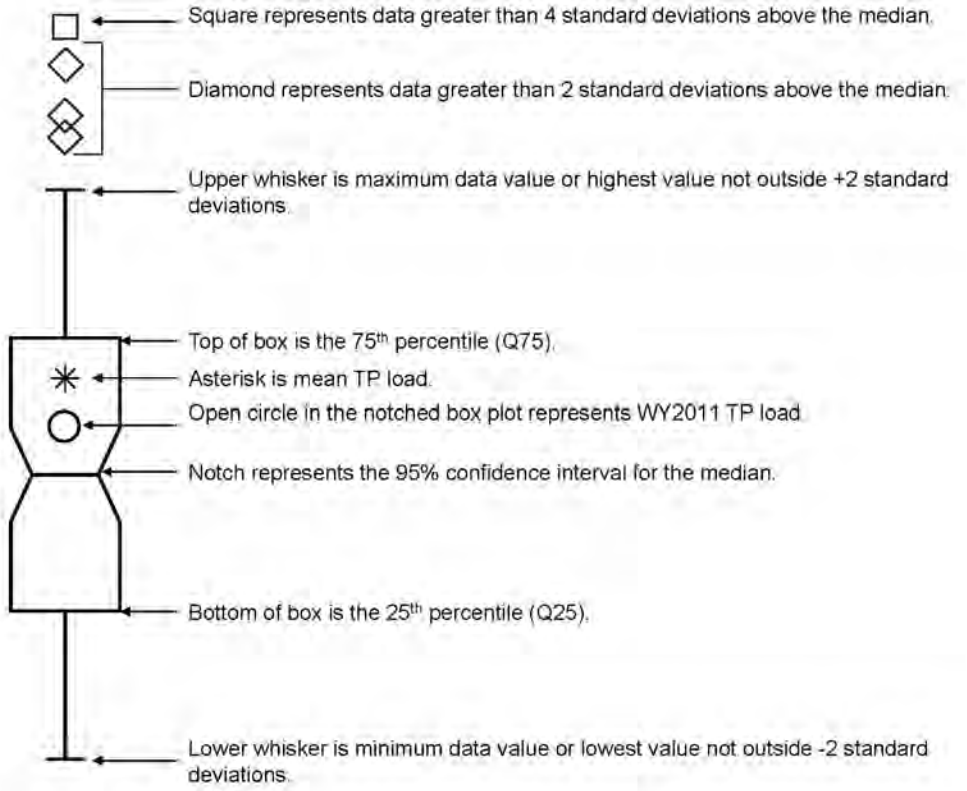


**Figure 28.** Description of box-and-whisker plot used in this appendix.