Appendix 4-1: Water Year 2012 Supplemental Evaluations for Regulatory Source Control Programs in the Lake Okeechobee Watershed

Kathleen Edgemon

Contributors: Chad Rucks, Steffany Gornak, Cheol Mo, Lucia Baldwin, William Baker, Cordella Miessau and Lacramioara Ursu

INTRODUCTION

The South Florida Water Management District (District/SFWMD) 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 Lake Okeechobee Watershed Phosphorus Source Control Program consists of a combination of distinct and coordinated efforts, including the SFWMD Works of the District (WOD) Phosphorus Control Program, SFWMD Environmental Resource Permitting (ERP)/Surface Water Management Permitting (SW), and Florida Department of Agriculture and Consumer Services (FDACS) Notice of Intent Best Management Practices (BMP) Program. The WOD program is a mandated nonpoint source control program focusing on nutrient discharges from new and existing rule-specified agricultural and nonagricultural land uses in portions of the watershed. The ERP/SW permits apply to agricultural and nonagricultural 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 BMP 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 2013. The District will then request approval from the Office of Fiscal Accountability and Regulatory Reform to amend Chapter 40E-61, Florida Administrative Code (F.A.C). 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 described in the South Florida Water Management District Nutrient Source Control Programs section of Chapter 4 of this volume, while this appendix is specific to the Lake Okeechobee Watershed. Geospatial coverage of these source control programs in the each sub-watershed are provided in **Figures 1** through **16** (all figures appear after text and tables) in the Lake Okeechobee Watershed, including lands that have WOD and ERP/SW permits, and agricultural lands that are enrolled in an FDACS BMP program based on Notice of Intent to Implement documentation as of June 2012.

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 2012 (WY2012) (May 1, 2011–April 30, 2012), 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). The data presented in this appendix consists of the current water year TP loads along with TP loads for the past 10 years (WY2002–WY2011). 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 a 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 load 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 BMPs implemented on site. For the first year, this report on phosphorus loading excludes 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 are 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) 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 of this volume, which assess the water quality of the watershed as a whole.

LAKE OKEECHOBEE WATERSHED TOTAL PHOSPHORUS LOADS

Consistent with the Lake Okeechobee Watershed Construction Project Phase II Technical Plan (SFWMD et al., 2008), the Lake Okeechobee Watershed is divided into 16 performance basins, which consist of sub-watersheds and summary basins. The sub-watershed and summary basin boundaries have been revised based on recent hydrologic studies. Table 4-1 in Chapter 4 presents observed annual TP loads for each of the 16 performance basins in the Lake Okeechobee Watershed for WY2012. TP loads measured from all land areas within the watershed are reported in this section, regardless of where the flow is discharged. This includes discharges into the watersheds of the St. Lucie and Caloosahatchee rivers. For example, for basins in 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 17** through **32** show the observed basin performance for each basin since WY2002.

UPPER KISSIMMEE

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 WY2002 are provided in **Figure 17**. The WY2012 TP load was 61.5 metric tons (mt), with a FWM concentration of 61 parts per billion (ppb).

Because most of the storm water from the Upper Kissimmee Sub-watershed flows directly into the multiple lakes and not through the primary canal system, the majority of the runoff is not monitored. Monitoring sites on three major tributaries were identified as locations that may be used to characterize the effectiveness of the source control programs. These tributaries are included **Table 1**, along with S-63A, a site identified as having high TP concentrations with a recommendation to continue monitoring.

Table 1. Water Year 2012 (WY2012) (May 1, 2011–April 30, 2012) Upper Kissimmee tributary monitoring. [Note: ac-ft – acre-feet, mt – metric tons; NA - not available, ppb – parts per billion; TP – total phosphorus.]

Tributary/Site	Flow (ac-ft)	TP FWMC[1] (ppb)	TP Load (mt)
Boggy Creek	65,965	29	2.38
Shingle Creek	97,967	55	6.64
Reedy Creek	NA	54	NA
S-63A Site	96,373	114	13.53

[1]Reedy Creek represents a mean that is not flow weighted.

LOWER KISSIMMEE

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 18**. The WY2012 TP load was 109.9 mt, with a FWM concentration of 201 ppb.

S-133

The observed annual TP loads and FWM concentrations for the S-133 Summary Basin are based on samples and flows measured at the S-133 structure (**Figure 19**). The WY2012 TP load was 0.3 mt, with a FWM concentration of 233 ppb.

S-135

The observed annual TP loads and FWM concentrations for the S-135 Summary Basin are based on samples and flows measured at the S-135 structure (**Figure 20**). The WY2012 TP load was 0.01 mt, with a FWM concentration of 39 ppb.

S-154

The observed annual TP loads and FWM concentrations for the S-154 Summary Basin are based on samples and flows measured at the S-154 structure (**Figure 21**). The WY2012 TP load was 6.1 mt, with a FWM concentration of 599 ppb.

S-154C

The observed annual TP loads and FWM concentrations for the S-154C Summary Basin are based on samples and flows measured at the S-154C structure (**Figure 22**). The WY2012 TP load was 0.7 mt, with a FWM concentration of 387 ppb.

S-191

The observed annual TP loads and FWM concentrations for the S-191 Summary Basin are based on samples and flows measured at the S-191 structure (**Figure 23**). The WY2012 TP load was 31.4 mt, with a FWM concentration of 526 ppb.

LAKE ISTOKPOGA

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 WY2002 are provided in **Figure 24**. The WY2012 TP load was 17.4 mt, with a FWM concentration of 62 ppb.

The TP load measured at the S-68 structure includes the attenuation effect of Lake Istokpoga. To characterize the effectiveness of the source control programs for the entire sub-watershed, the tributaries shown in **Table 2** will continued to be monitored.

Table 2. WY2012 Lake Istokpoga tributary monitoring.

Tributary/Site	Flow (ac-ft)	TP Concentration (ppb)	TP Load (mt)
Arbuckle Creek	214,408	137	36.20
Josephine Creek	10,433	56	0.72

INDIAN PRAIRIE

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, L-61E, S-71, S-72, S-84, S-127, S-129, and S-131 structures. The loads that are flowing through the Indian Prairie Sub-watershed from the Lake Istokpoga Sub-watershed through the S-68 structure are accounted for in the Indian Prairie Sub-watershed load calculation, The observed annual TP loads and FWM concentrations for the Indian Prairie Sub-watershed (since WY2002) are provided in **Figure 25**. The WY2012 TP load was 32.6 mt with a FWM concentration of 361 ppb.

FISHEATING CREEK

The observed annual TP loads for the Fisheating Creek Summary Basin are based on samples and flows measured in Fisheating Creek at State Road 78 in Lakeport. The TP loads and FWM concentrations since WY2002 are provided in **Figure 26**. The WY2012 TP load was 23.7 mt with a FWM concentration of 198 ppb.

NICODEMUS SLOUGH

The observed annual TP loads for the Nicodemus Slough Summary Basin are based on samples and flows measured at the C-5 and S-342N structures. The observed TP loads and FWM concentrations since WY2002 are provided in **Figure 27**. The WY2012 TP load was 0.4 mt, with a FWM concentration of 383 ppb.

EAST CALOOSAHATCHEE

In the East Caloosahatchee Basin, the observed TP loads are based on samples and flows measured at the S-235, S-77, and S-78 structures. Flows and loads passing through this basin are accounted for at these structures also. The observed annual TP loads and FWM concentrations are provided in **Figure 28**. The WY2012 TP load was 34.0 mt with a FWM concentration of 165 ppb.

S-4/INDUSTRIAL CANAL

In the S-4/Industrial Canal Basin, the observed TP loads are based on samples and flows measured at the S-235, S-310, and EPD-07 structures. Additionally, observed flows and TP loads at the S-4 and S-169 structures are used to determine the load passing through the basin. The observed annual TP loads and FWM concentrations for the basin are provided in **Figure 29**. The WY2012 TP load was 10.8 mt with a FWM concentration of 183 ppb.

C-44

East Lake Okeechobee Sub-watershed observed annual TP loads are based on samples and flows measured at S-308C and S-80. **Figure 30** provides TP loads and FWM concentrations for the C-44 Basin. The WY2012 TP load was 10.4 mt with a FWM concentration of 170 ppb.

L-8

The L-8 Basin observed annual TP loads are based on samples and flows measured at the C-10A, S-5AS, S-5AE, S-5AW, and WPB2 structures. **Figure 31** provides TP loads and FWM concentrations for the L-8 Basin. The WY2012 TP load was 9.7 mt with a FWM concentration of 98 ppb.

SOUTH LAKE OKEECHOBEE SUB-WATERSHED

The South Lake Okeechobee Sub-watershed consists of the Everglades Agricultural Area (EAA) basins S-2, S-3, and S-5A, as well as EAA diversion basins. The EAA's existing source control performance measures are defined by Chapter 40E-63, F.A.C., and reported within Chapter 4 and Appendix 4-2 of this volume, but exclude the EAA diversion basins. The EAA

diversion basins historically discharged to Lake Okeechobee and were required by the Everglades Forever Act (EFA) to divert discharge to the EAA canals for treatment in the EAA stormwater treatment areas (STAs). The combined observed annual TP loads from the EAA diversion basins both to Lake Okeechobee and to the EAA canals is presented in this appendix.

The observed annual TP loads from the EAA diversion basins are based on samples and flows measured at the C-12A, C-10, C-12, S-236, C-4A, EBPS3, ESPS2, SSDDMC, and SFCD5E structures. [Note: The S-4 structure and the Industrial Canal (S-310) are within the Lake Okeechobee Operating Permit's South Region, but are part of the West Lake Okeechobee Sub-watershed.] The observed TP loads and FWM concentrations for the EAA diversion basins by water year are provided in **Figure 32**. The TP loading data for this sub-watershed consider only discharges from the EAA diversion basins, as the runoff from the EAA areas regulated by Chapter 40E-63, F.A.C., are not hydrologically distinguishable as within or outside the South Lake Okeechobee Sub-watershed boundary. The WY2012 TP load discharged from the South Lake Okeechobee Sub-watershed's EAA Diversion Basins was 7.7 mt with a FWM concentration of 146 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 District, 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 33** through **40.** These sites include WY2012 mean TP for all samples taken during a flow event. Note, the mean TP for stations flowing into and out of Lake Okeechobee includes flow both into and out of the lake. Also note that the sites where flow is measured are displaying means and are not flow weighted.

SUB-WATERSHED OBSERVED ANNUAL TOTAL PHOSPHORUS LOAD BREAKDOWN

Figure 41 summarizes the percentages for WY2012 observed TP load, along with the percentages of total land area represented by each sub-watershed**. Figure 42** provides a box-and-whisker plot for the 16 sub-watersheds. The data used to construct this figure included loading information from WY2002 to WY2012.

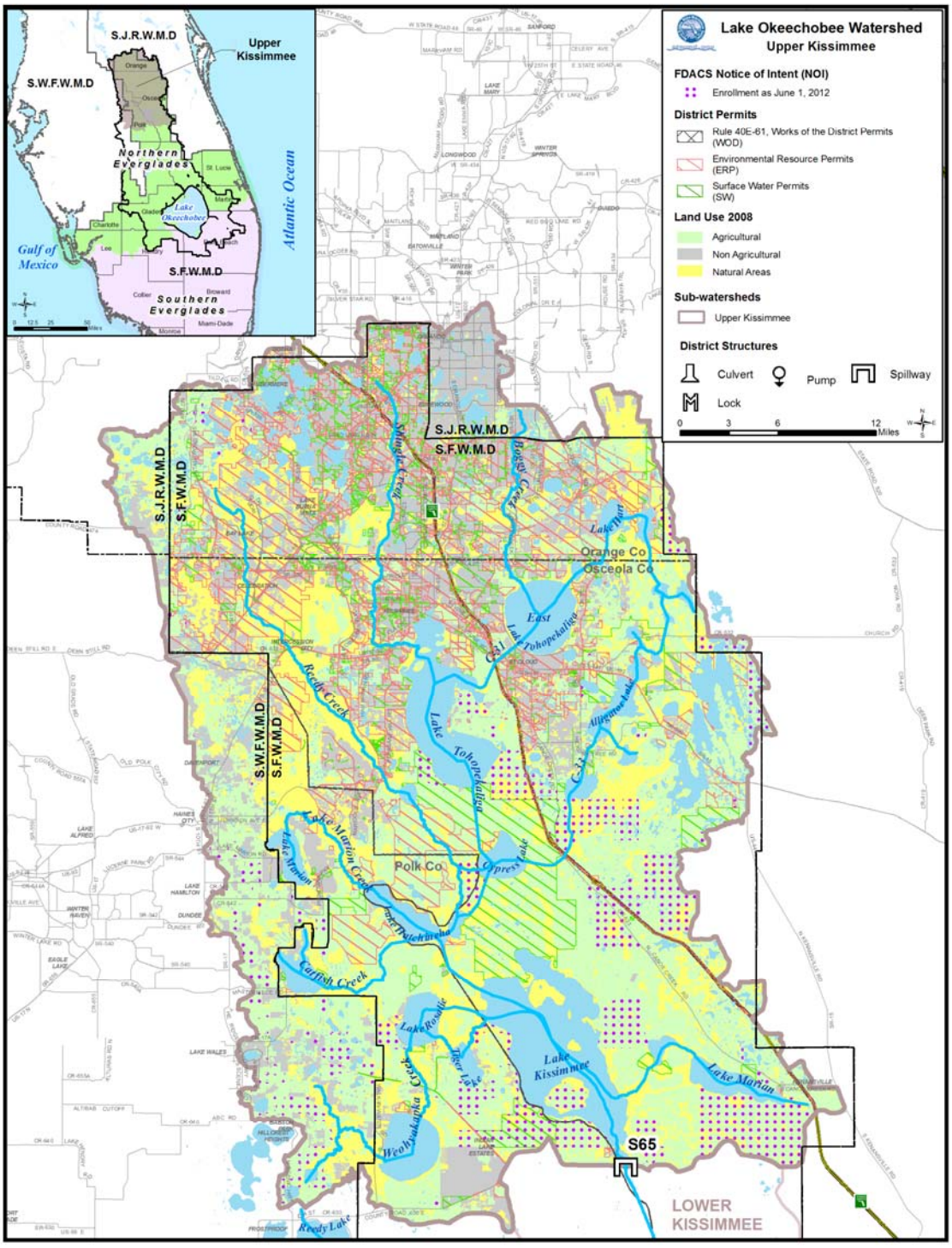


Figure 1. Source control program coverage in the Upper Kissimmee Sub-watershed. [Note: Co – County, FDACS – Florida Department of Agriculture and Consumer Services, S.F.W.M.D. – South Florida Water Management District, S.J.R.W.M.D. – St. Johns Water Management District, S.W.F.W.M.D. – Southwest Florida Water Management District.]

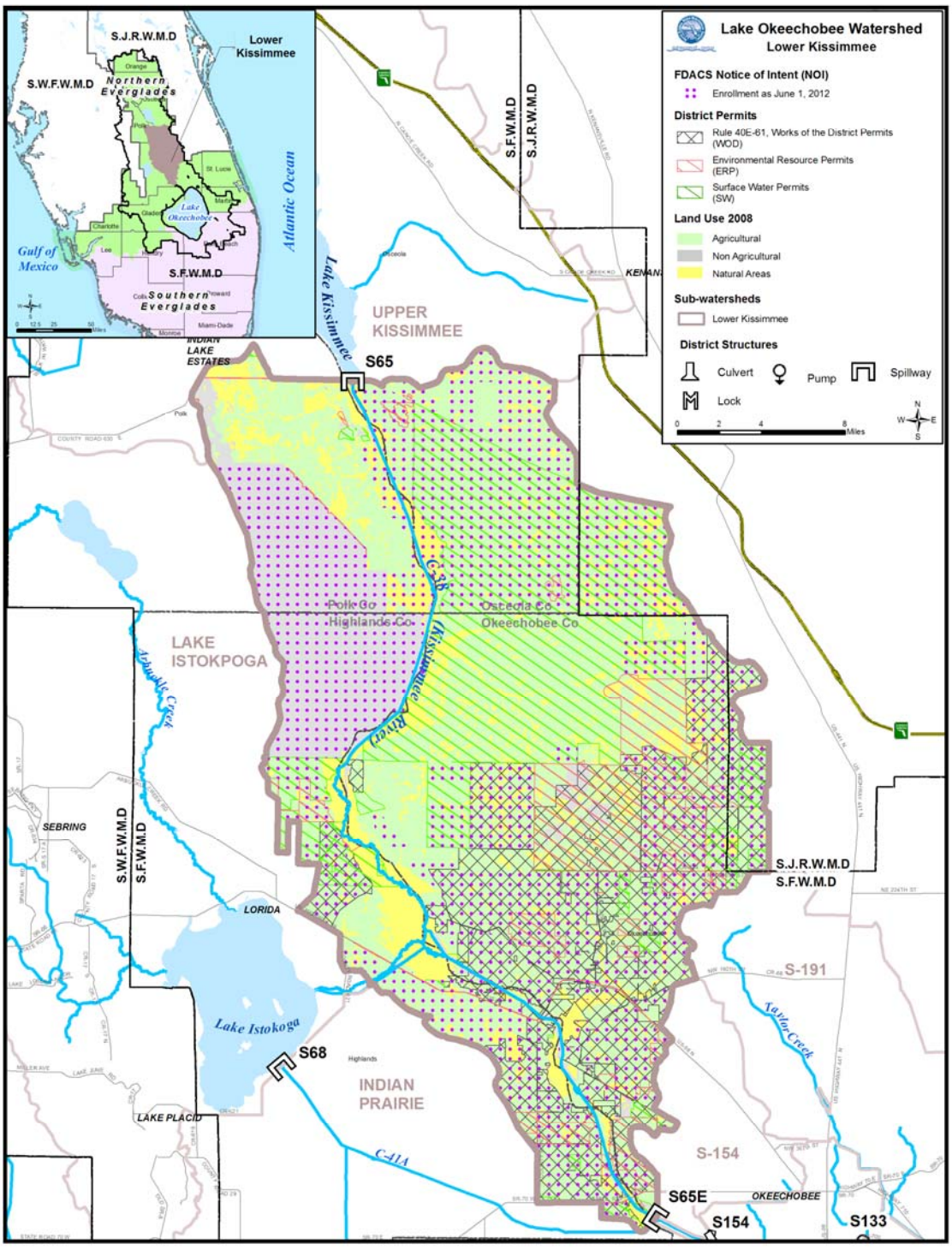


Figure 2. Source control program coverage in the Lower Kissimmee Sub-watershed.

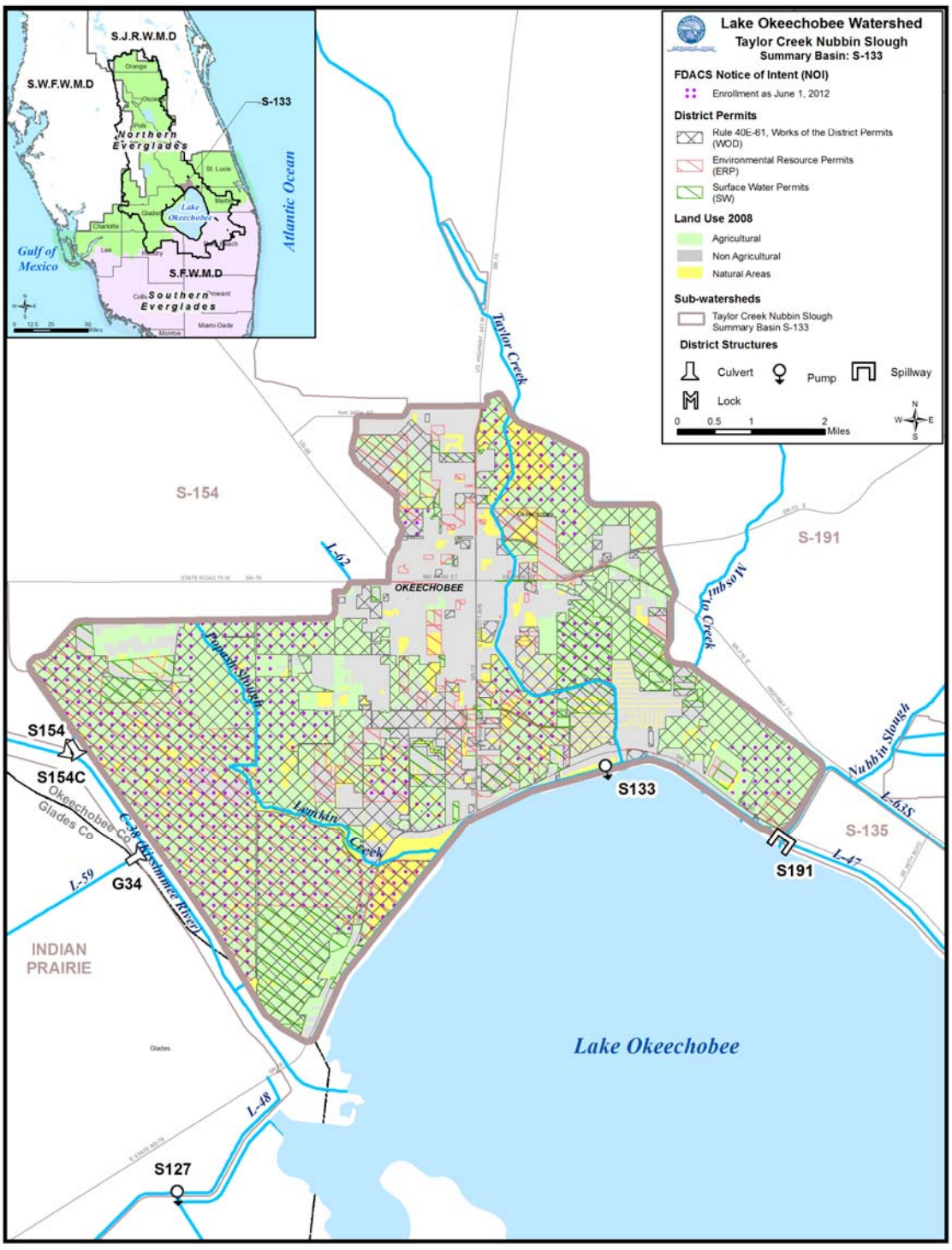


Figure 3. Source control program coverage in the Taylor Creek/Nubbin Slough Sub-watershed, S-133 Basin.

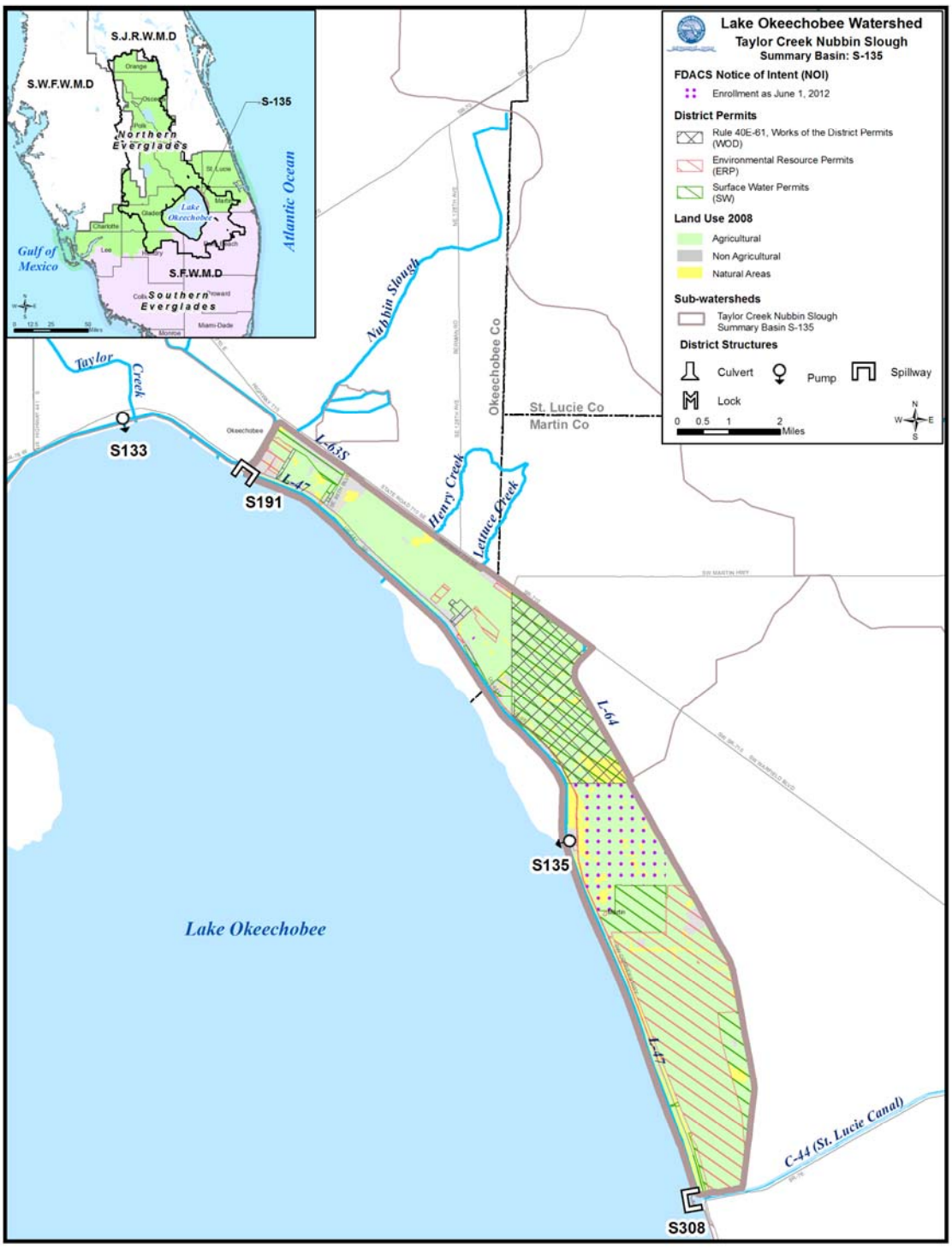


Figure 4. Source control program coverage in the Taylor Creek/Nubbin Slough Sub-watershed, S-135 Basin.

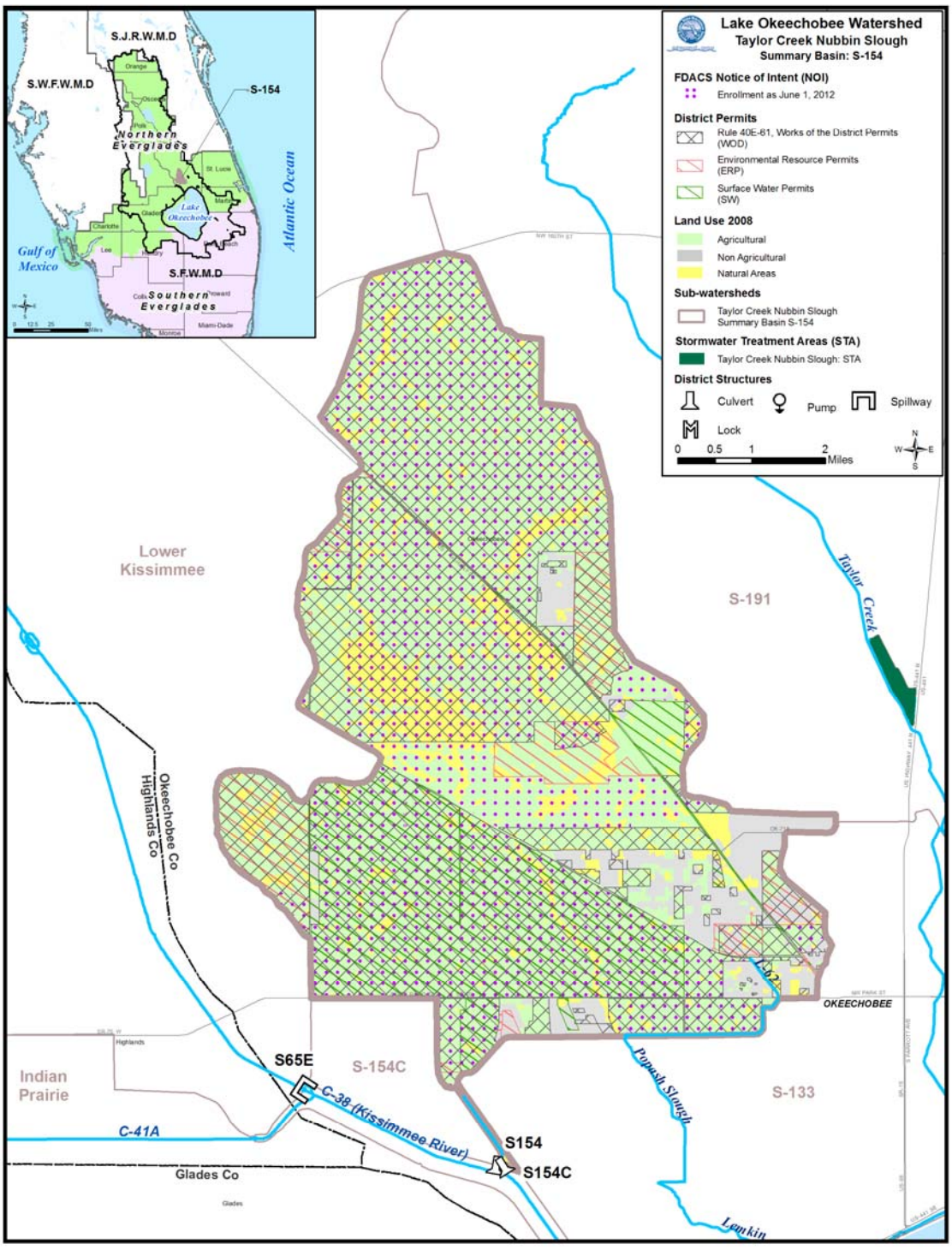


Figure 5. Source control program coverage in the Taylor Creek/Nubbin Slough Sub-watershed, S-154 Basin.

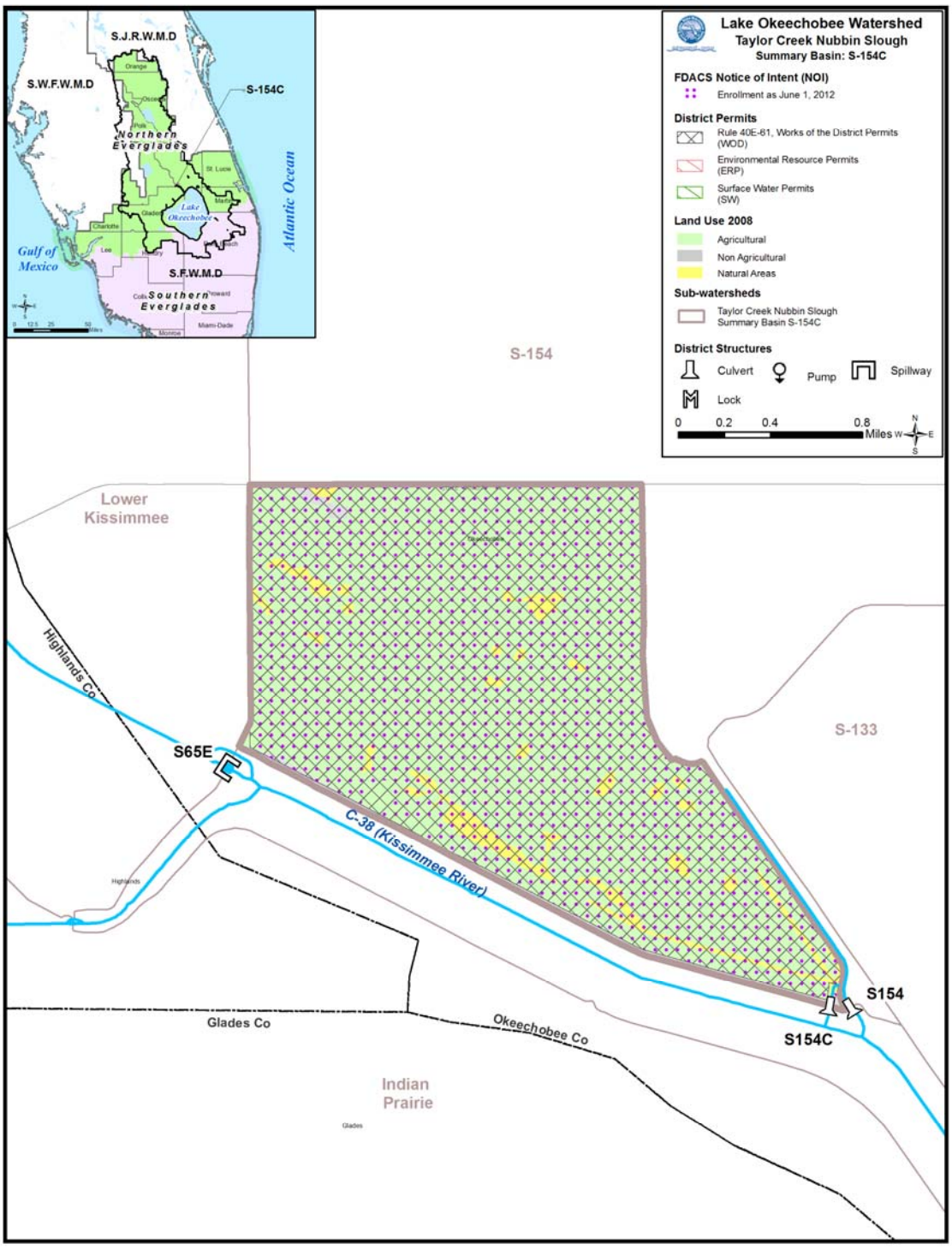


Figure 6. Source control program coverage in the Taylor Creek/Nubbin Slough Sub-watershed, S-154C Basin.

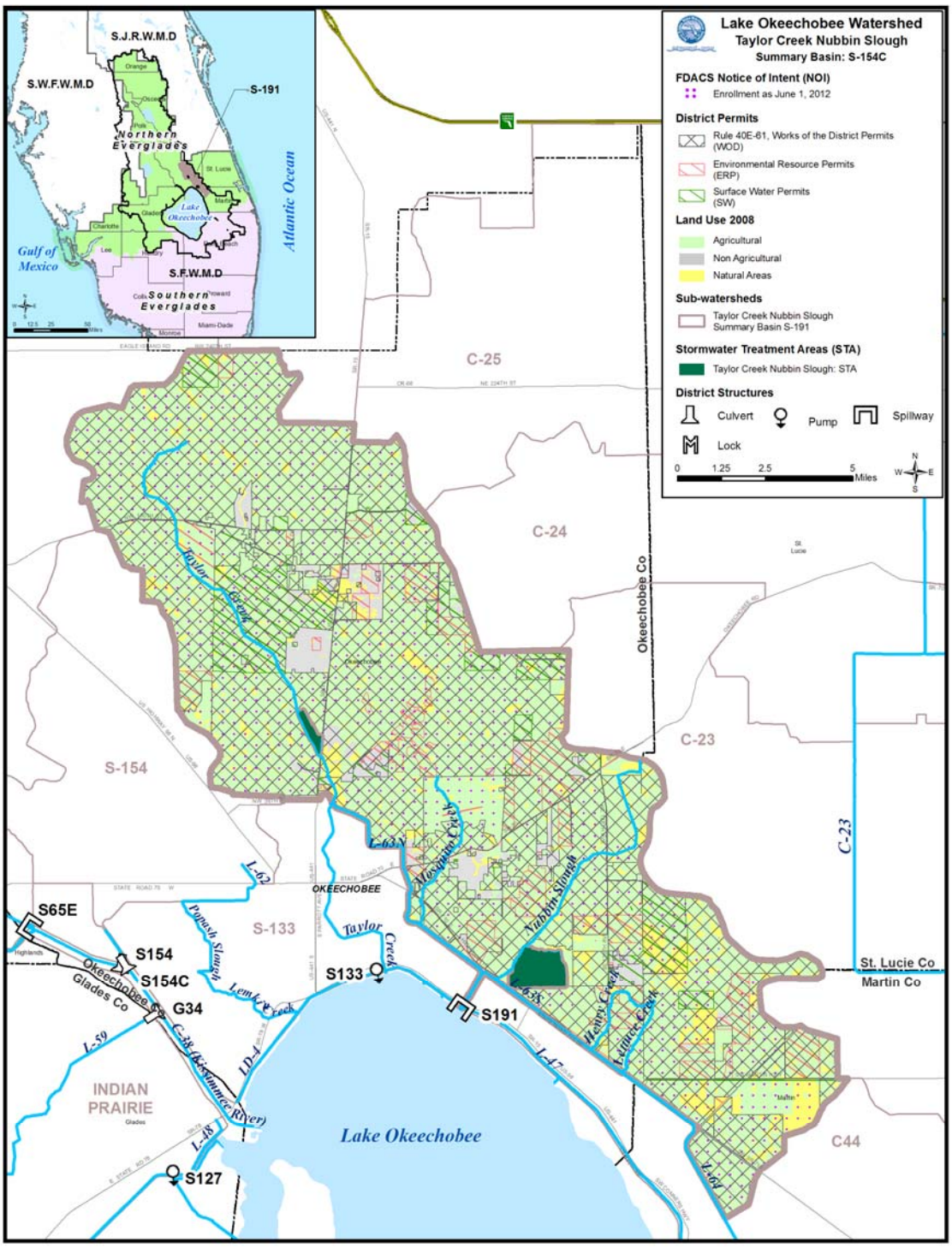


Figure 7. Source control program coverage in the Taylor Creek/Nubbin Slough Sub-watershed, S-191 Basin.

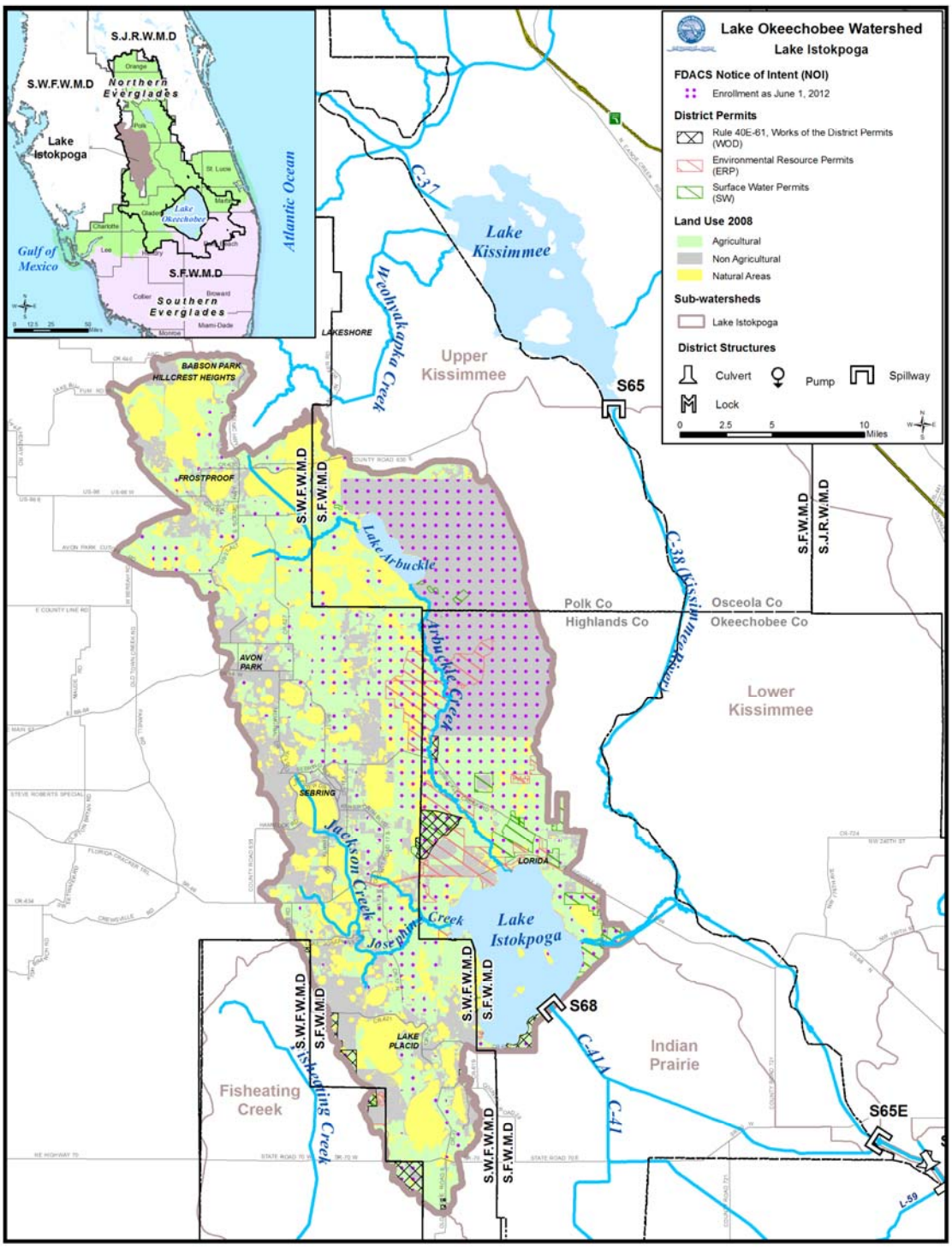


Figure 8. Source control program coverage in the Lake Istokpoga Sub-watershed.

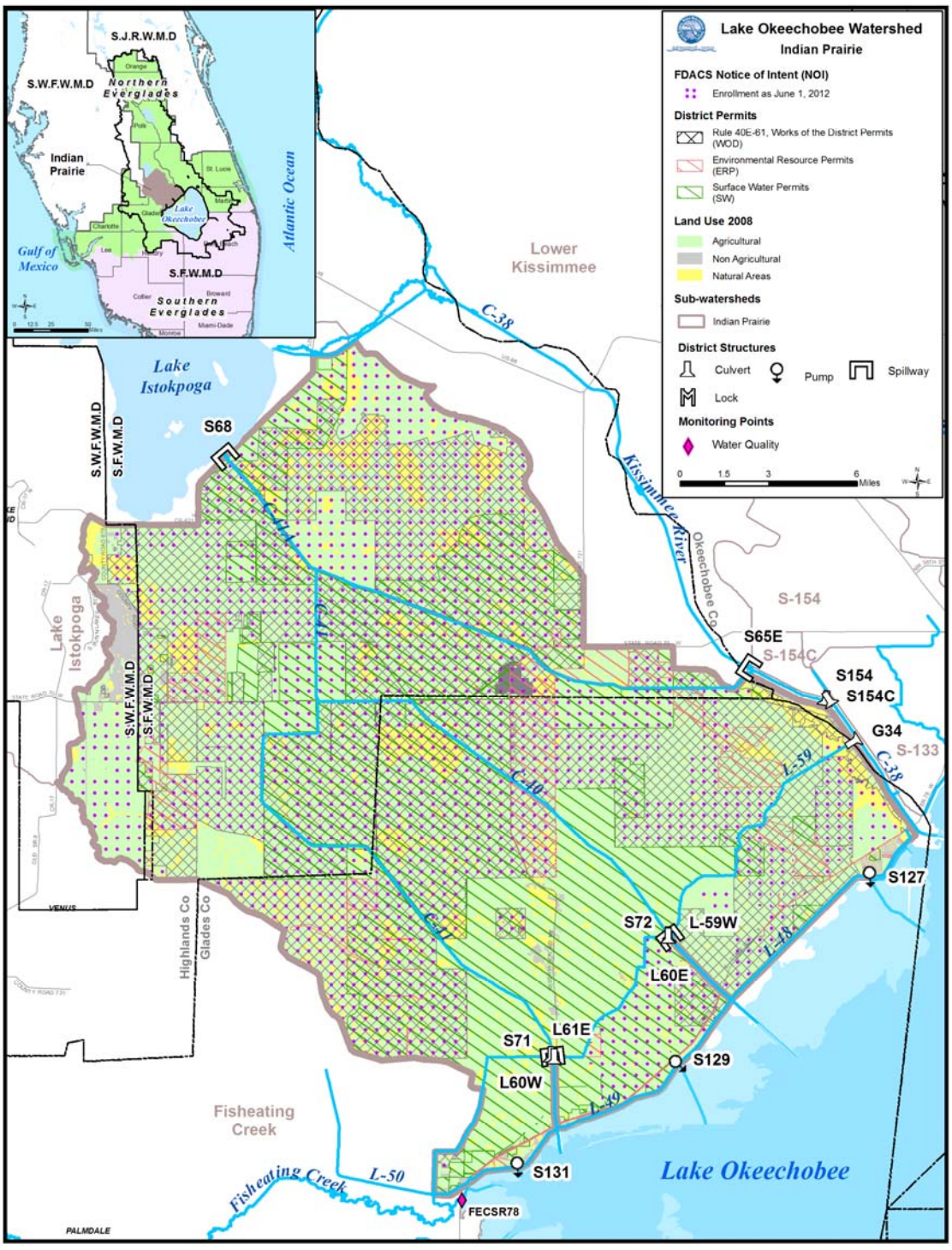


Figure 9. Source control program coverage in the Indian Prairie Sub-watershed.

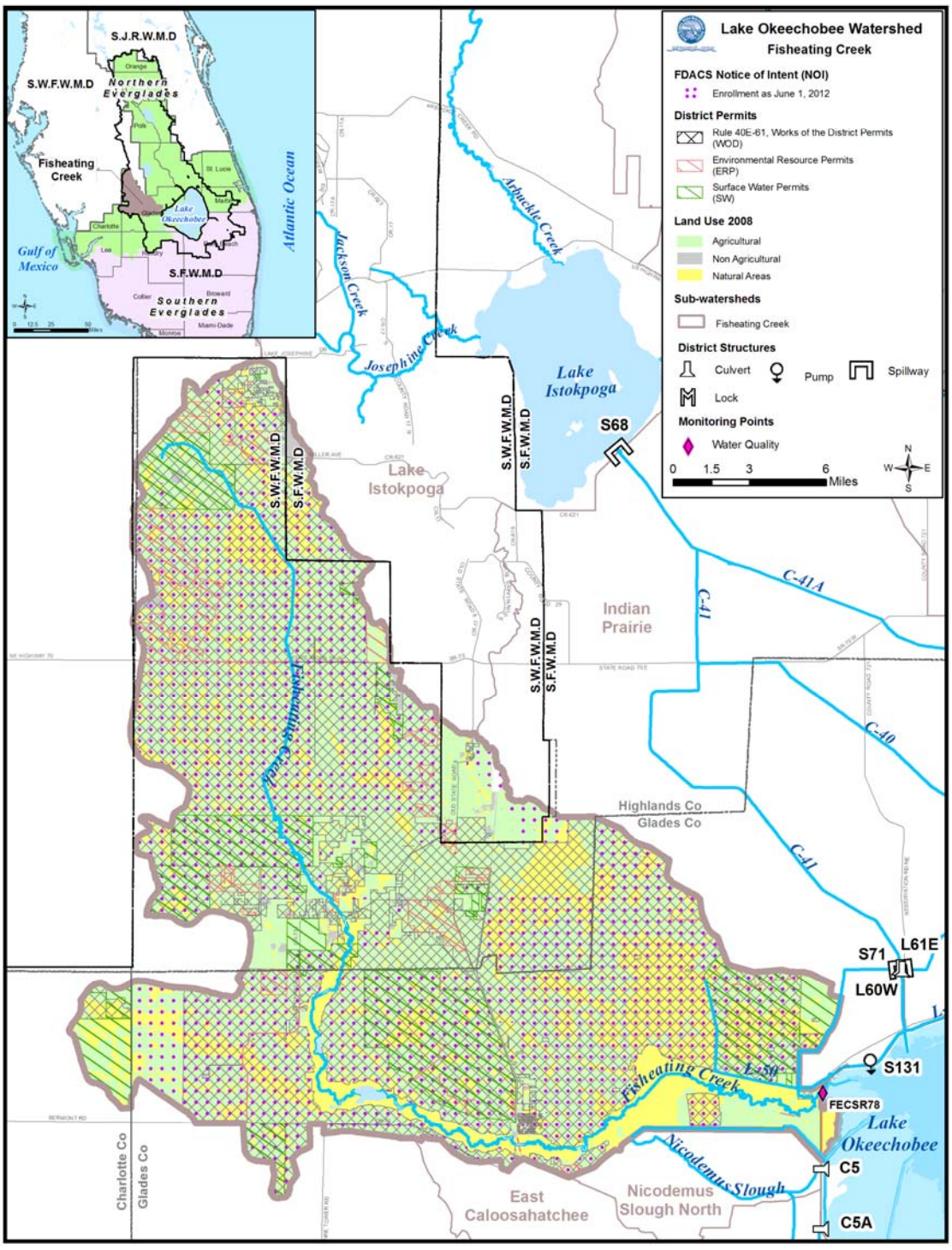


Figure 10. Source control program coverage in the Fisheating Creek Sub-watershed, Fisheating Creek Basin.

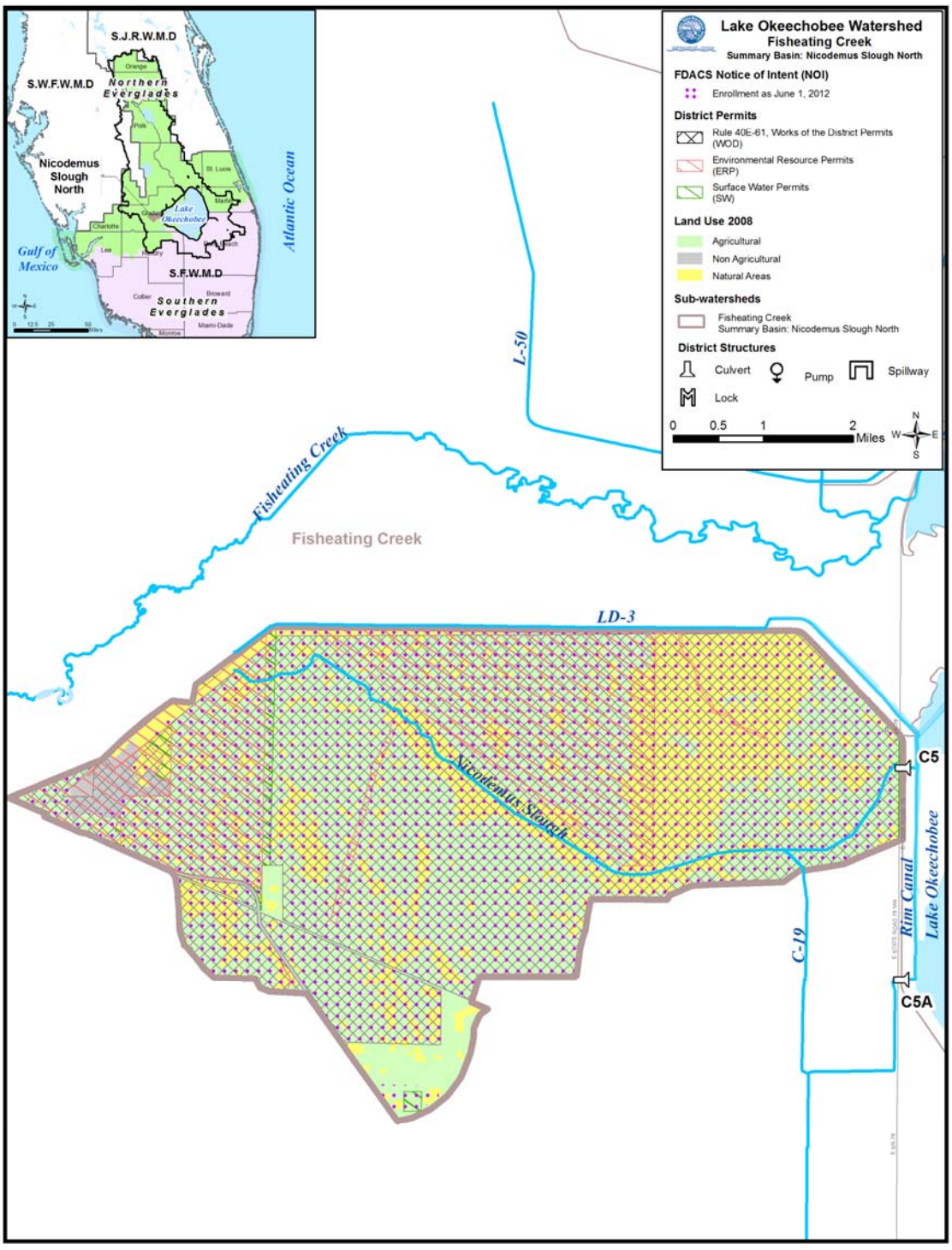


Figure 11. Source control program coverage in the Fisheating Creek Sub-watershed, Nicodemus Slough Basin.

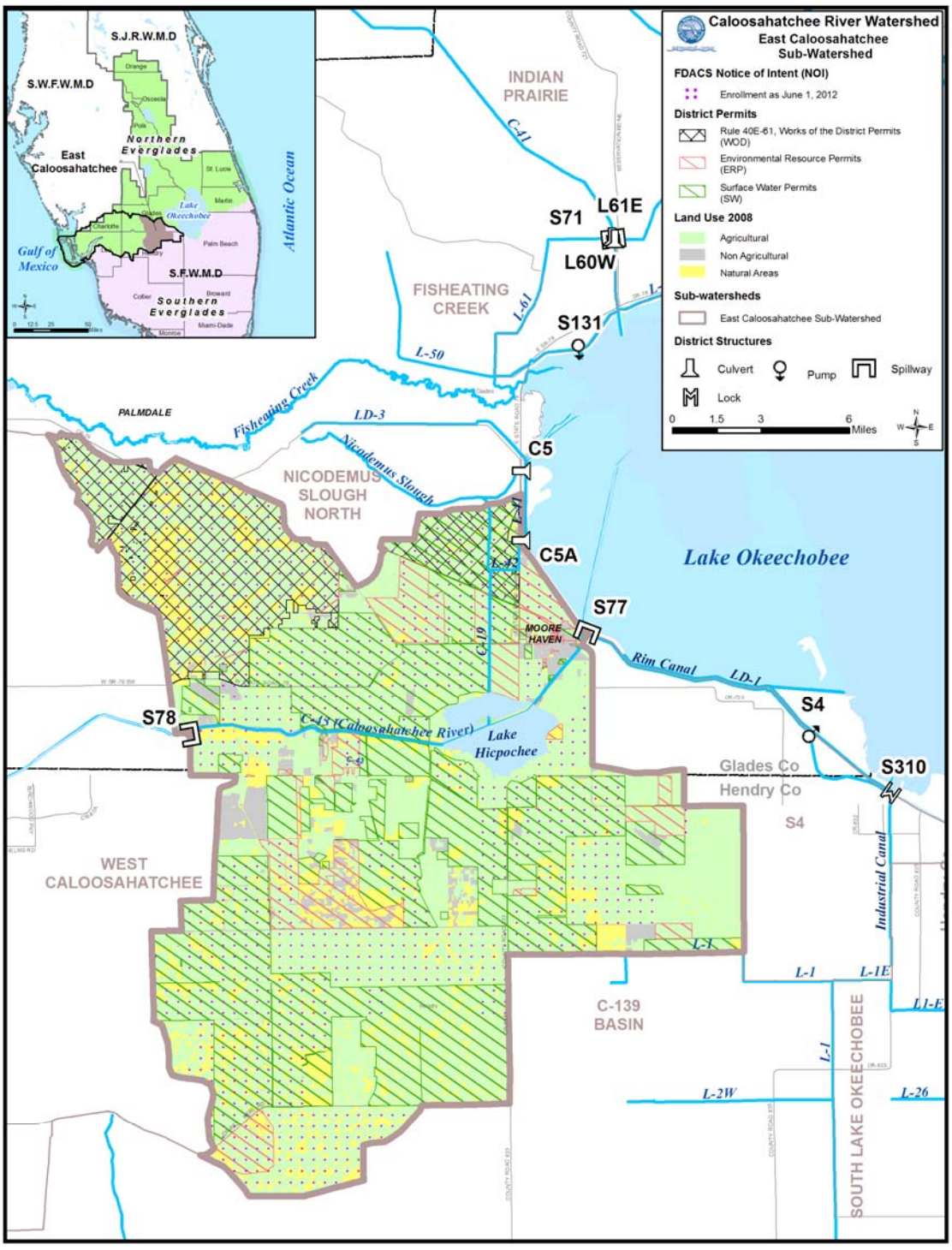


Figure 12. Source control program coverage in the West Lake Okeechobee Sub-watershed, East Caloosahatchee Basin.

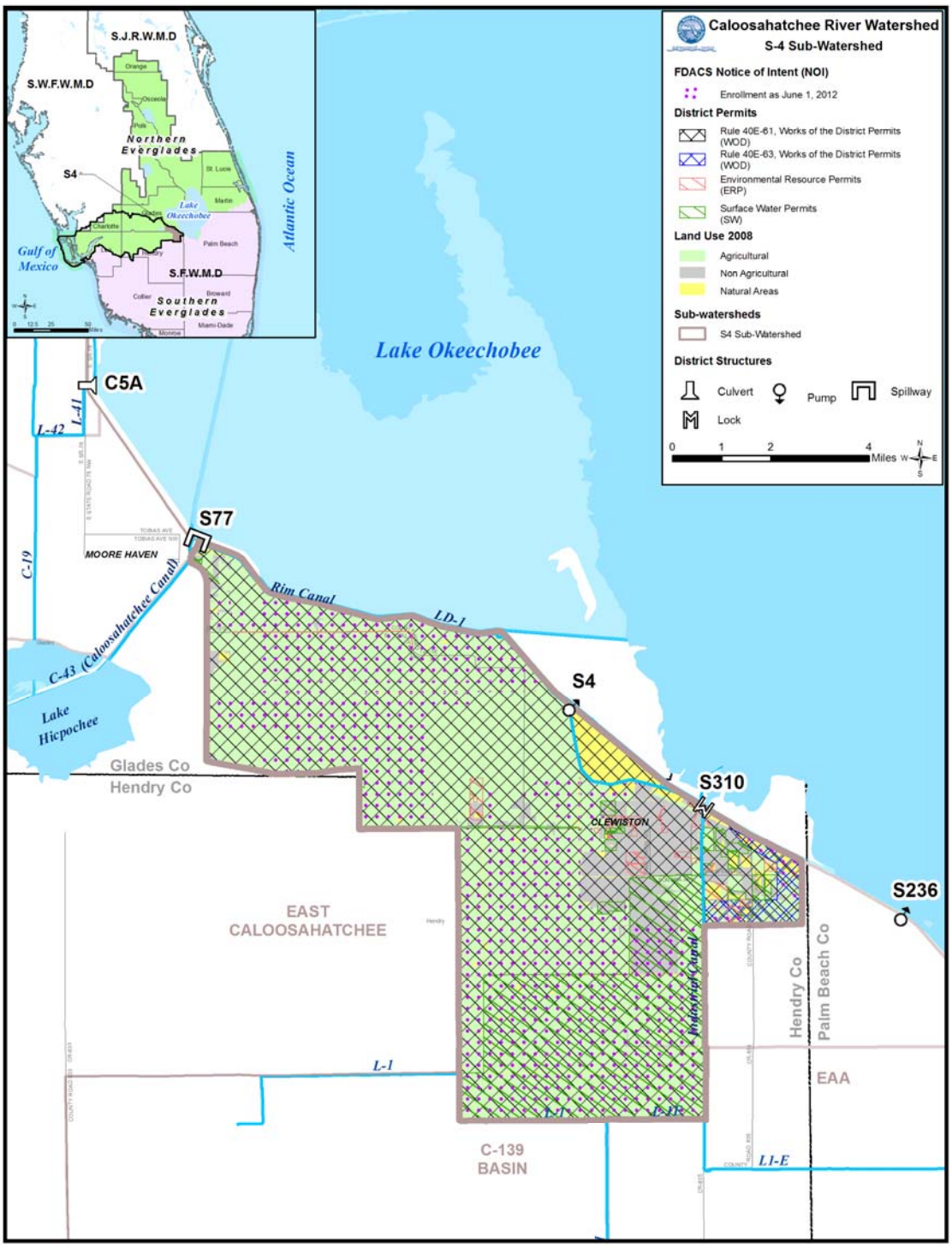


Figure 13. Source control program coverage in the West Lake Okeechobee Sub-watershed, S-4 Basin.

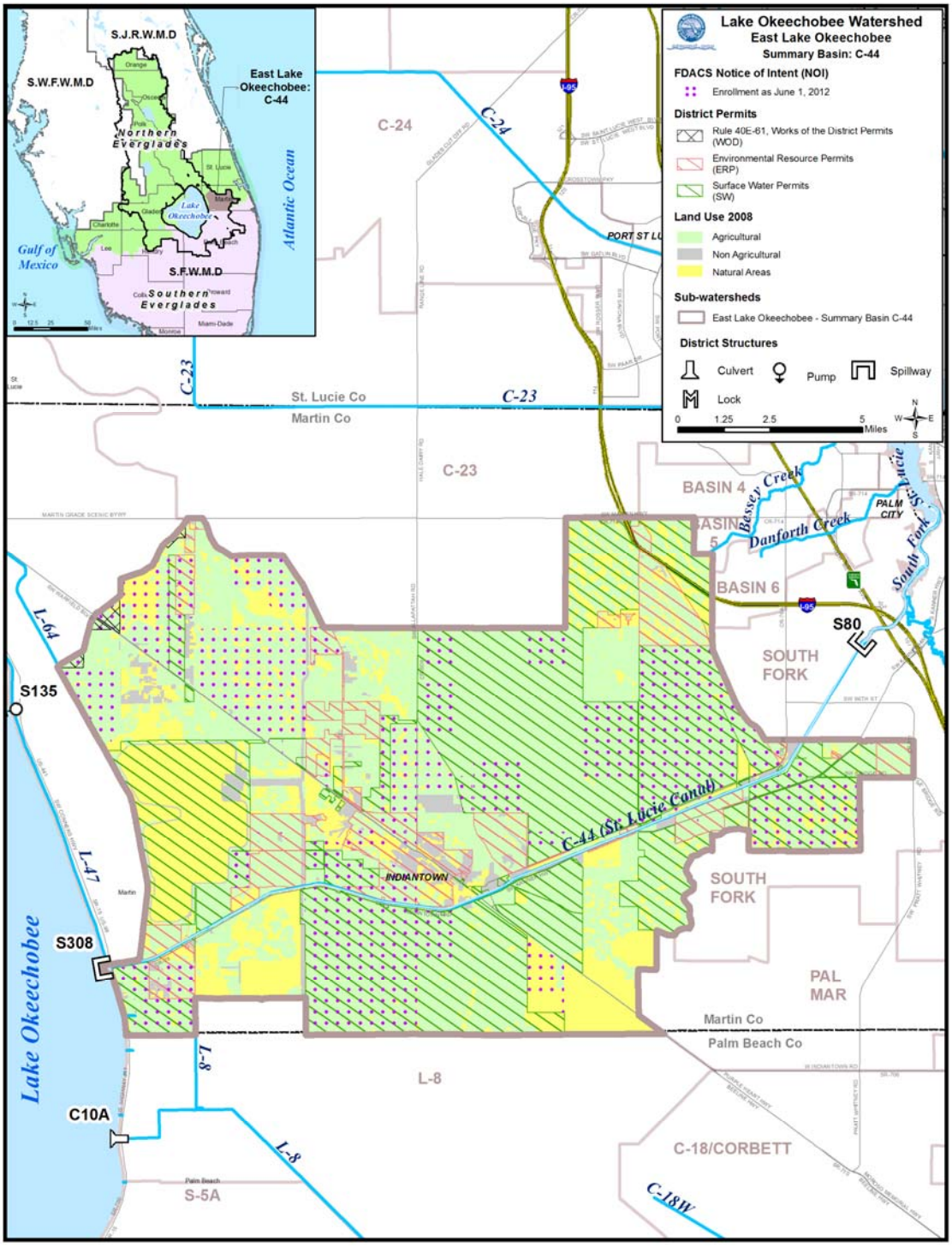


Figure 14. Source control program coverage in the East Lake Okeechobee Sub-watershed, C-44 Basin.

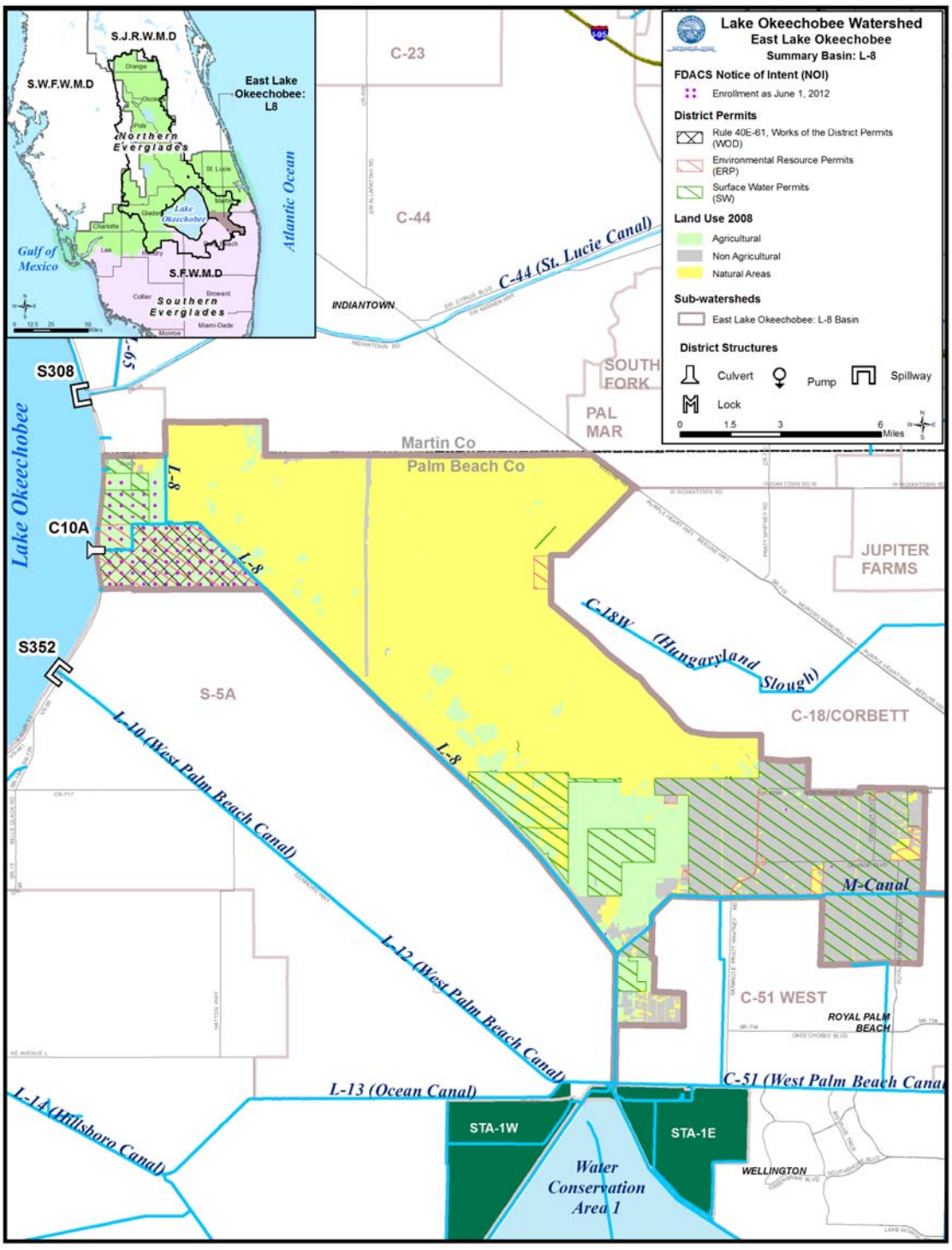


Figure 15. Source control program coverage in the East Lake Okeechobee Sub-watershed, L-8 Basin. [Note: STA-1E – Stormwater Treatment Area 1 East, STA-1W – Stormwater Treatment Area 1 West.]

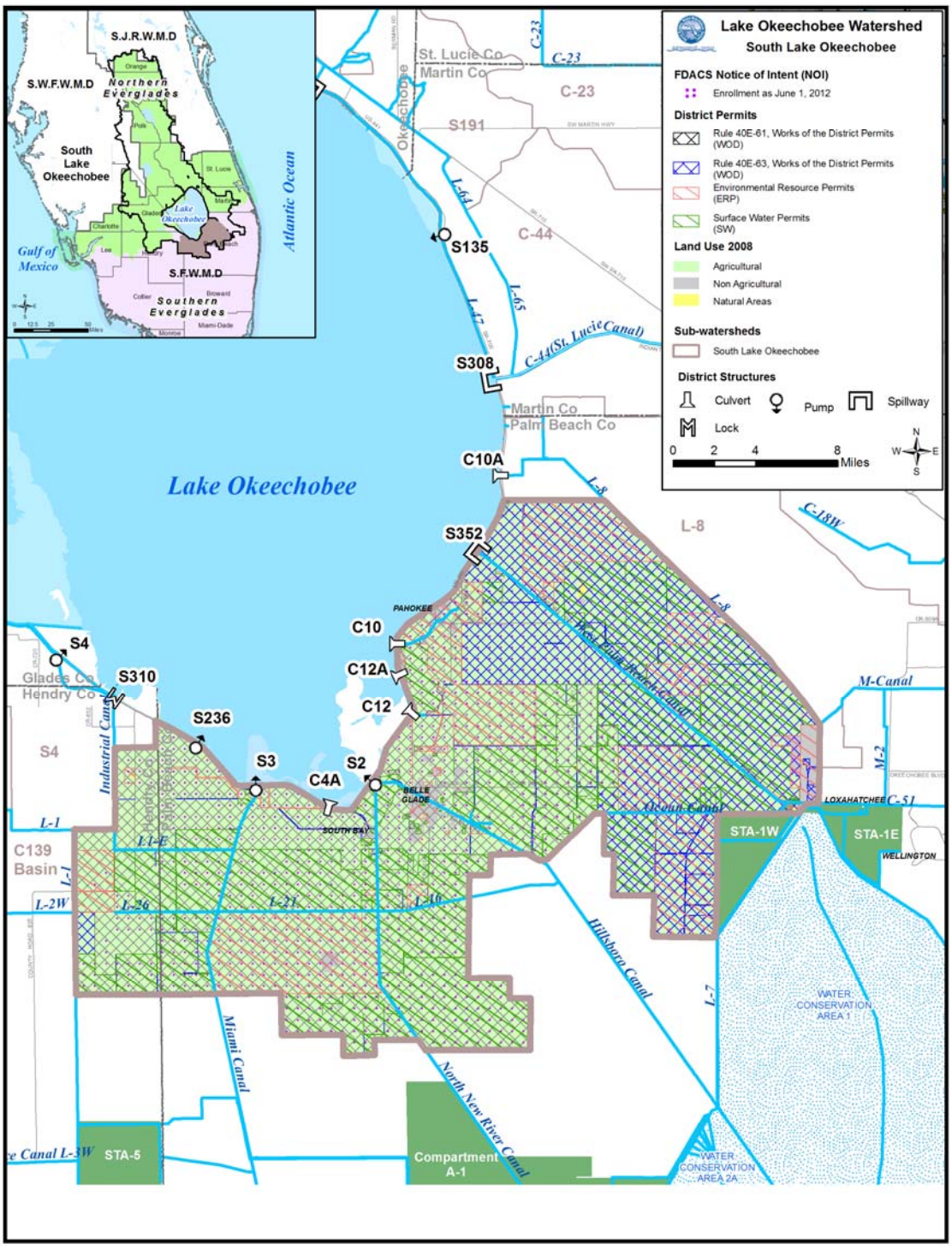


Figure 16. Source control program coverage in the South Lake Okeechobee Sub-watershed.

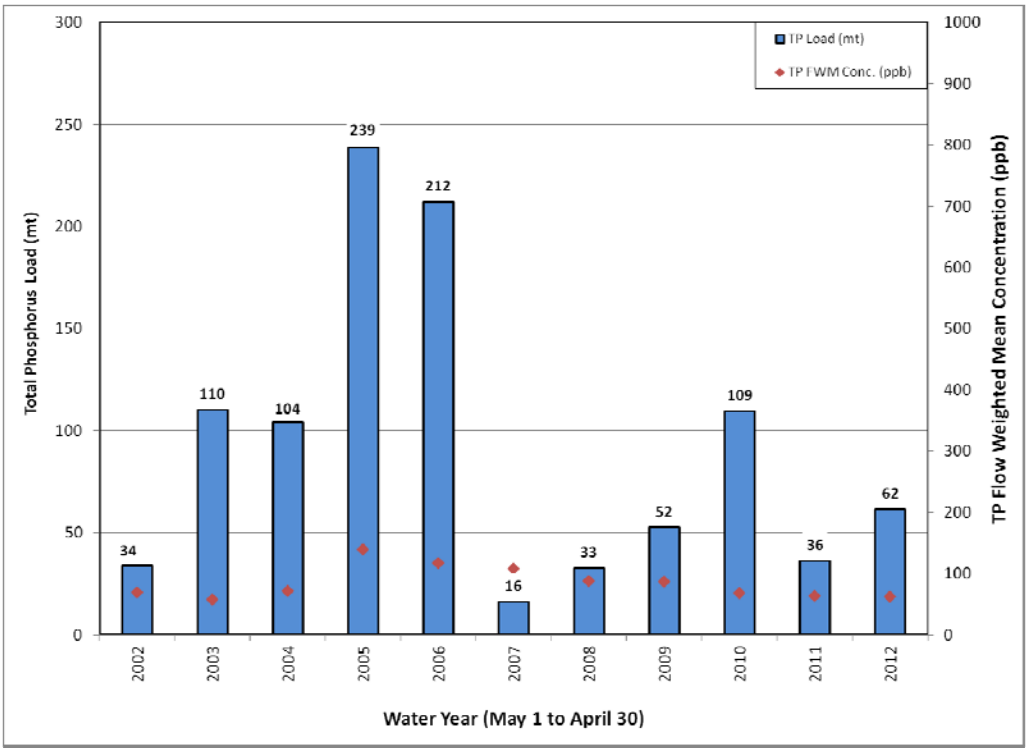


Figure 17. Upper Kissimmee Sub-watershed observed total phosphorus (TP) loads in metric tons (mt) and flow-weighted mean (FWM) concentrations in parts per billion (ppb) for Water Year 2002 through 2012 (WY2002–WY2012) (May 1, 2001–April 30, 2012).

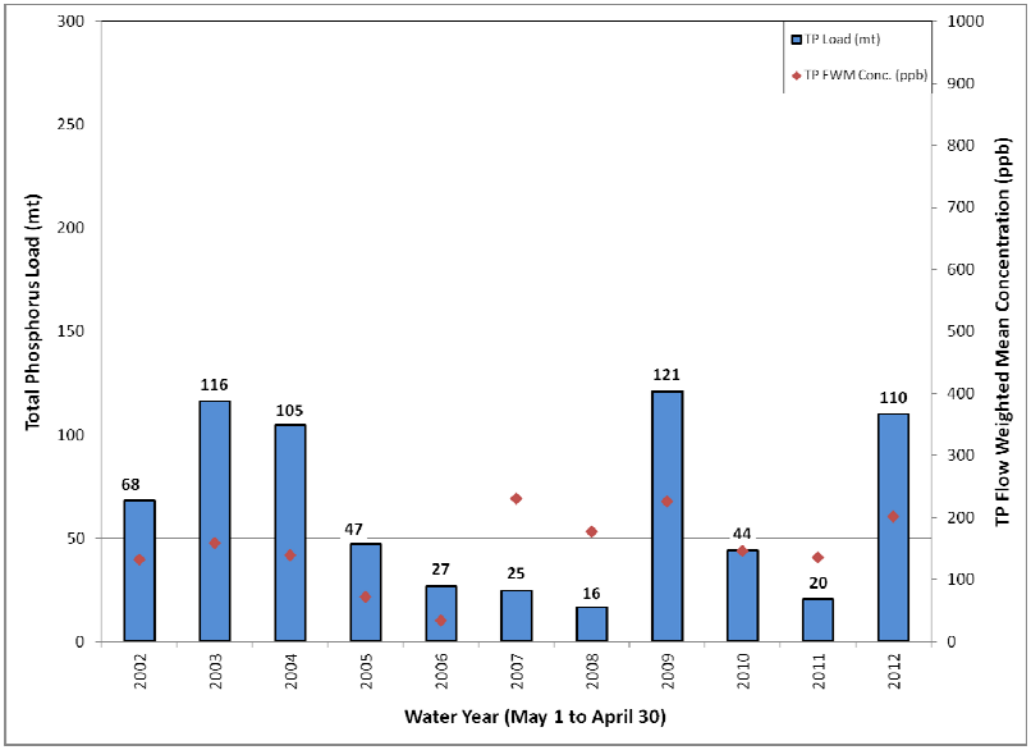


Figure 18. Lower Kissimmee Sub-watershed observed TP loads and FWM concentrations (WY2002–WY2012).

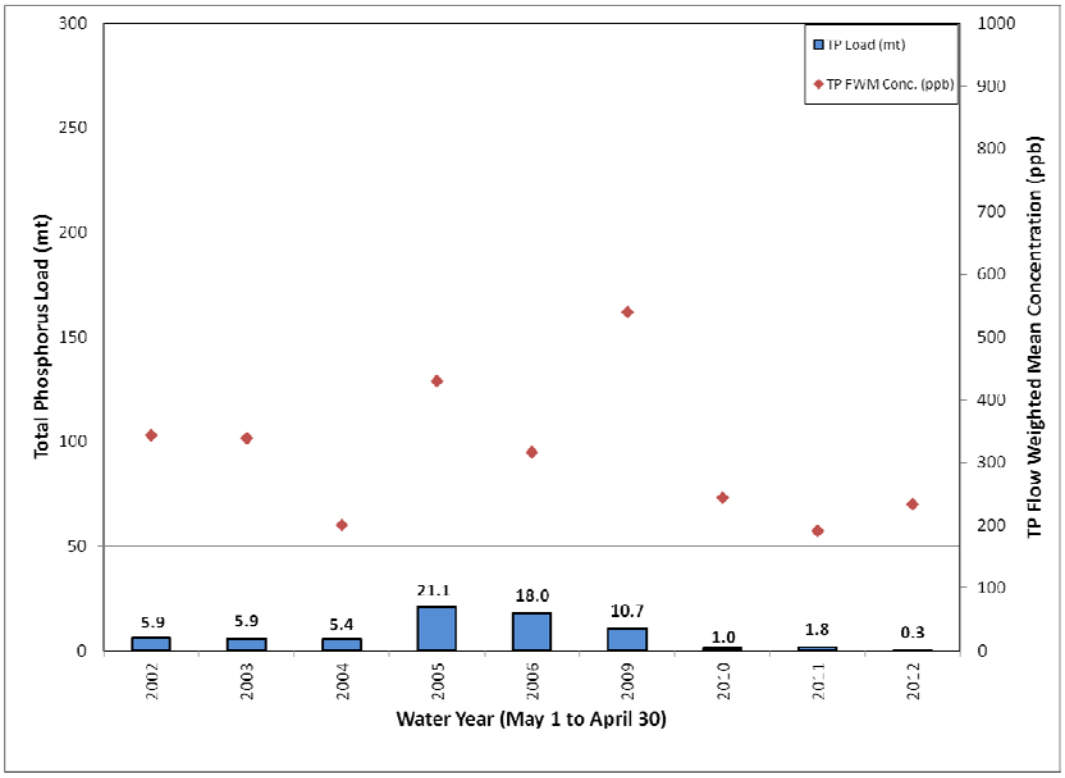


Figure 19. Taylor Creek/Nubbin Slough Sub-watershed, S-133 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

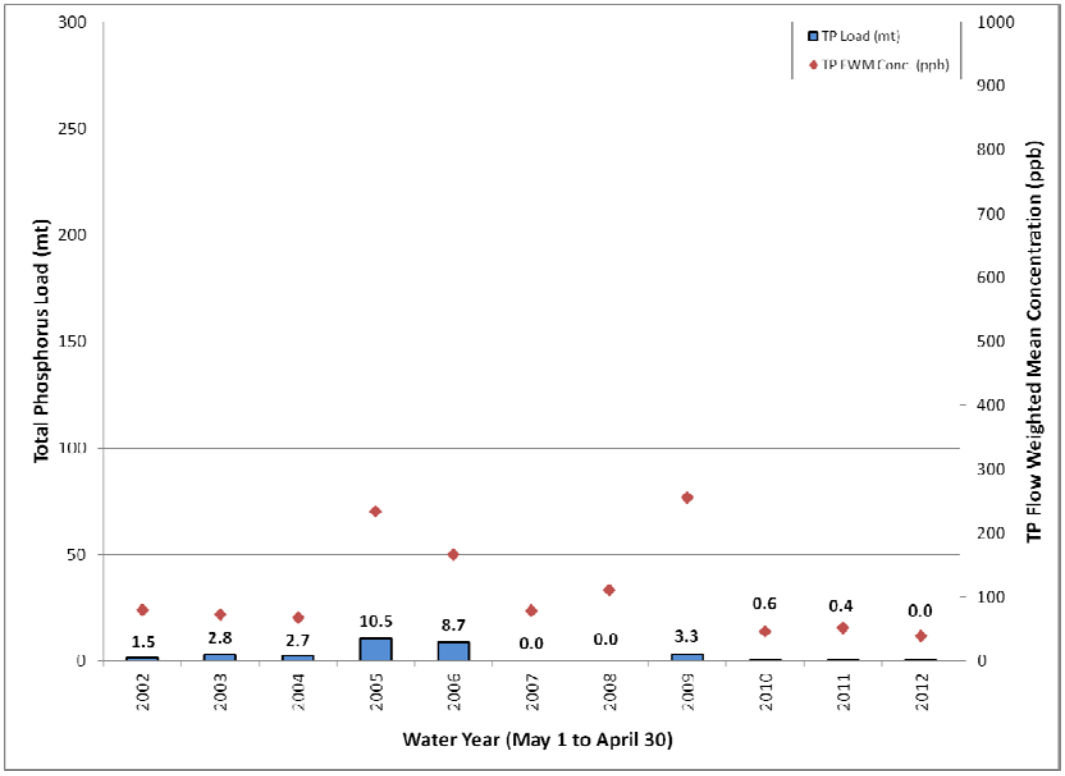


Figure 20. Taylor Creek/Nubbin Slough Sub-watershed, S-135 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

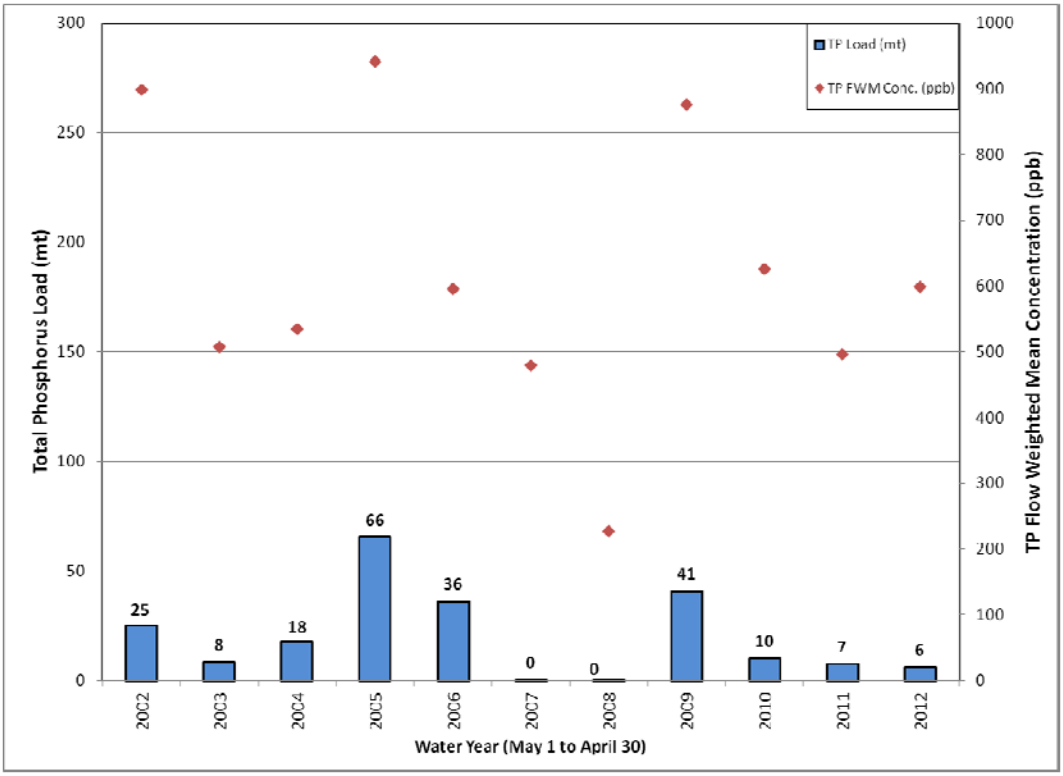


Figure 21. Taylor Creek/Nubbin Slough Sub-watershed, S-154 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

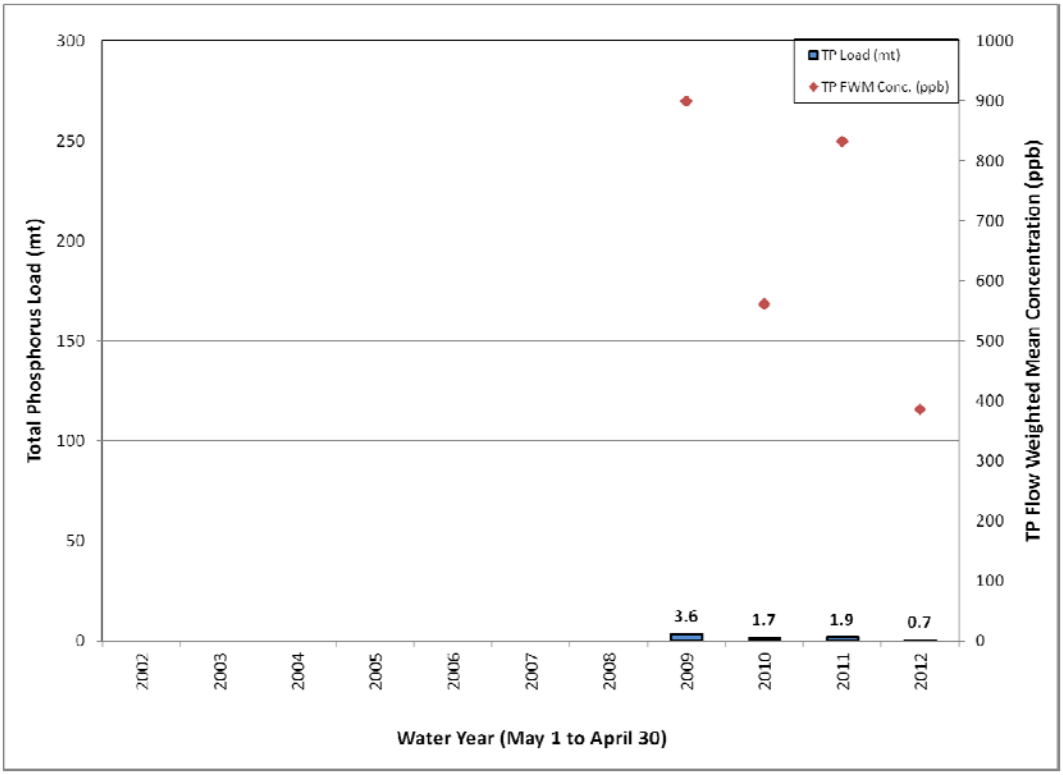


Figure 22. Taylor Creek/Nubbin Slough Sub-watershed, S-154C Basin observed TP loads and FWM concentrations (WY2002–WY2012).

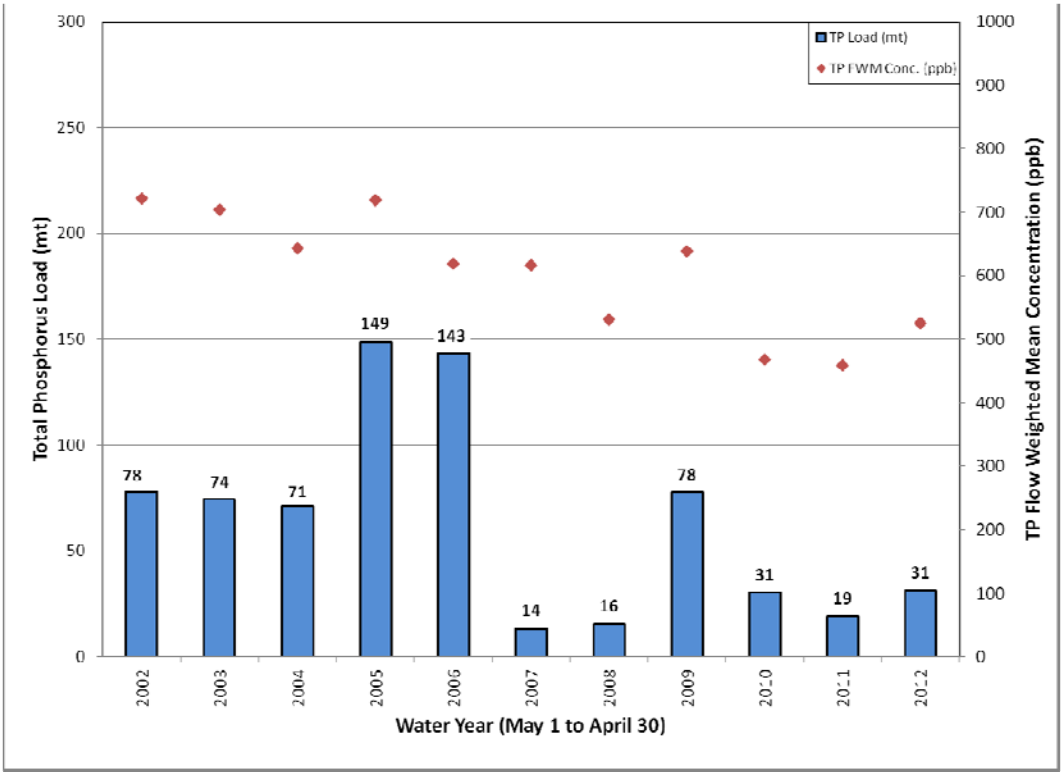


Figure 23. Taylor Creek/Nubbin Slough Sub-watershed, S-191 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

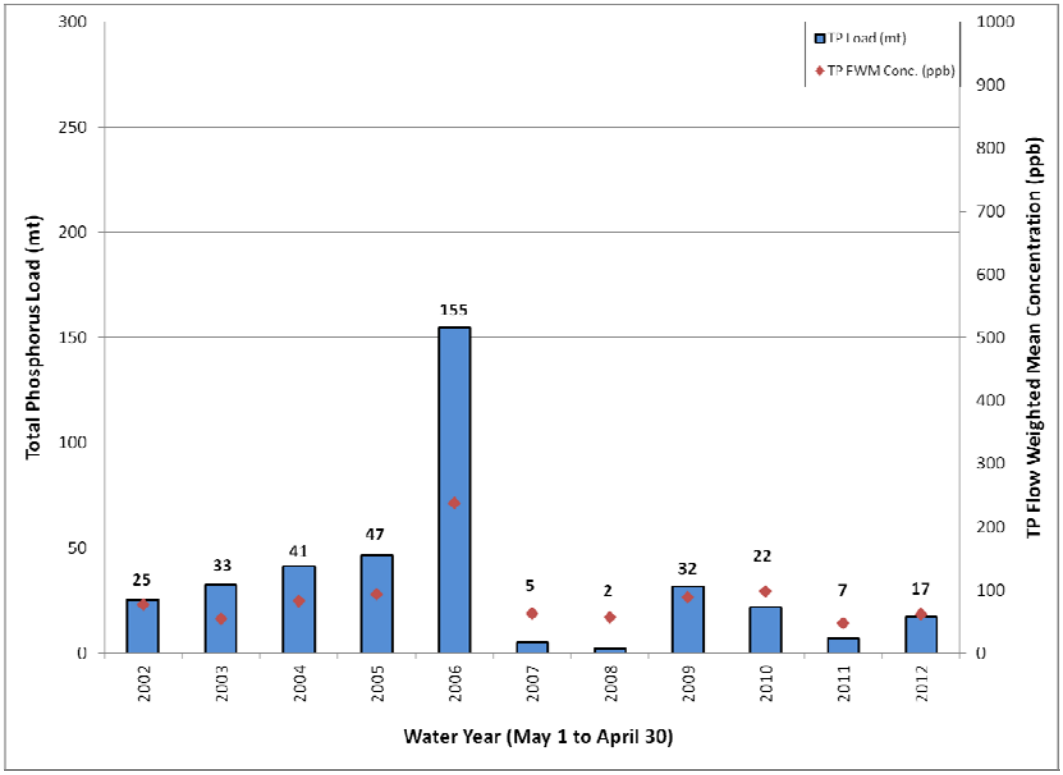


Figure 24. Lake Istokpoga Sub-watershed observed TP loads and FWM concentrations (WY2002–WY2012).

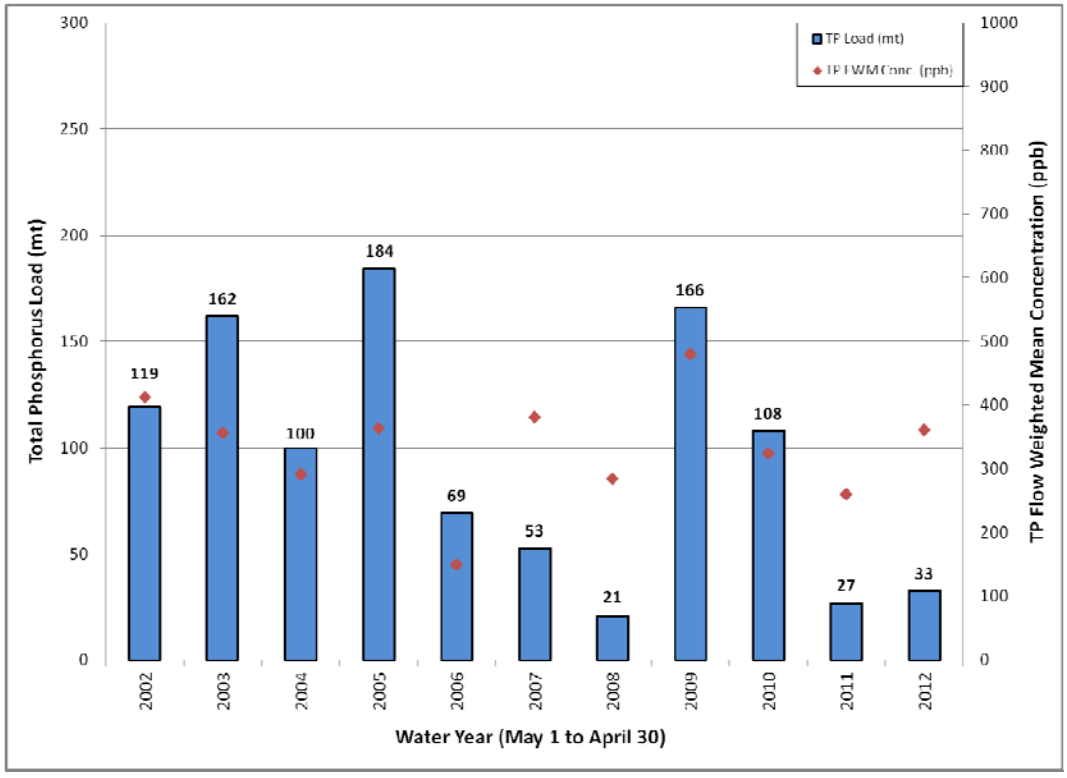


Figure 25. Indian Prairie Sub-watershed observed TP loads and FWM concentrations (WY2002–WY2012).

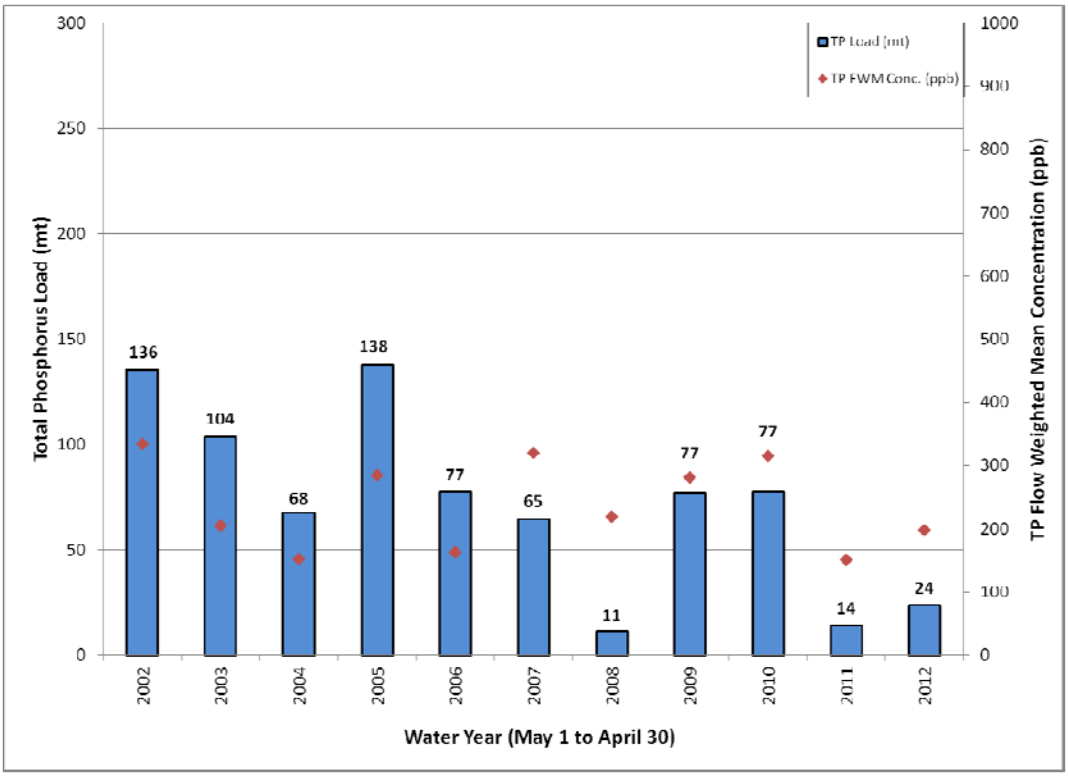


Figure 26. Fisheating Creek/Nicodemus Slough Sub-watershed, Fisheating Creek Basin observed TP loads and FWM concentrations (WY2002–WY2012).

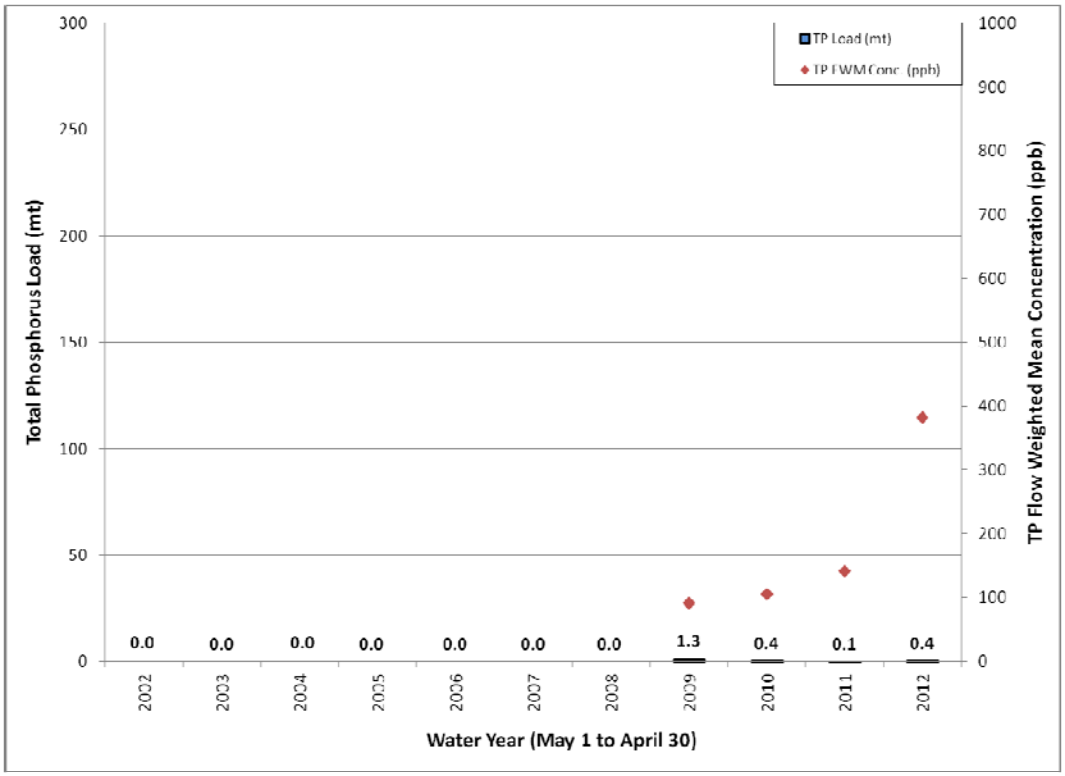


Figure 27. Fisheating Creek/Nicodemus Slough Sub-watershed, Nicodemus Slough Basin observed TP loads and FWM concentrations (WY2002–WY2012).

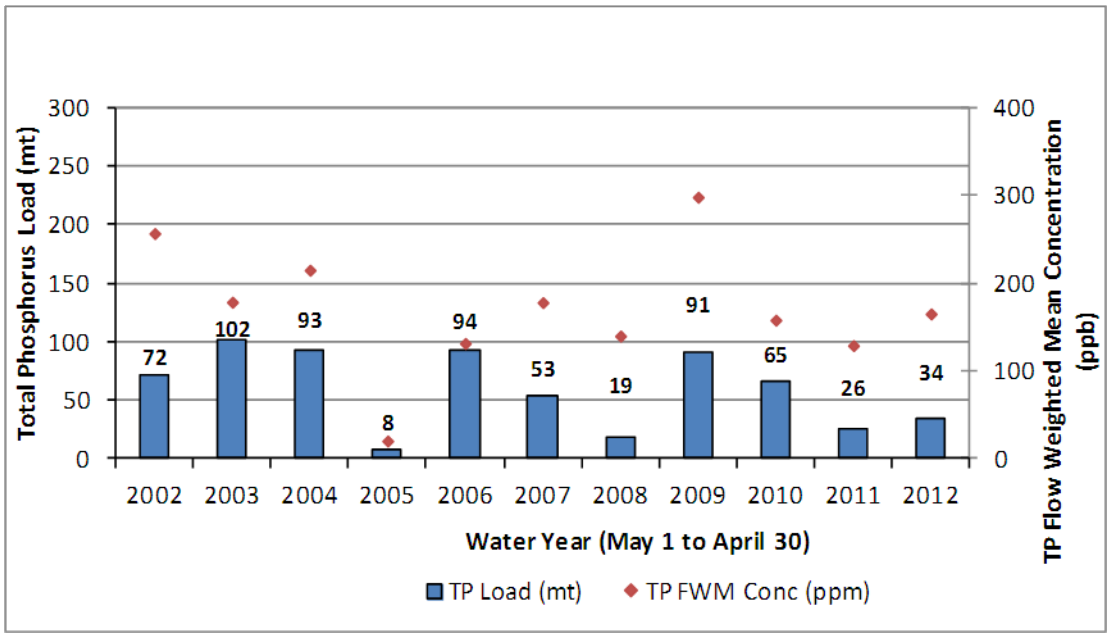


Figure 28. West Lake Okeechobee Sub-watershed, East Caloosahatchee Basin observed TP loads and FWM concentrations (WY2002–WY2012).

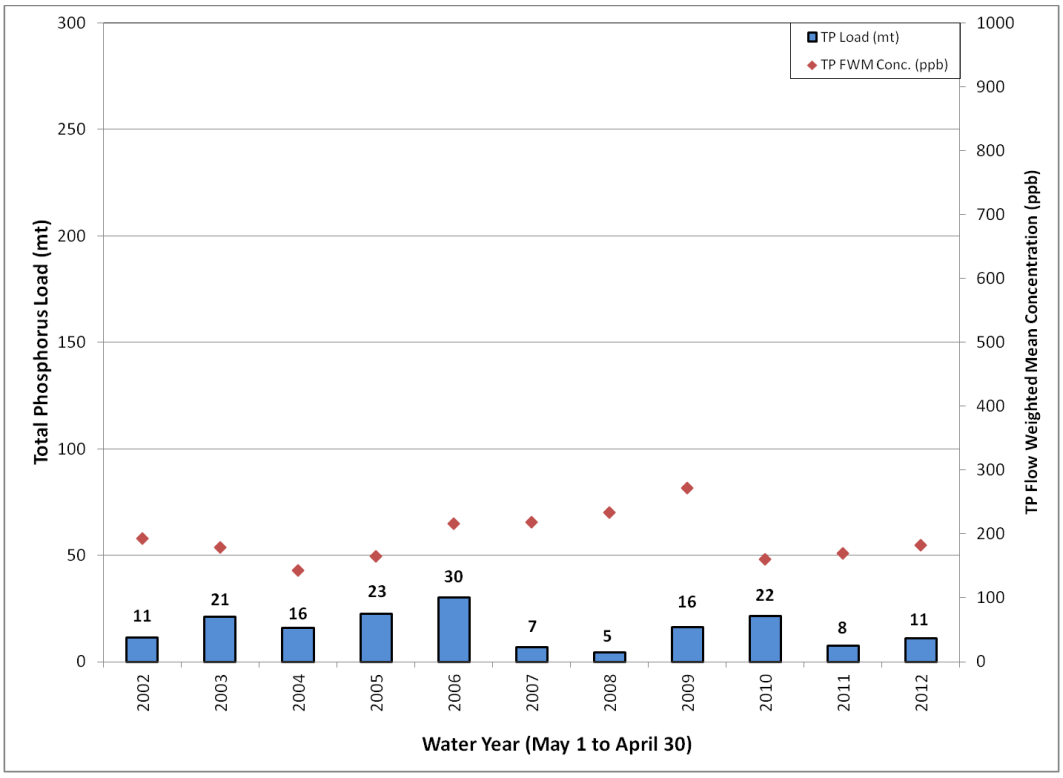


Figure 29. West Lake Okeechobee Sub-watershed, S-4/Industrial Canal Basin observed TP loads and FWM concentrations (WY2002–WY2012).

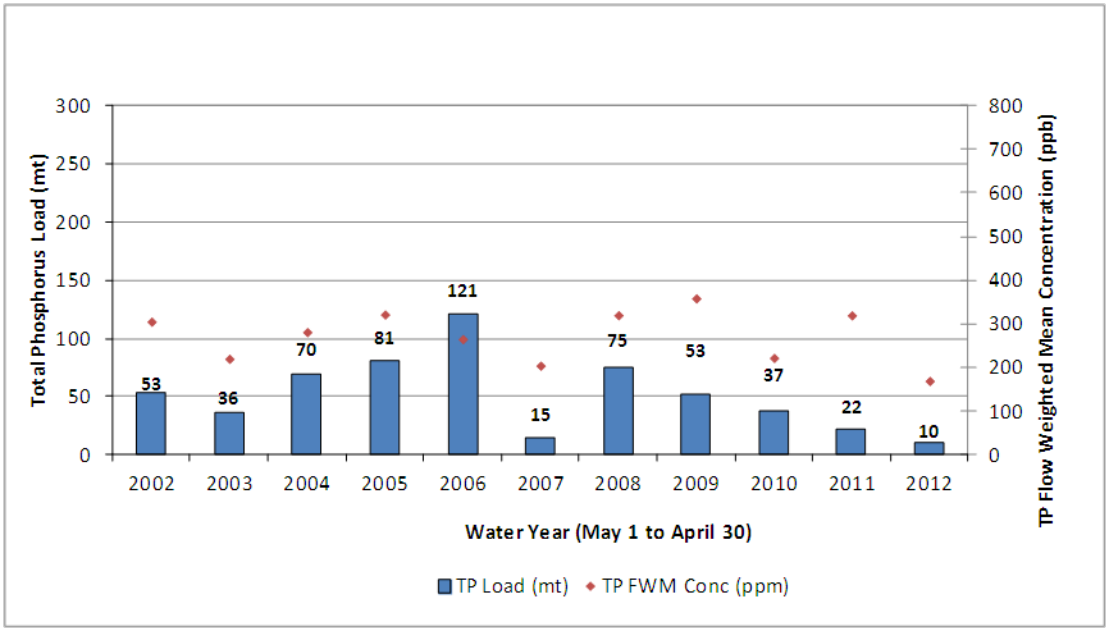


Figure 30. East Lake Okeechobee Sub-watershed, C-44 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

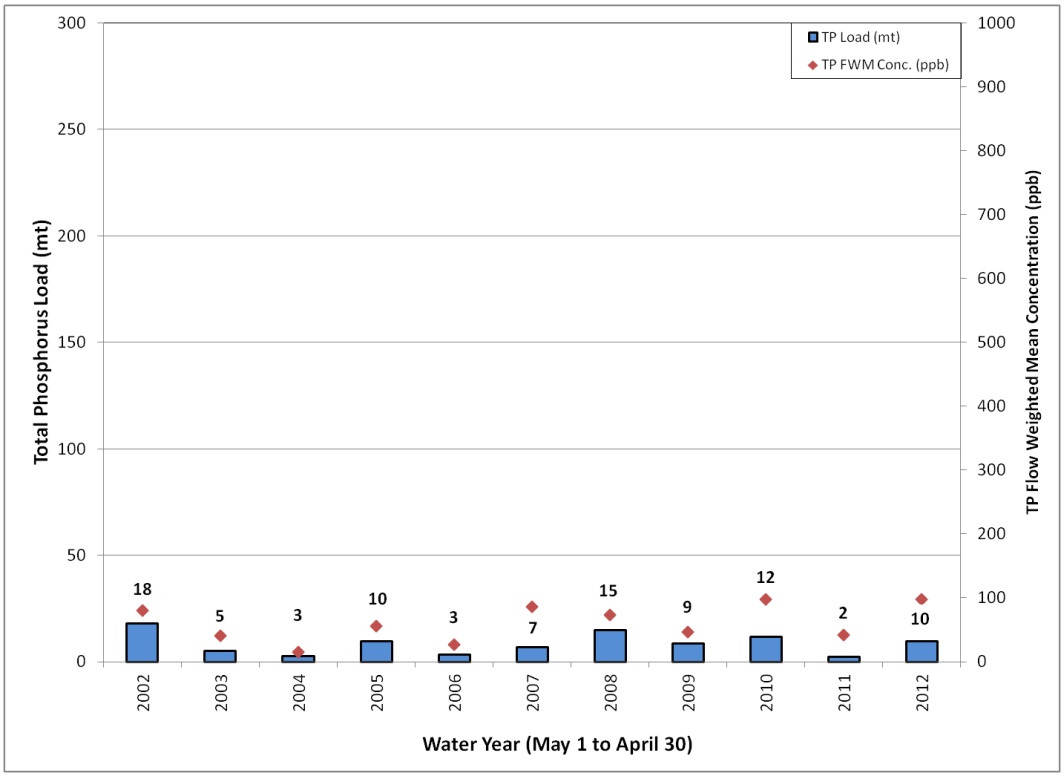


Figure 31. East Lake Okeechobee Sub-watershed, L-8 Basin observed TP loads and FWM concentrations (WY2002–WY2012).

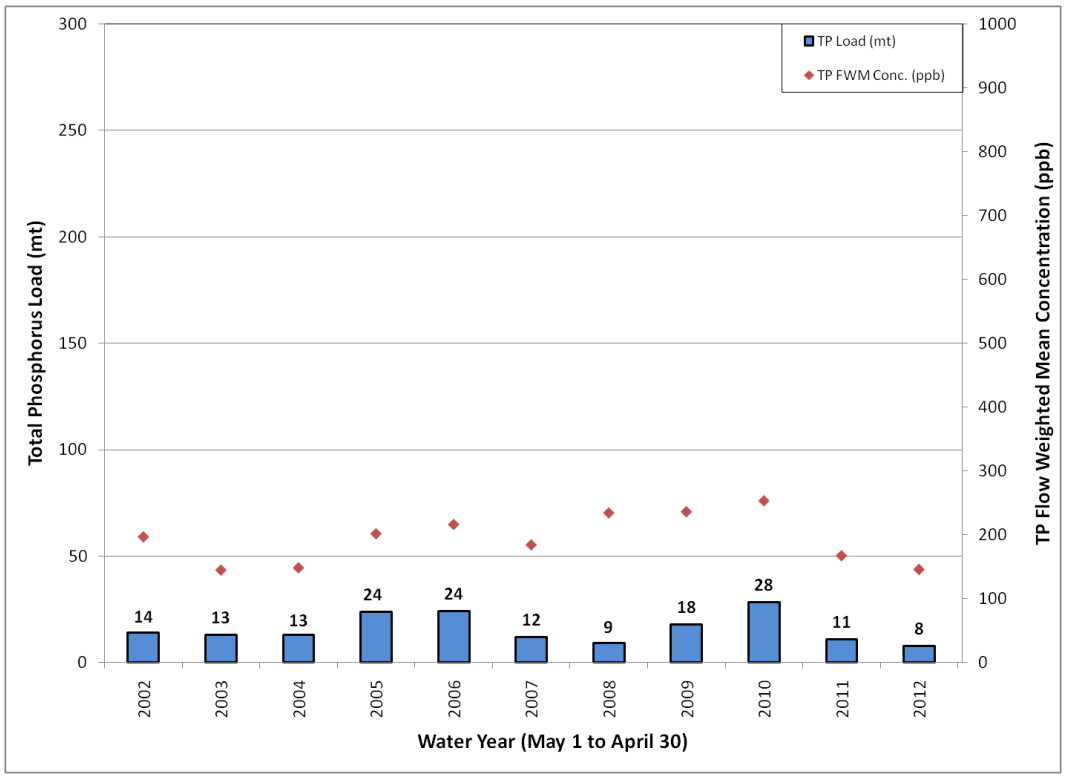


Figure 32. South Lake Okeechobee Sub-watershed observed TP loads (into Lake Okeechobee only) and FWM concentrations (WY2002–WY2012).

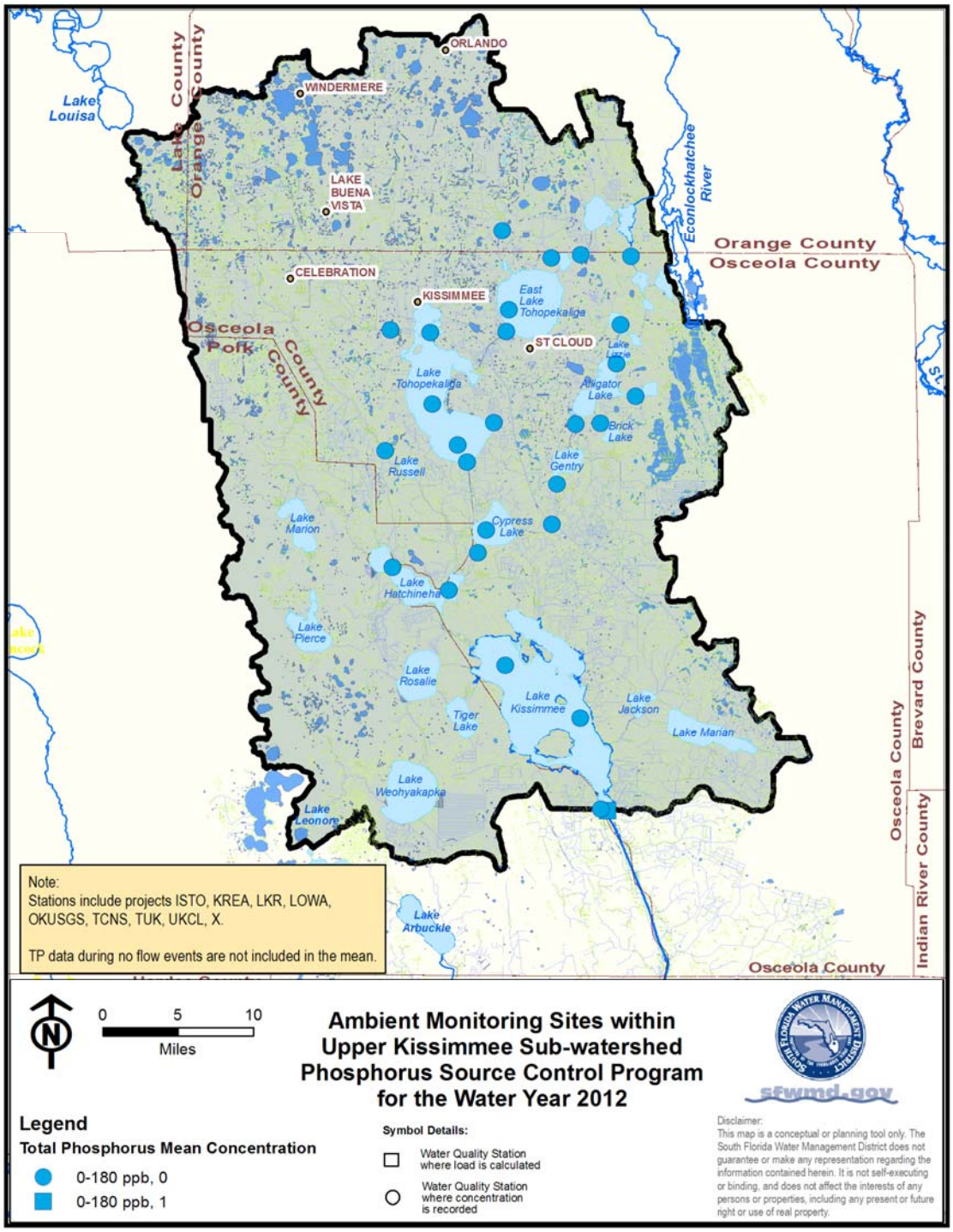


Figure 33. Upper Kissimmee Sub-watershed average TP concentrations in ppb for WY2012.

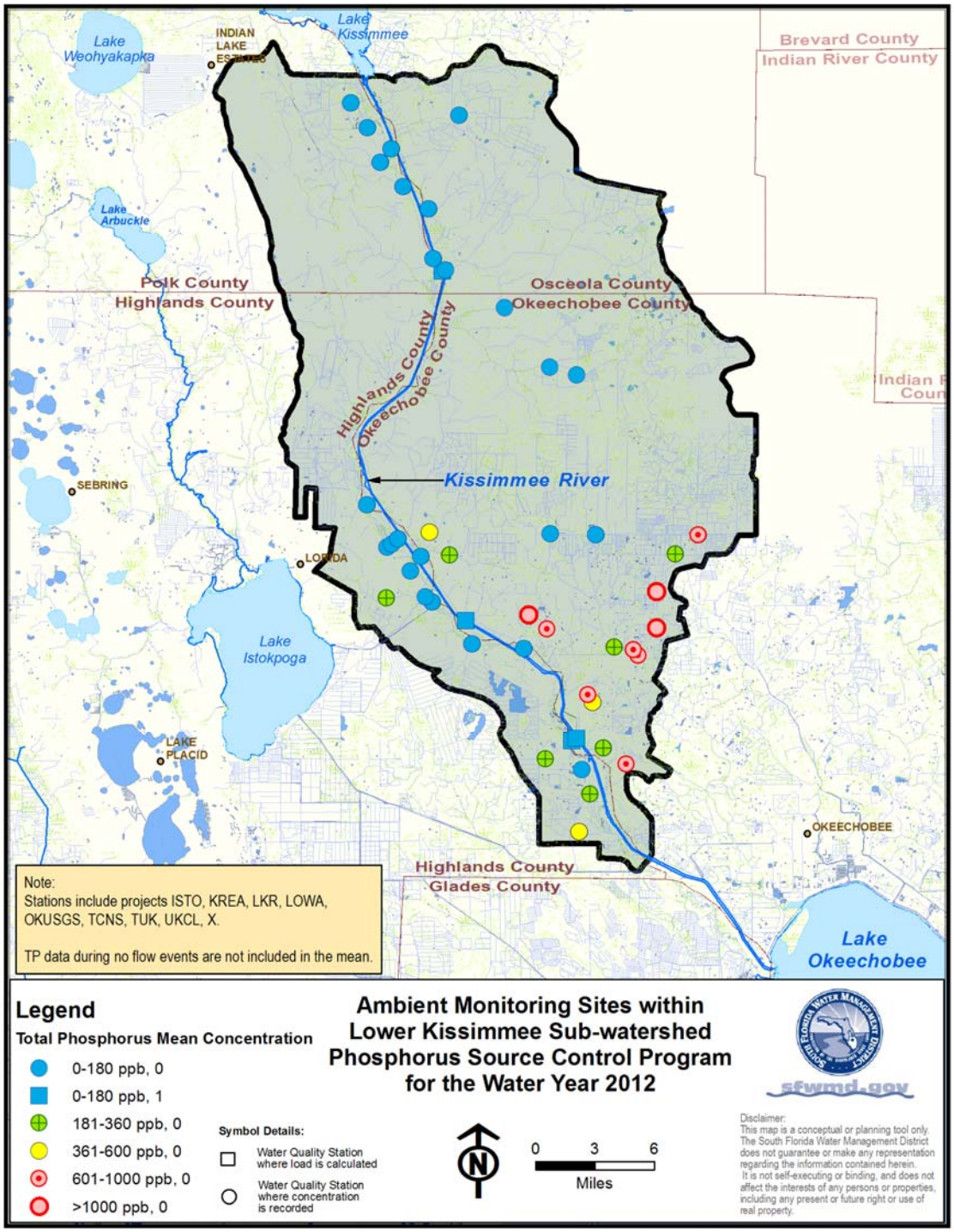


Figure 34. Lower Kissimmee Sub-watershed average TP concentrations in ppb for WY2012.

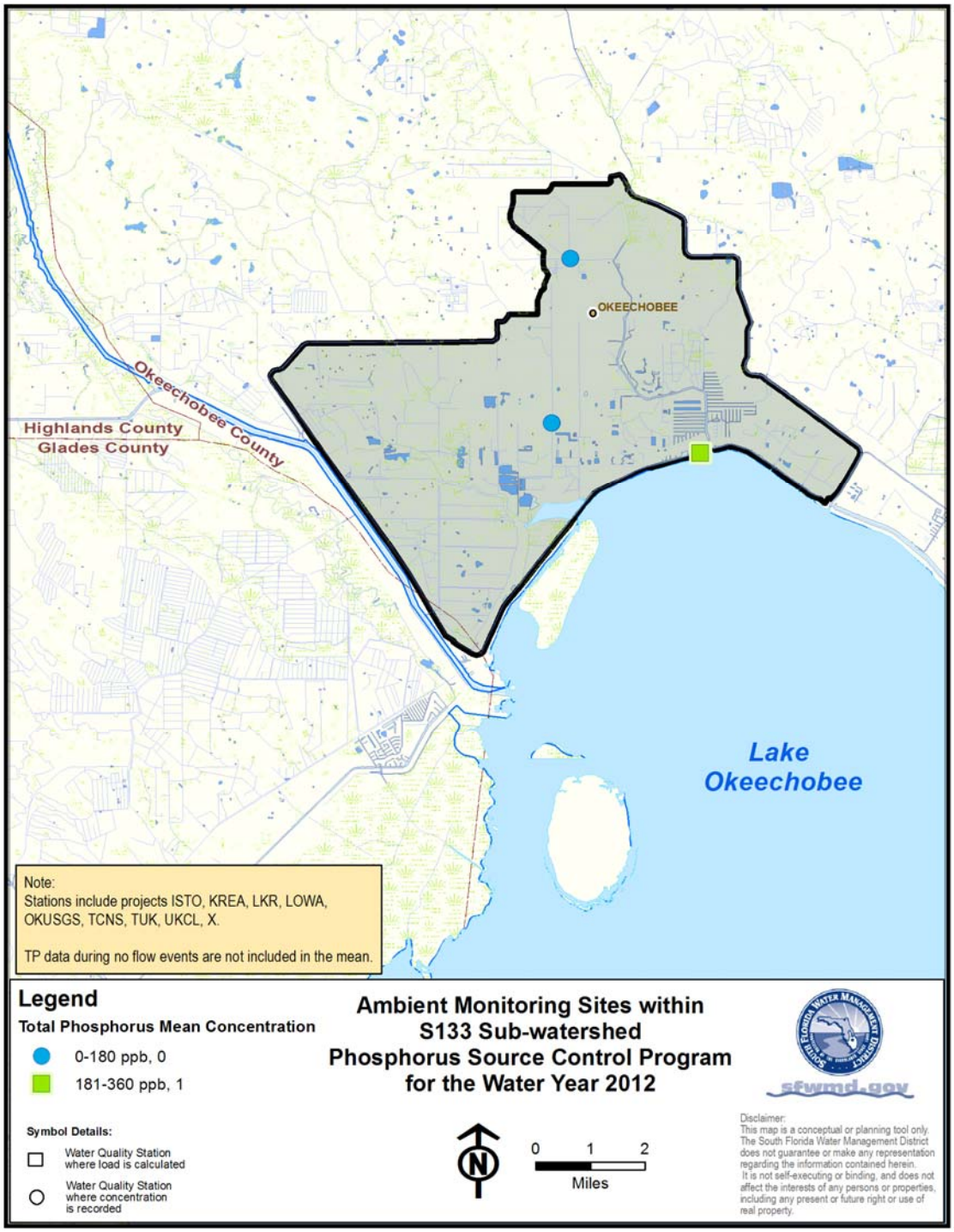


Figure 35. Taylor Creek/Nubbin Slough Sub-watershed, S-133 Basin average TP concentrations in ppb for WY2012.

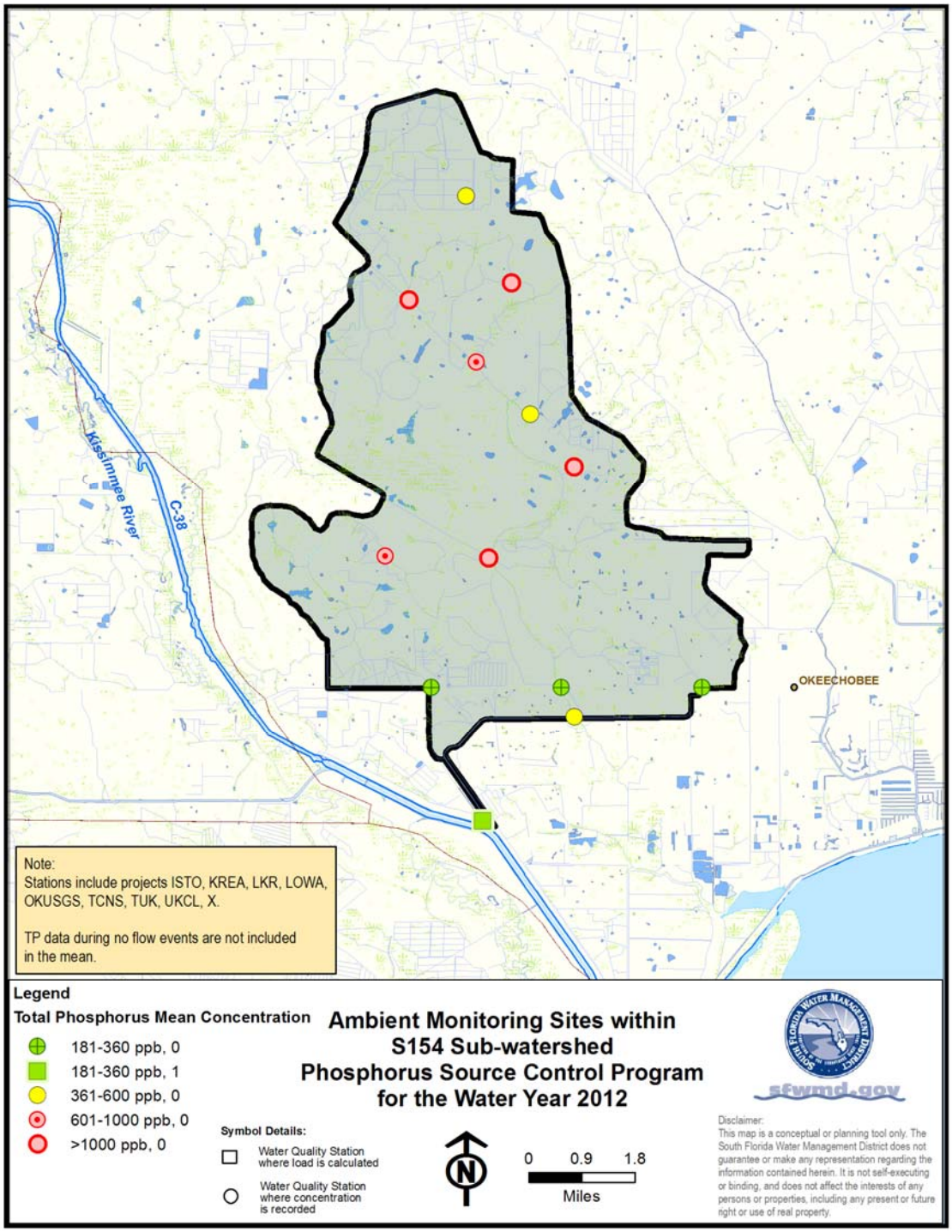


Figure 36. Taylor Creek/Nubbin Slough Sub-watershed, S-154 Basin average TP concentrations in ppb for WY2012.

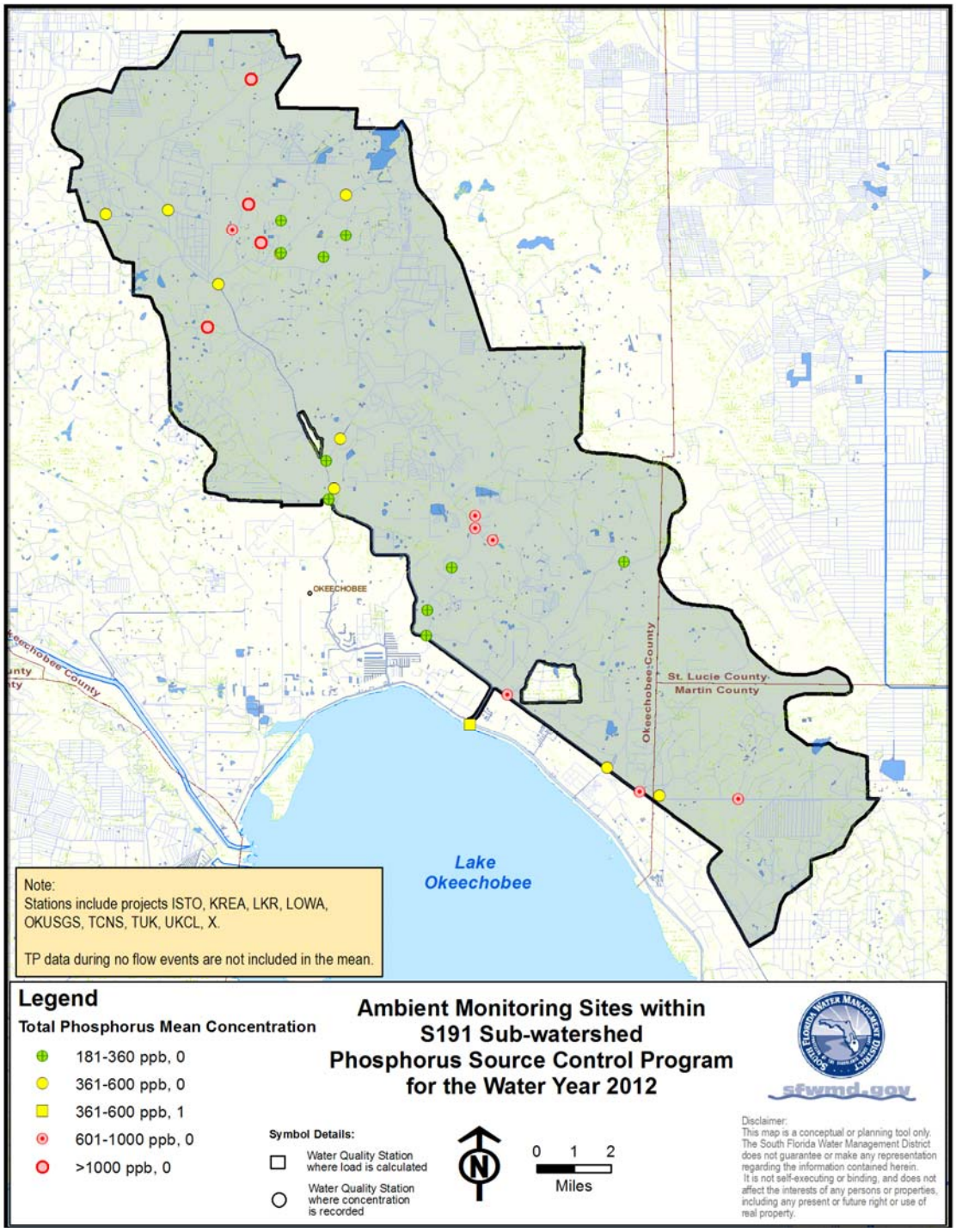


Figure 37. Taylor Creek/Nubbin Slough Sub-watershed, S-191 Basin average TP concentrations in ppb for WY2012.

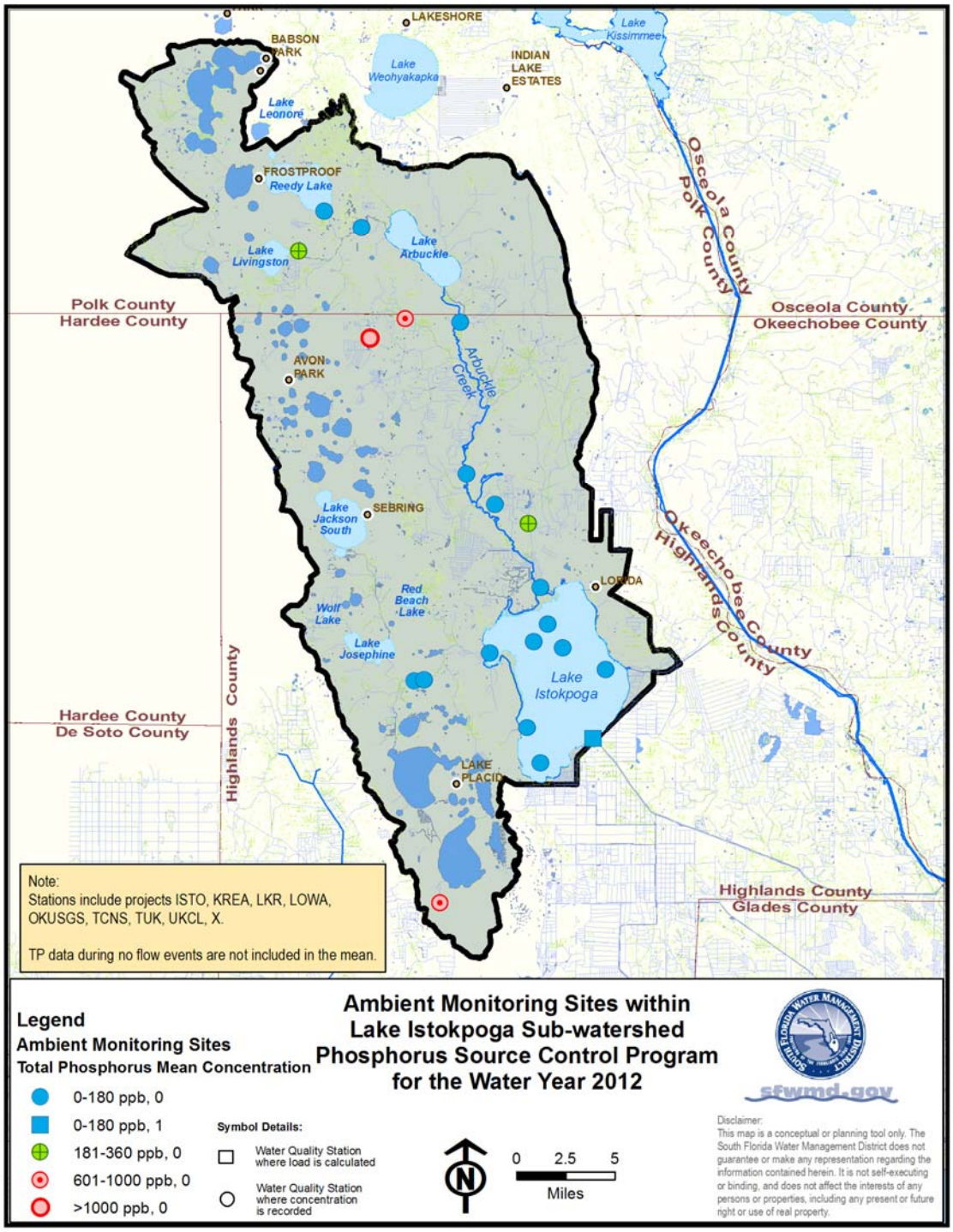


Figure 38. Lake Istokpoga Sub-watershed average TP concentrations in ppb for WY2012.

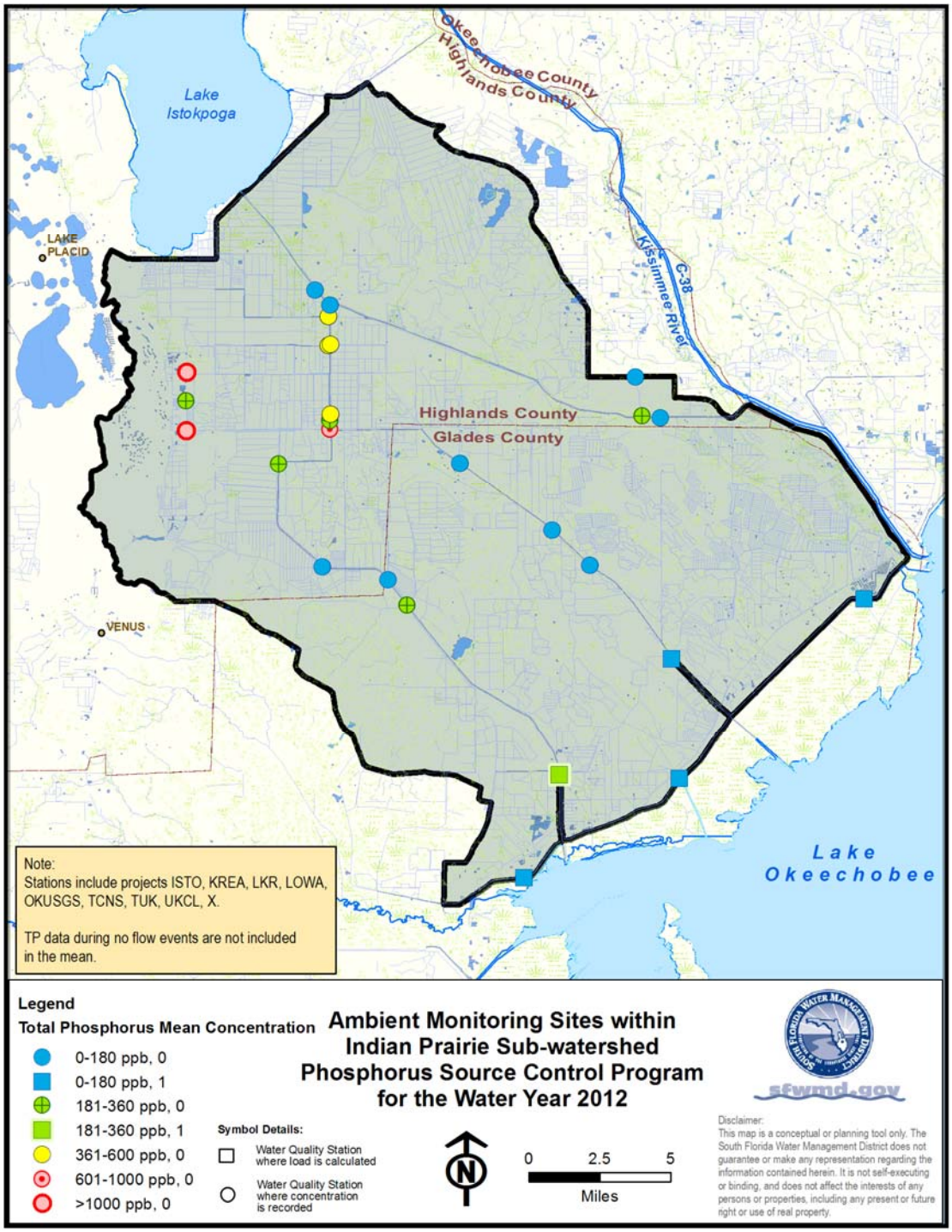


Figure 39. Indian Prairie Sub-watershed average TP concentrations in ppb for WY2012.

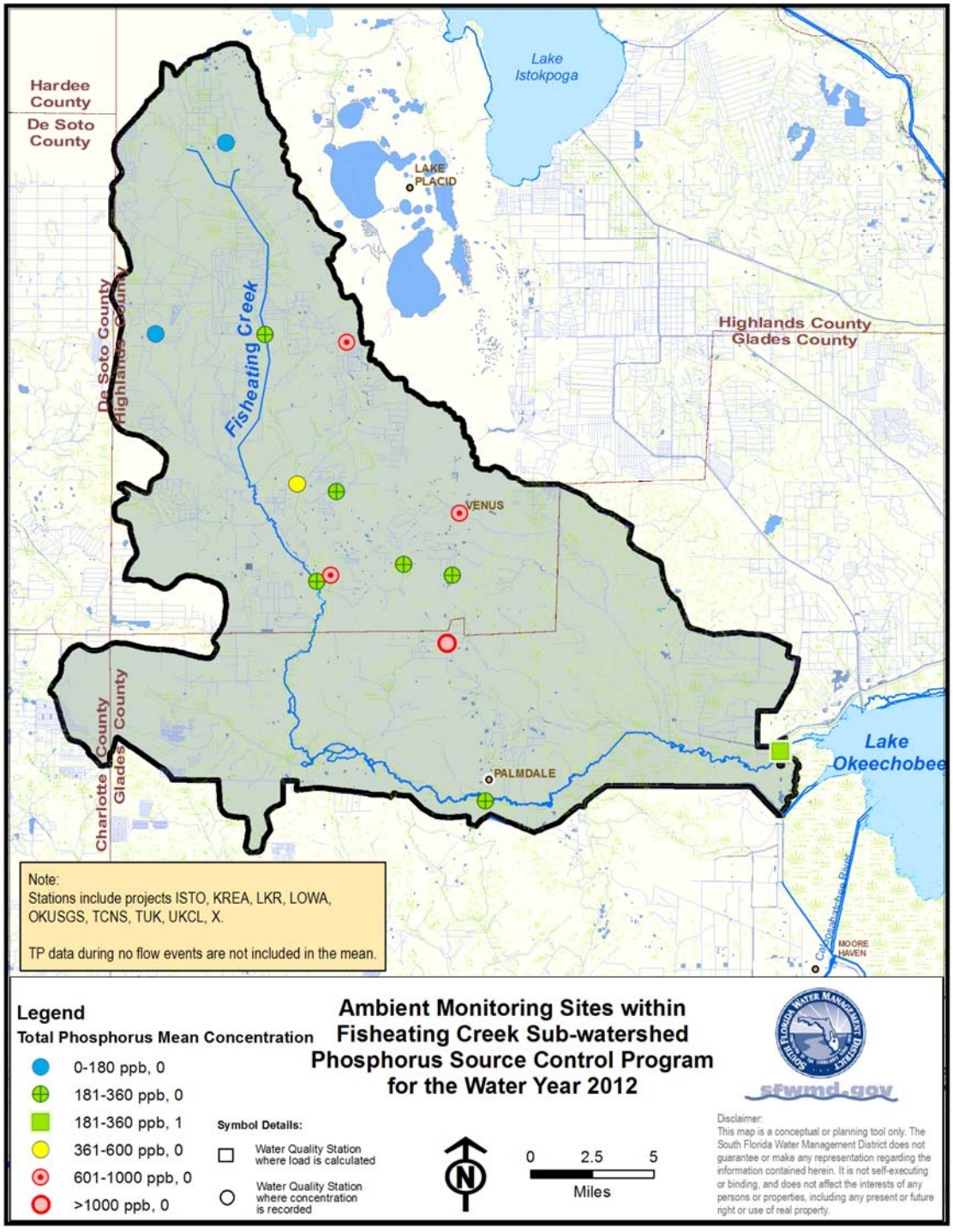


Figure 40. Fisheating Creek Sub-watershed, Fisheating Creek Basin average TP concentrations in ppb for WY2012.

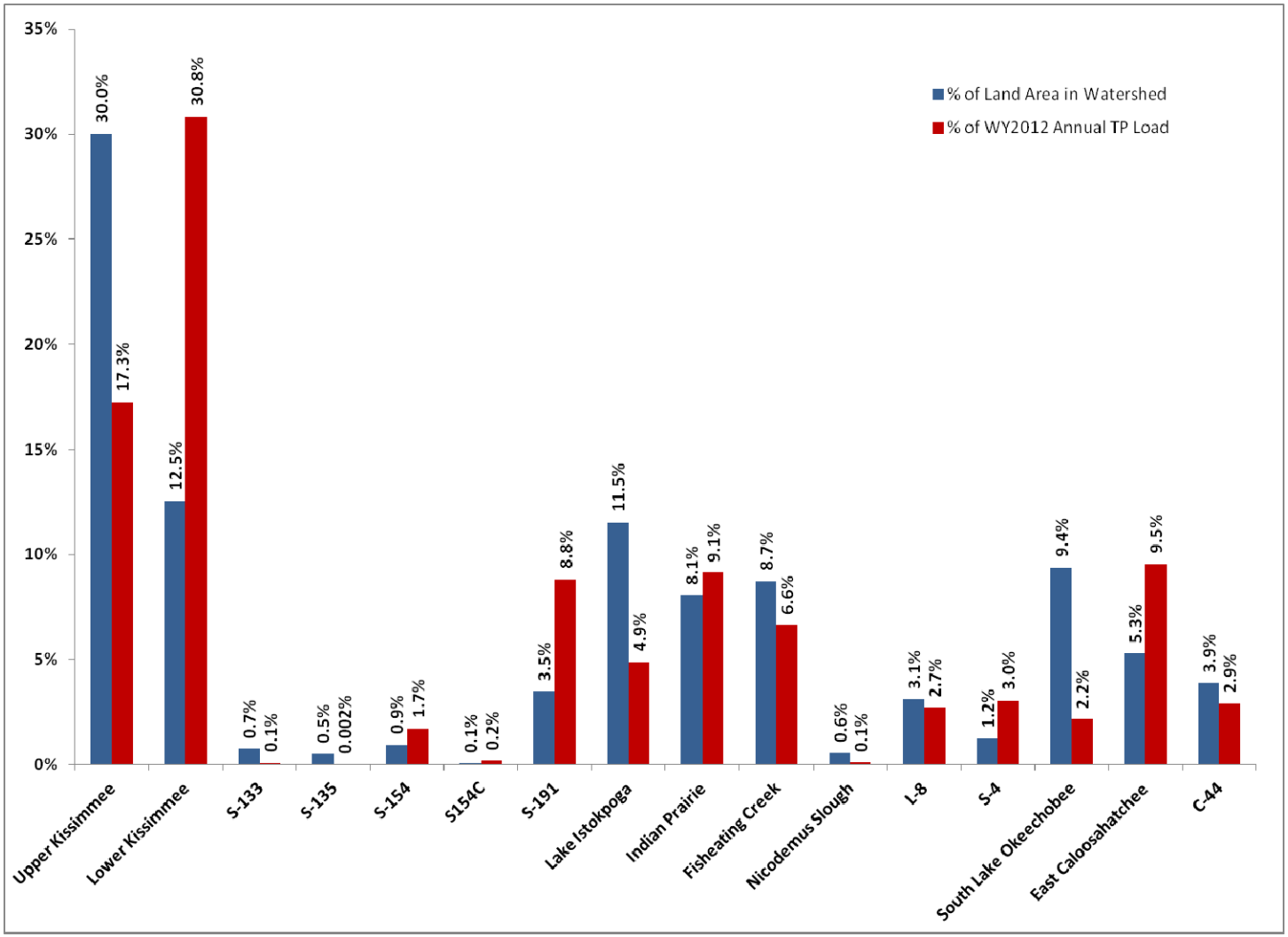
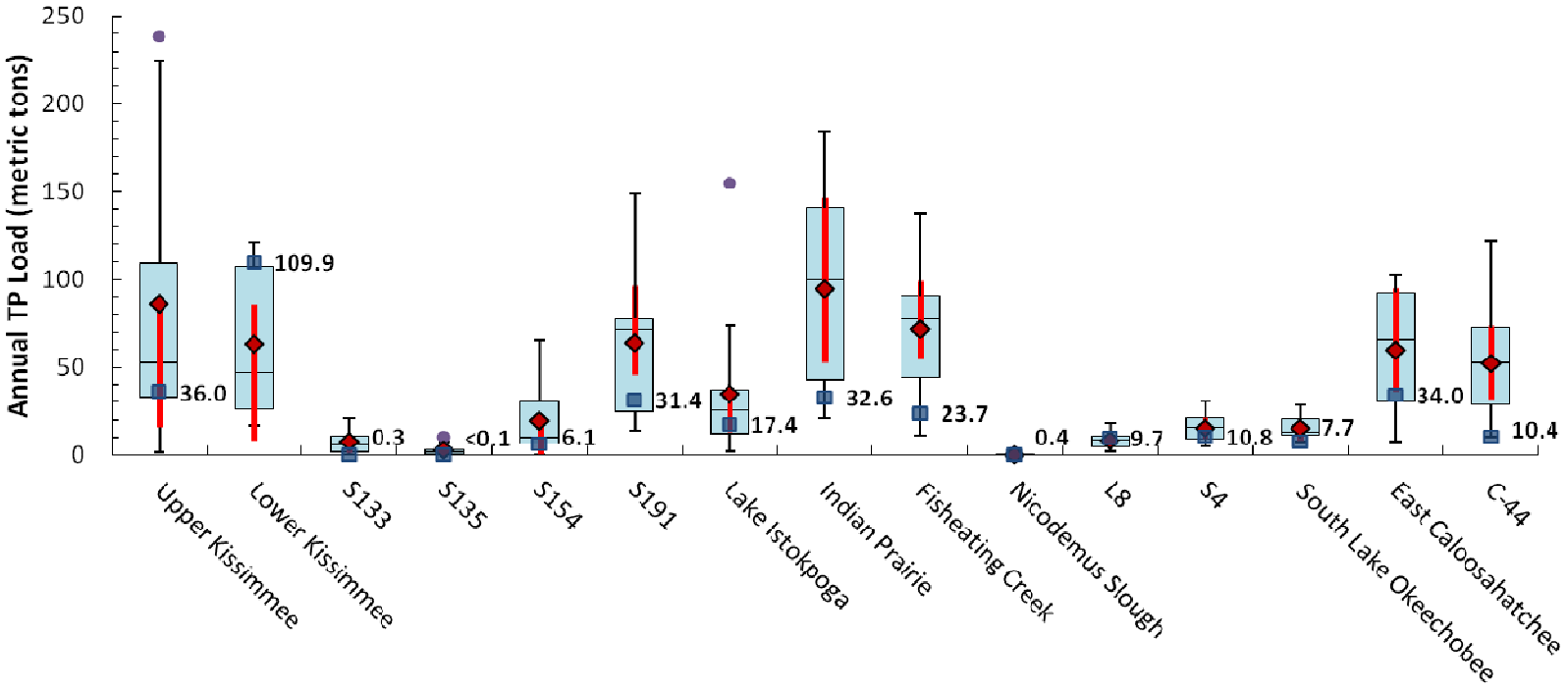


Figure 41. Distribution of WY2012 annual observed TP loads in mt and land areas for sub-watersheds within the Lake Okeechobee Watershed. [Excludes the Everglades Agricultural Area (EAA) Basins S-2, S-3, and S-5A.]



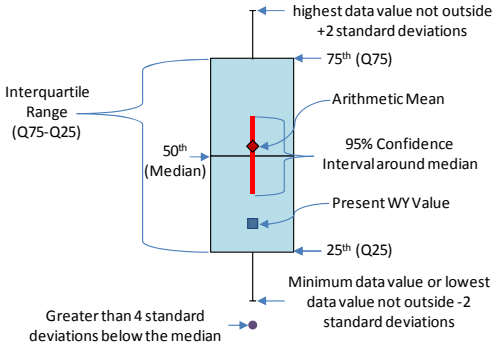


Figure 42. Comparison of TP loads for each sub-watershed and summary basin within the Lake Okeechobee Watershed as a box-and-whisker plot.

LITERATURE CITED

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.

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.