A Brief Discussion of Lake Okeechobee Pollution

G. Goforth – 8/22/2018

The source of the toxic blue green algae currently damaging estuarine ecosystems, regional economies and human health is a very polluted Lake Okeechobee[1](TCPalm 2018a). As a result of this pollution, on July 2, 2018, NOAA satellite image indicated that 90 percent of the surface of Lake Okeechobee was covered with a blue green algae bloom (**Figure 1**). Members of every branch of Florida government, state agencies and others have known about the source of this pollution for almost 50 years: excessive levels of nutrient loads in stormwater from the surrounding watershed. Lake Okeechobee is one of the largest lakes in the United States, with a surface area of approximately 730 square miles. The lake is approximately 9 ft deep. The watershed that contributes flow and nutrients to Lake Okeechobee is approximately 3.5 million acres in size and consists of nine hydrologic sub-watersheds (**Figure 2**). Only 12 percent of the watershed is residential or built-up, while fifty-six percent is agricultural and rangeland, with the rest in wetlands and other water bodies (SFWMD 2018). The lake is almost completely enclosed by a 143-mile earthen dam (Herbert Hoover Dike) with 36 major water control strutures that control flow into and out of the lake. Fisheating Creek is the only remaining unregulated natural connection to the lake.

For more than 4 decades state and federal agencies have implemented activities designed to reduce the pollution entering the lake, including conducted research, monitored water flow and water quality, established regulatory (i.e., permitting) programs, constructed regional storage and treatment systems, offered extensive dairy buyouts, and assisted agricultural landowners with best management practices (BMPs). However, the state continues to allow landowners to discharge high levels of nutrients with little to no enforcement, and the pollution of Lake Okeechobee and the estuaries continues. The water quality of the lake is at an all-time crisis level, and human health is suffering as polluted lake water is discharged to the estuaries. For calendar year 2017 the 5-yr average phosphorus loading to the lake was more than 5 times the pollution limit established for the watershed; this pollution target is called the "Total Maximum Daily Load" or "TMDL." The result: an algae bloom covered 90 percent of the lake this summer (NOAA 2018). In addition, the state's annual "progress report" on efforts to reduce pollution of the lake underestimates the actual loading to the lake. For the last two years the FDEP has published reports indicating phosphorus loading to the lake has decreased – yet these claims conflict with the measured loads to the lake, e.g., the average load measured in 2017 was almost 50% higher than reported by FDEP.

[1] Nutrient loading to the estuaries from local stormwater runoff is also excessive, however toxic algae blooms occur almost exclusively in association with large discharges from Lake Okeechobee (LaPointe et al. 2015, TCPalm 2016, TCPalm 2018b).

Figure 1. On July 2, 2018, 90 Percent of Lake Okeechobee Was Covered with blue-green algae Bloom (from NOAA)

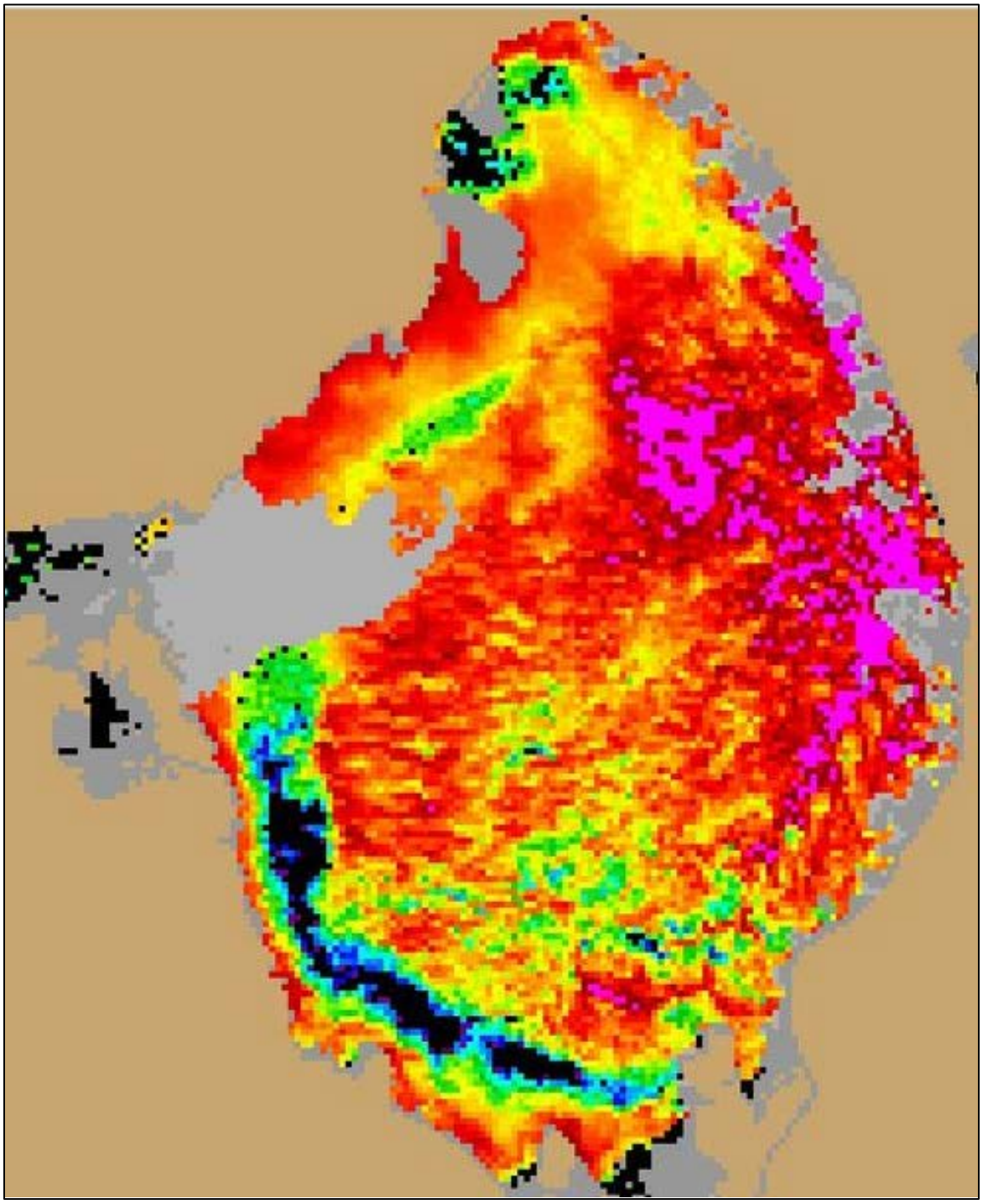


Figure 2. The Lake Okeechobee Watershed (from SFWMD 2018)

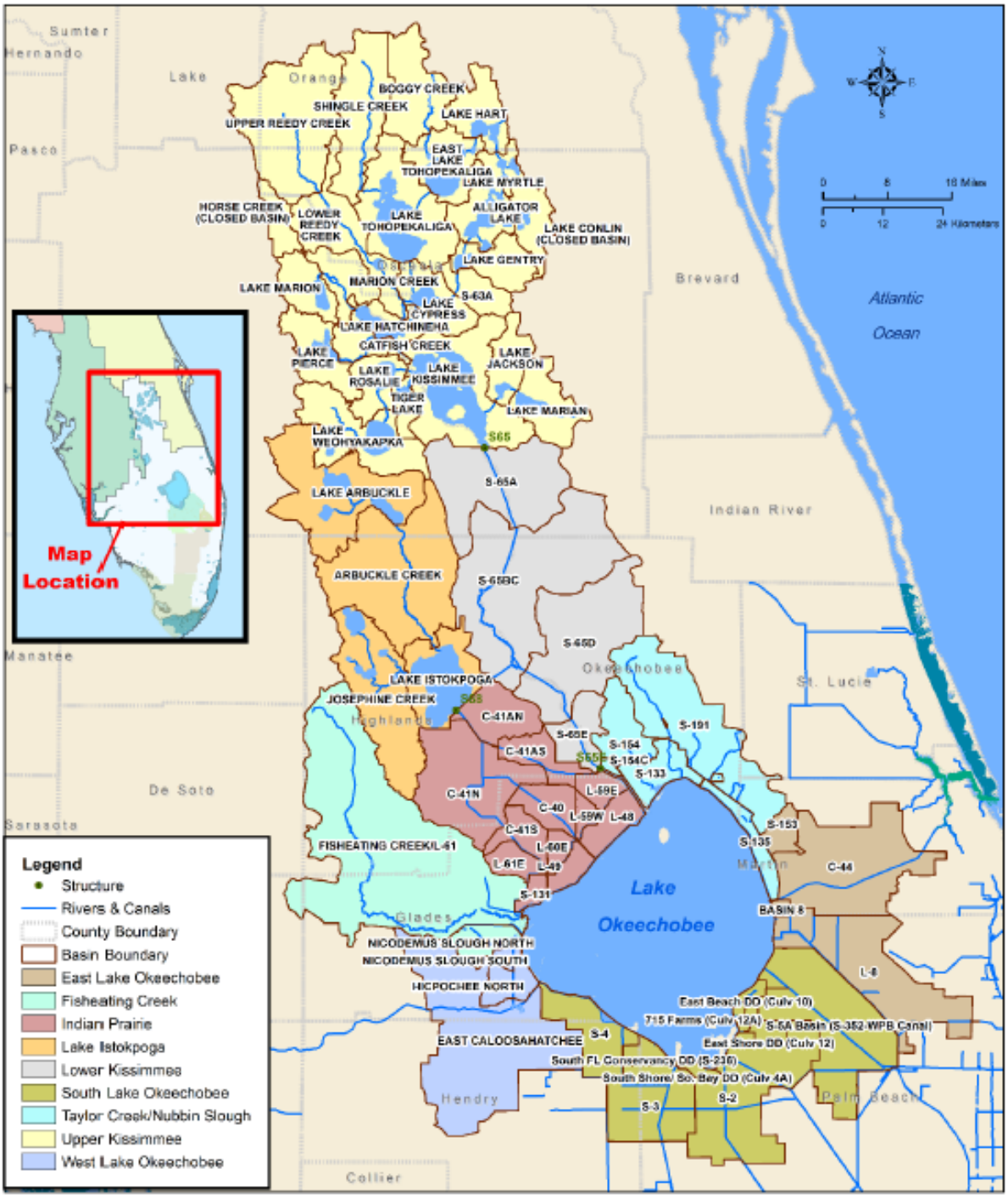


Figure 8B-1. LOW detailing major hydrologic features, subwatersheds, drainage basins (black labels indicate basins).

Historical Inflows to Lake Okeechobee (1963-2017)

Historical surface[2] inflows to the lake can be separated into two timeframes:

1. Prior to 1983
2. From 1983 to the present

Prior to 1983, stormwater runoff containing excessive levels of phosphorus and nitrogen from the Everglades Agricultural Area (EAA) was routinely discharged into the lake. During that period, flows from the EAA and the remainder of the South Sub-watershed made up approximately 16 percent of the total lake inflow (**Figure 3**). However, due to the elevated nutrient concentrations of this runoff, nitrogen loads from the South Sub-watershed made up 43 percent of the total nitrogen entering the lake (**Figure 4**). Assuming the runoff from the EAA began in 1960, and further assuming that flows and loads from the EAA from 1960 to 1973 occurred at the 1973-1982 average annual levels, it is estimated that between 1960 and 1982, the EAA contributed approximately 140 million pounds (63,350 metric tons) of total nitrogen to the lake, and approximately 2.9 million pounds (1,300 metric tons) of total phosphorus. Some of those loads may still be present in the lake sediment. With 49 active dairies, the Taylor Creek / Nubbin Slough Sub-watershed was the single largest source of phosphorus with 34 percent of the total lake inflow loads for the period 1973-1982 (**Figure 5**).

Flows entering the lake from the Upper Kissimmee Sub-watershed (i.e., that area from Lake Kissimmee north to Orlando) and the Lower Kissimmee Sub-watershed (Kissimmee River valley) during this time period comprised 45 percent of the inflows to the lake.

As a way to reduce the nutrient pollution entering the lake, beginning in 1979 the operations of the major structures (pump stations S-2 and S-3 and hurricane gate structure no. 5) were changed to divert nutrient laden runoff from the EAA to the Everglades. By the end of 1982 these operations, referred to as the Interim Action Plan, were complete.

From 1983 to the present, the flow to the lake from the EAA has been reduced by approximately 83 percent compared to pre-1983. Between 1983 and 2017, flows from the South Sub-watershed made up approximately 6 percent of the total lake inflow, 15 percent of the total nitrogen entering the lake and 7 percent of the total phosphorus entering the lake. Despite the diversion of most of the EAA runoff away from the lake, the average annual inflow to the lake from all basins has increased by about 10 percent since 1982. Approximately 49 percent of the flow entering the lake comes from the Upper Kissimmee and Lower Kissimmee Sub-watersheds.

[2] Surface inflows exclude direct rainfall on the lake.

A wide range of state and federal nutrient control programs have been implemented in the Lake Okeechobee Watershed (**Table 1**). In August 2001, the State developed a total maximum daily load (TMDL) of phosphorus for the lake's watershed, established specifically to reduce the frequency of algal blooms in the lake. State legislation (the 2000 Lake Okeechobee Protection Act 373.4595, F.S.) established a January 2015 deadline for achieving compliance with the TMDL. In December 2014, the Department adopted the Lake Okeechobee Basin Management Action Plan (BMAP) for total phosphorus. Hundreds of millions in public funds have been spent on dairy buyouts, agricultural best management practices, regional water quality treatment projects, and other efforts. However, the state continues to allow landowners to discharge high levels of nutrients with little to no enforcement or accountability, and the pollution of Lake Okeechobee and the estuaries continues. The water quality of the lake is at an all-time crisis level, and human health is suffering as polluted lake water is discharged to the estuaries. The 2016 Florida Water Law deleted the January 2015 deadline to achieve compliance with the TMDL, and replaced it with a 20-yr timeframe tied to the BMAP. In addition, the 2016 law replaced the regulatory program that would have held individual landowners accountable for pollution from their land (i.e., the Works of the District permitting program) with the BMAP process, a process that does not hold individual landowners accountable for pollution from their land.

Nitrogen loading and concentrations to the lake have decreased since the diversion of the EAA runoff (**Figures 6-8**). Still, the 5-yr average annual nitrogen load to the lake has increased steadily since 2010. Phosphorus loads to the lake have not decreased substantially. In fact, the average phosphorus load has also increased steadily since 2010. During calendar year 2017 the average annual phosphorus loading to the lake was more than 5 times the TMDL allocation for the watershed, while the concentration rose to almost 800 parts per billion, almost 4 times the concentration observed in 1982. The result: an algae bloom covered 90 percent of the lake this summer (2018).

In addition, the state's annual BMAP "progress report" describing efforts to reduce pollution of the lake significantly underestimates the actual loading to the lake (**Figures 9-10**). For the last two years the FDEP has published reports indicating phosphorus loading to the lake has decreased – yet these claims conflict with the measured loads to the lake, e.g., the measured average load in 2017 was almost 50% higher than reported by FDEP.

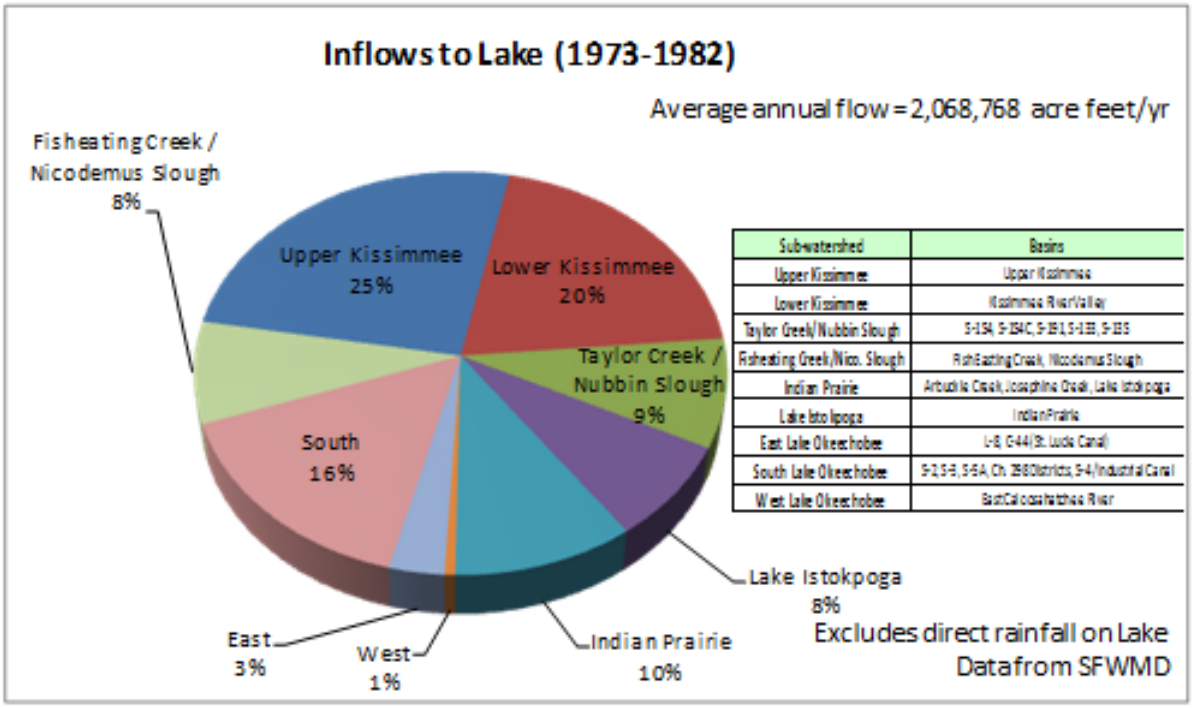
SFWMD reports that perhaps 30,000 metric tons of total phosphorus may reside in the top 10 cm of sediments of Lake Okeechobee, which creates an internal loading source that may equal or exceed the external loading source.

Summary: The water quality of the lake is at an all-time crisis level, and human health, the environment and the regional economy is suffering as polluted lake water is discharged to the estuaries. For 2017 the average annual phosphorus loading to the lake was more than 5 times the TMDL allocation for the watershed. The result: an algae bloom covered 90 percent of the lake this summer.

The nutrient concentrations and loads vary significantly among the nine sub-watersheds. For the period since 1982, approximately 45-55 percent of the nutrient loads came from those sub-watersheds directly north of the Lake (Upper Kissimmee, Lower Kissimmee and Taylor Creek/Nubbin Slough). Approximately 35 percent of the nutrient load came from the sub-watersheds located northwest of the Lake (Lake Istokpoga, Indian Prairie and Fisheating Creek/Nicodemus Slough). The remaining sub-watersheds east, south and west of the Lake contributed approximately 15-25 percent of the nutrient loads.

Note: Some parties have stated that 90-95 percent of the water entering the lake comes from the "north", with some parties specifically indicating the Upper and Lower Kissimmee Sub-watersheds. This is incorrect. The confusion stems from the FDEP permit which defines the "North Region" as containing multiple sub-watersheds, including the Upper Kissimmee, Lower Kissimmee, Taylor Creek / Nubbin Slough, Lake Istokpoga, Indian Prairie and the Fisheating Creek / Nicodemus Slough sub-watersheds. As shown in **Figure 3**, during 1983-2017 less than 50 percent of the water entering the lake comes from the Upper and Lower Kissimmee Sub-watersheds.

Figure 3. Distribution of Inflows to Lake Okeechobee.



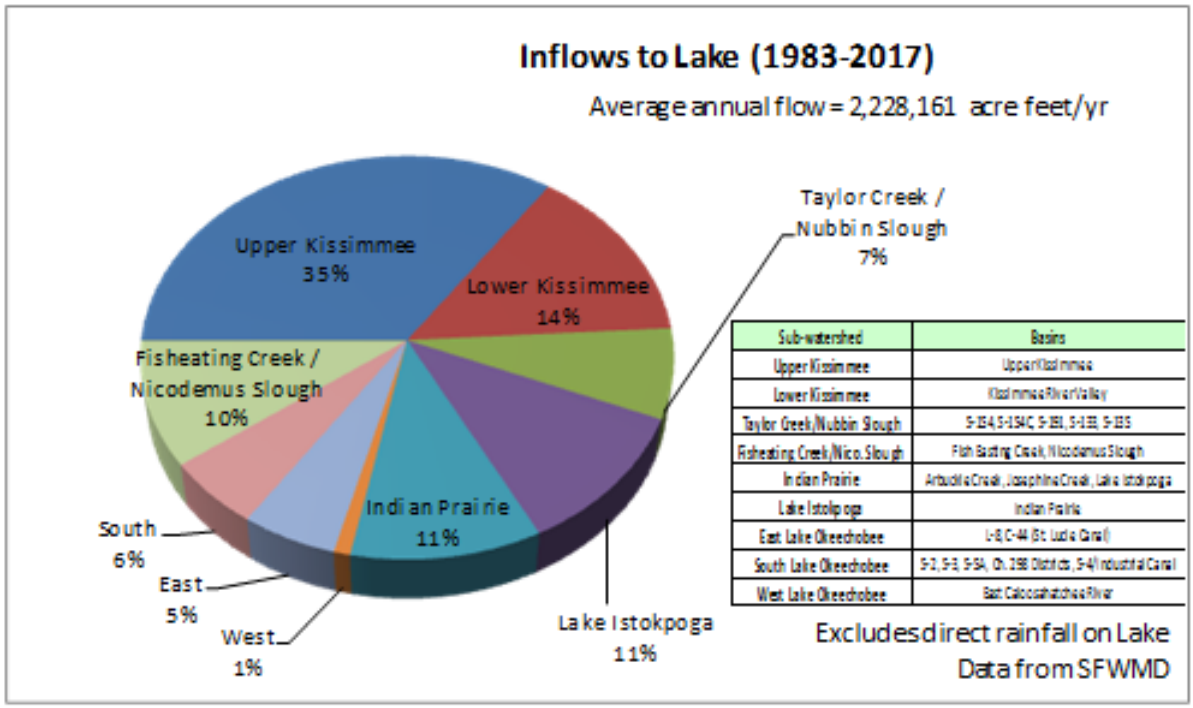
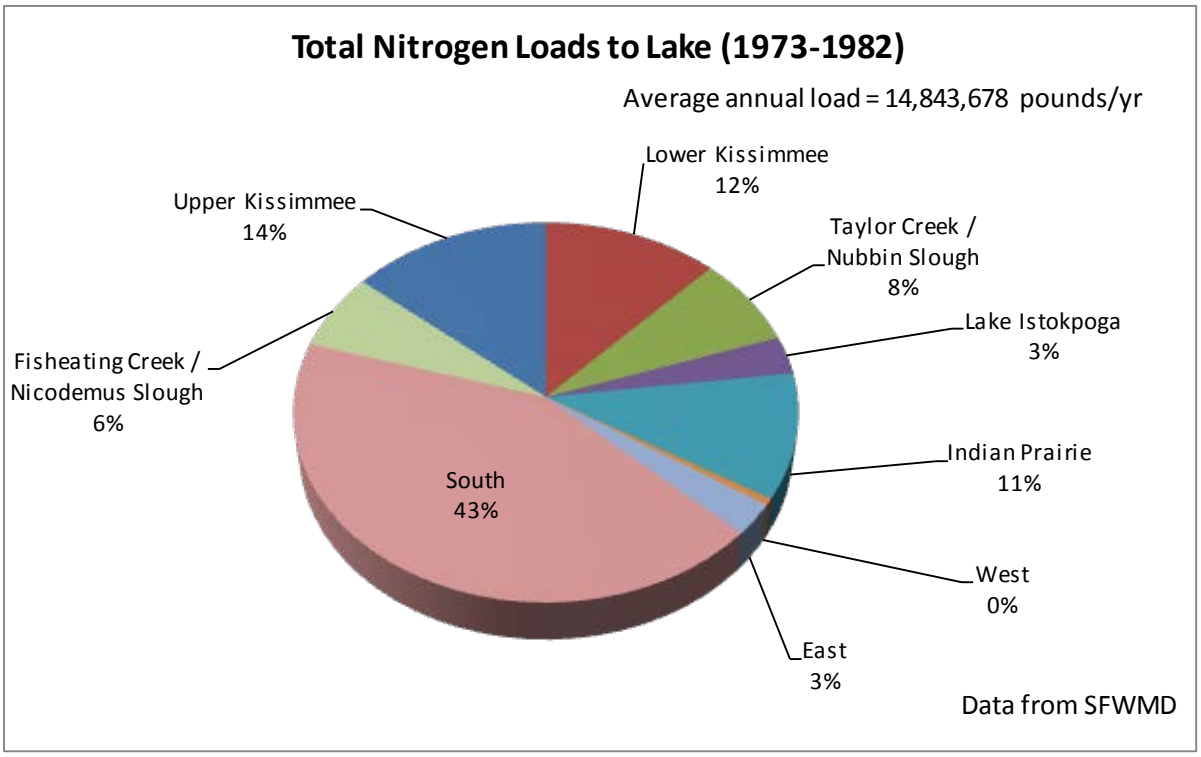


Figure 4. Distribution of Inflow Nitrogen Loads to Lake Okeechobee.



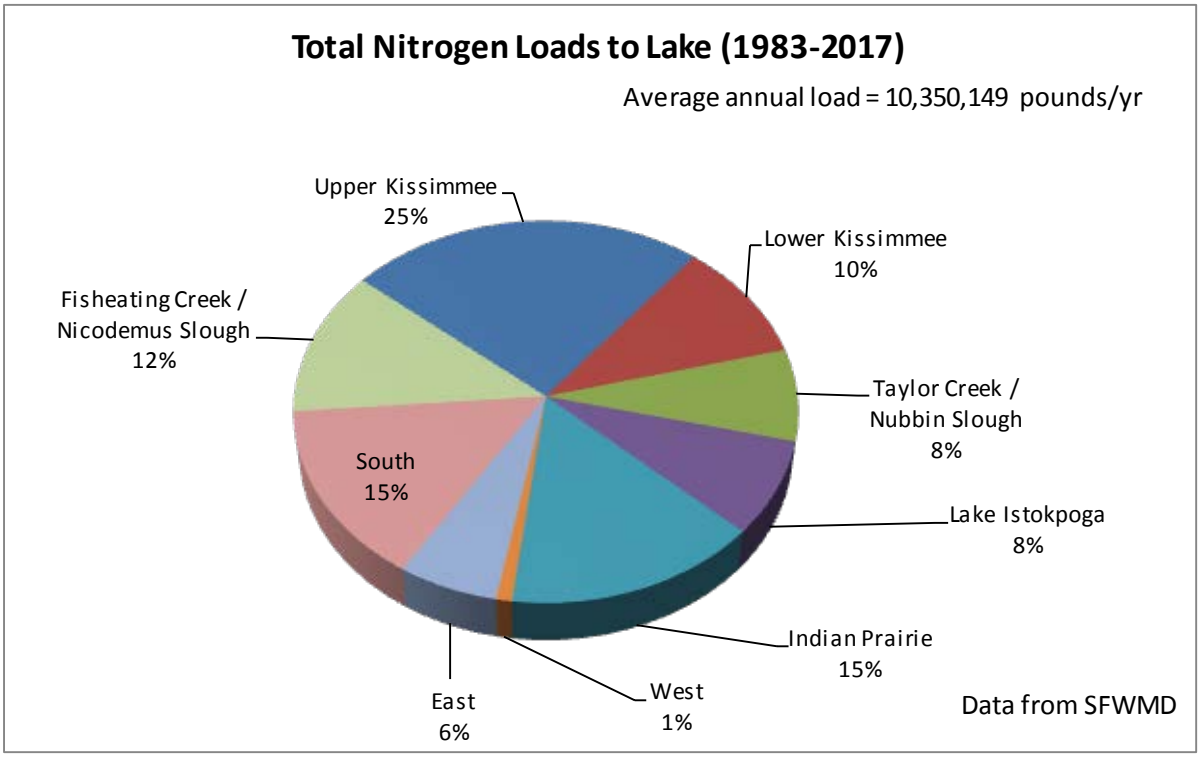
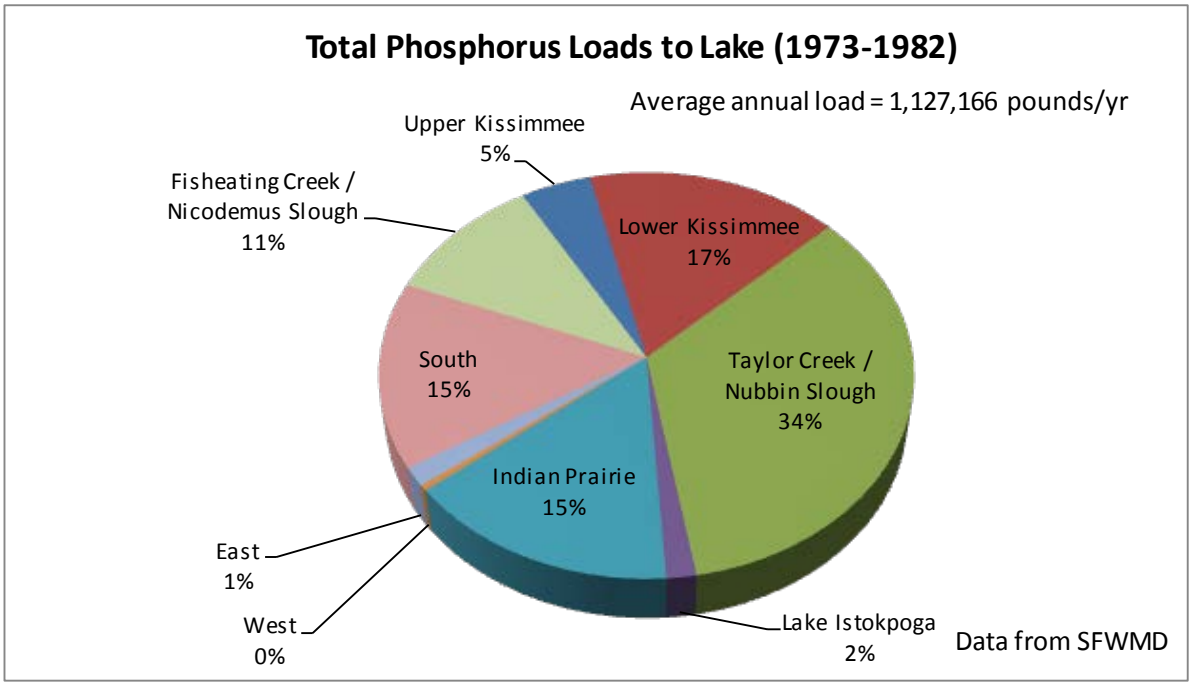


Figure 5. Distribution of Inflow Phosphorus Loads to Lake Okeechobee.



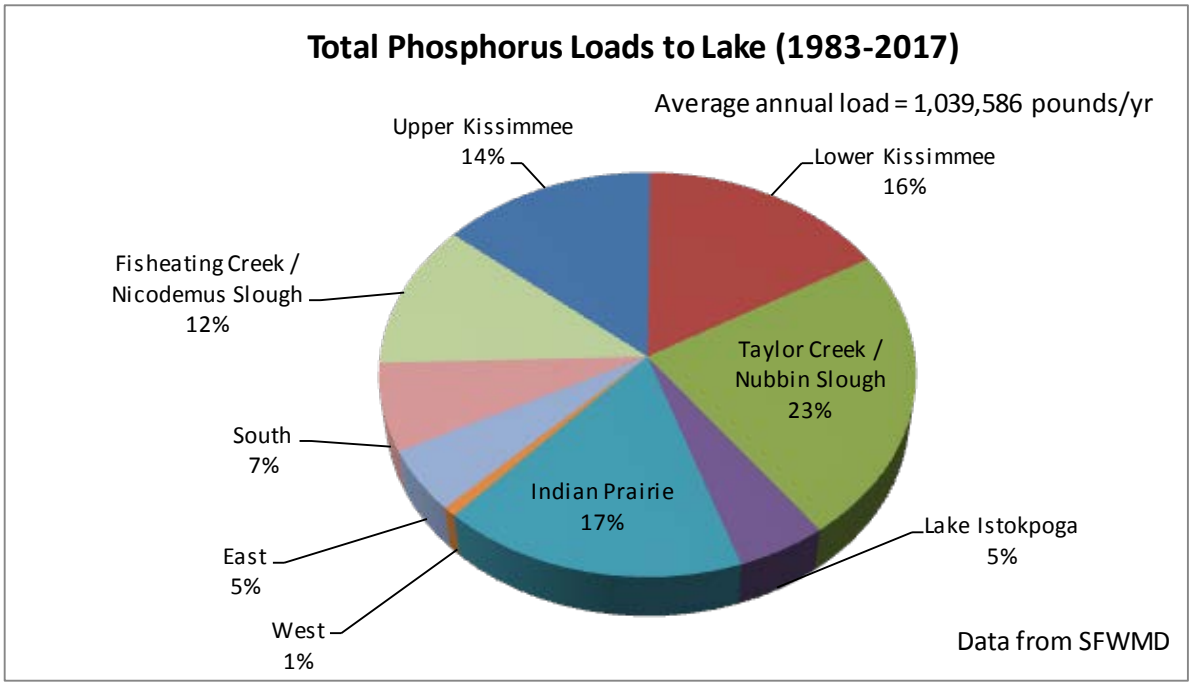
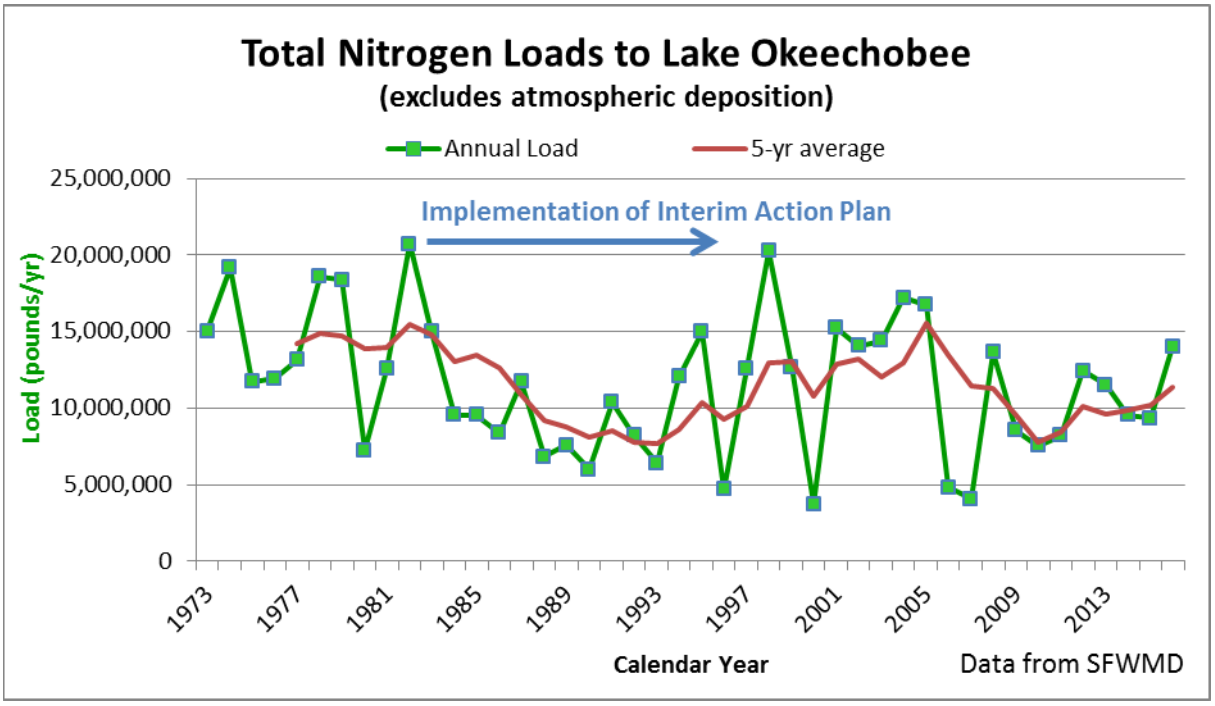


Table 1. Summary of Nutrient Control Programs in the Lake Okeechobee Watershed (from Goforth et al. 2013).

Table 2-3. Summary of the source control implementation time frame for the Lake Okeechobee Watershed.

Timeframe	Event
1970s	FDER Dairy regulatory programs begin
1972	Clean Water Act and Florida Water Resources Act
	South Florida Water Management District Stormwater Permitting Begins
1978	Florida Established Non-Point Source Management Programs
1981	Rural Clean Water Program Taylor Creek Headwaters
1984	FDER Biosolids/Domestic Wastewater Residuals Regulations
1985	Florida State stormwater rule adopted, retention ponds became required for new development
1986	New citrus groves were required to include onsite reservoirs for stormwater runoff.
1987	Surface Water Improvement and Management Act for Lake Okeechobee enacted
1987	FDER Dairy Rule for Lake Okeechobee Basin
1989	Chapter 40E-61, the Lake Okeechobee Works of the District Rule adopted by SFWMD
1990	National Pollutant Discharge Elimination System Programs
1992	Chapter 40E-63, the Everglades Agricultural Area Works of the District Rule adopted by SFWMD
1995	SFWMD Environmental Resource Permitting Regulatory Program adopted
1995	Kissimmee River Restoration Project
1999	Florida Watershed Restoration Act
2000	The Lake Okeechobee SWIM Act is revised to become the Lake Okeechobee Protection Act
2003	FDOH Septage Application requires Agricultural Use Plan
2003	FDACS adopts Rule 5M-3, the BMP rule for the priority basins S-191, S-154, S-65 D and S-65E.
2003	FDACS Land Application of Animal Wastes (Rule 5M-3)
2004	FDOH Wastewater Master Plans
2005	The geographic area of the Lake Okeechobee Protection Act is expanded to include the Upper Kissimmee and the Lake Istokpoga Sub-watersheds.
2006	FDACS expands BMP rule 5M-3 to the entire Lake Okeechobee Watershed
2007	The LOPA is revised to become the Northern Everglades and Estuaries Protection Program
2007	FDACS Urban Turf Fertilization Rule (Rule 5E-1.003)
2011	FDACS amends BMP Rule 5M-3 to the entire Northern Everglades
Beyond 2012	Elimination of land application of biosolids
	Proposed FDEP Numeric Nutrient Criteria

Figure 6. Time Series of Inflow Nutrient Loads to Lake Okeechobee.



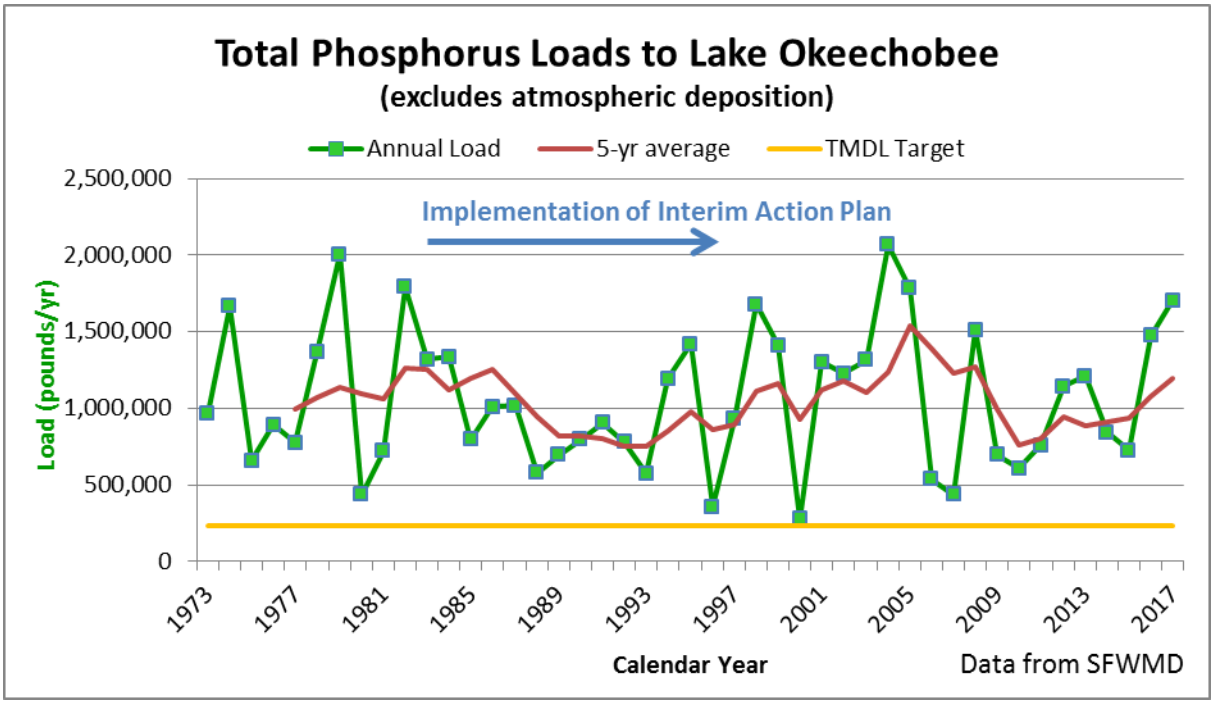
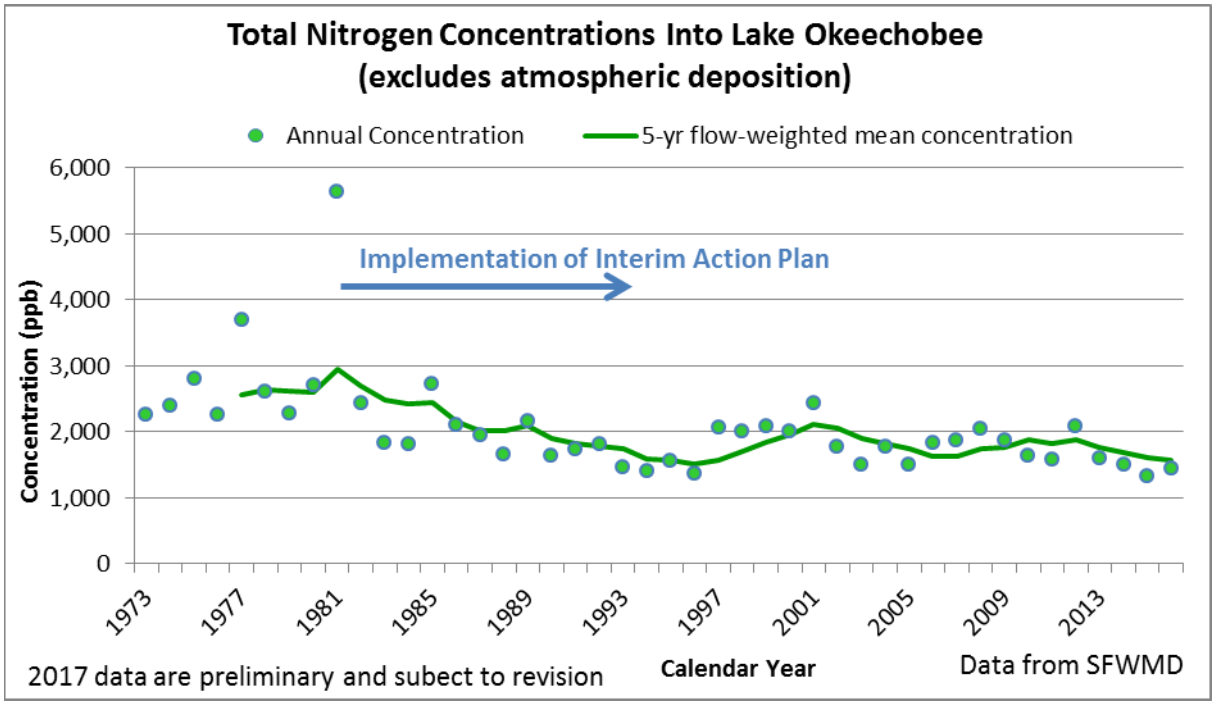


Figure 7. Time Series of Inflow Nutrient Concentrations to Lake Okeechobee.



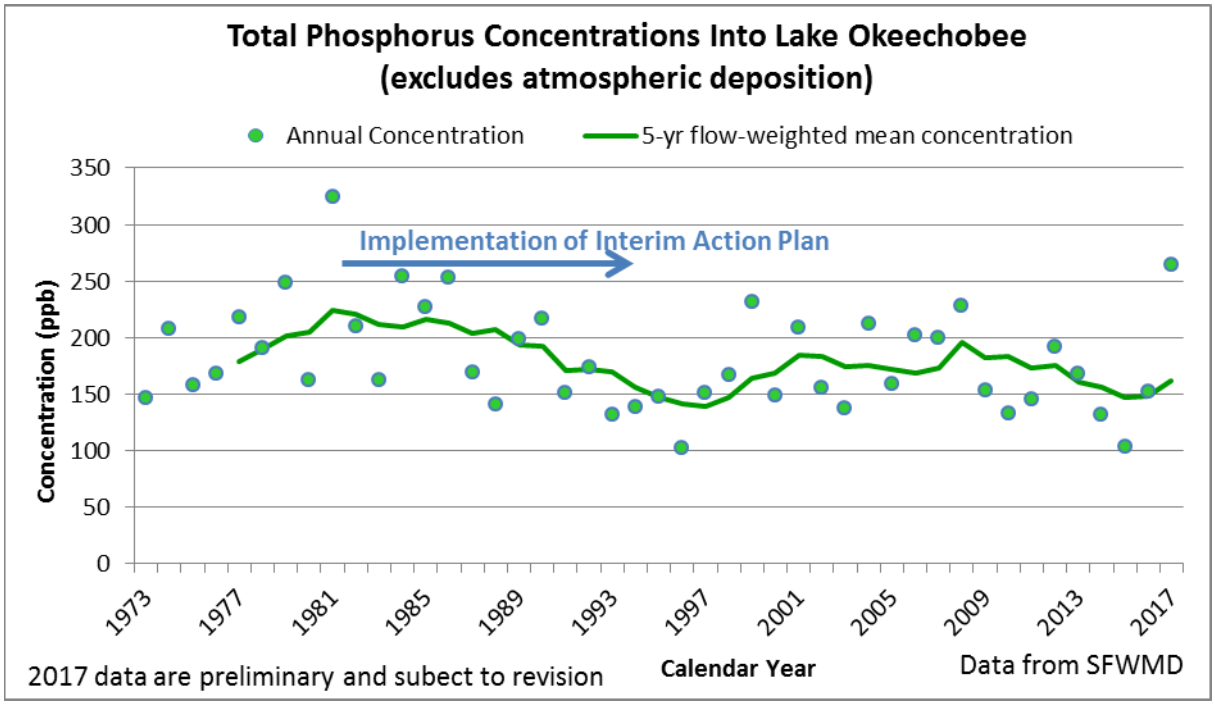


Figure 8. Inflow, outflow and in-lake nutrient concentrations (SFWMD 2018).

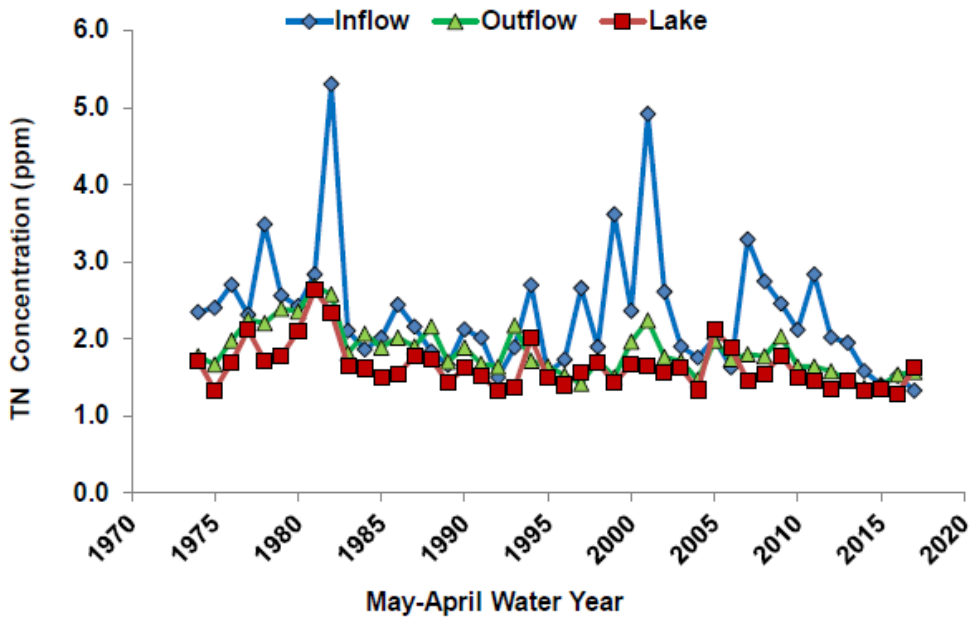


Figure 8B-28. Timelines of inflow, outflow, and lake average TN concentrations calculated from the lake N budget.

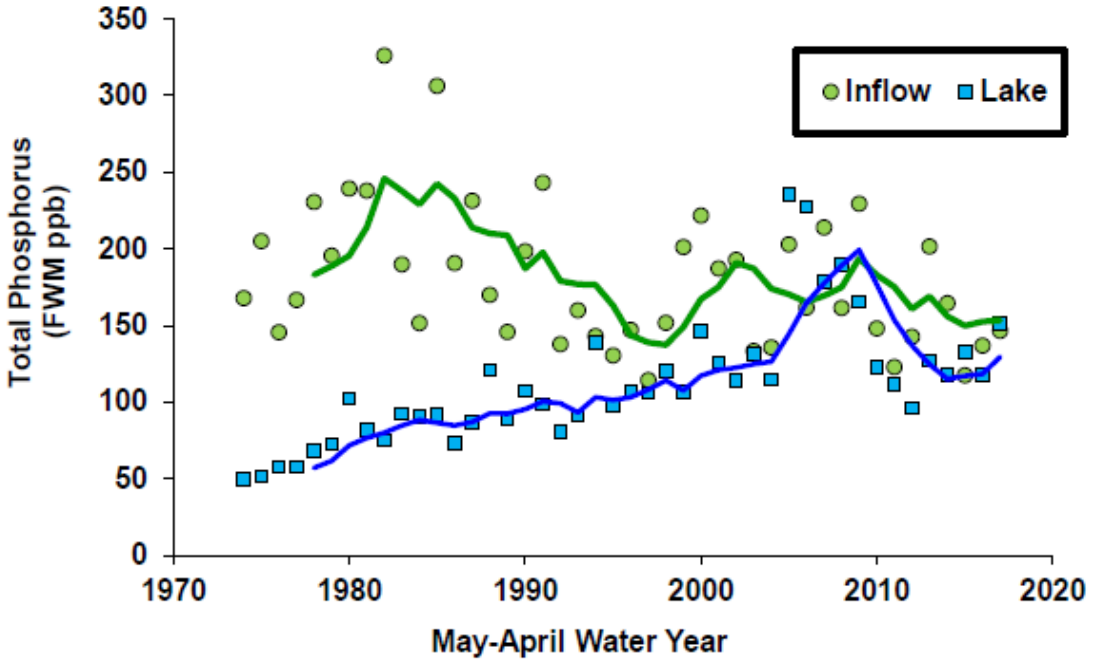
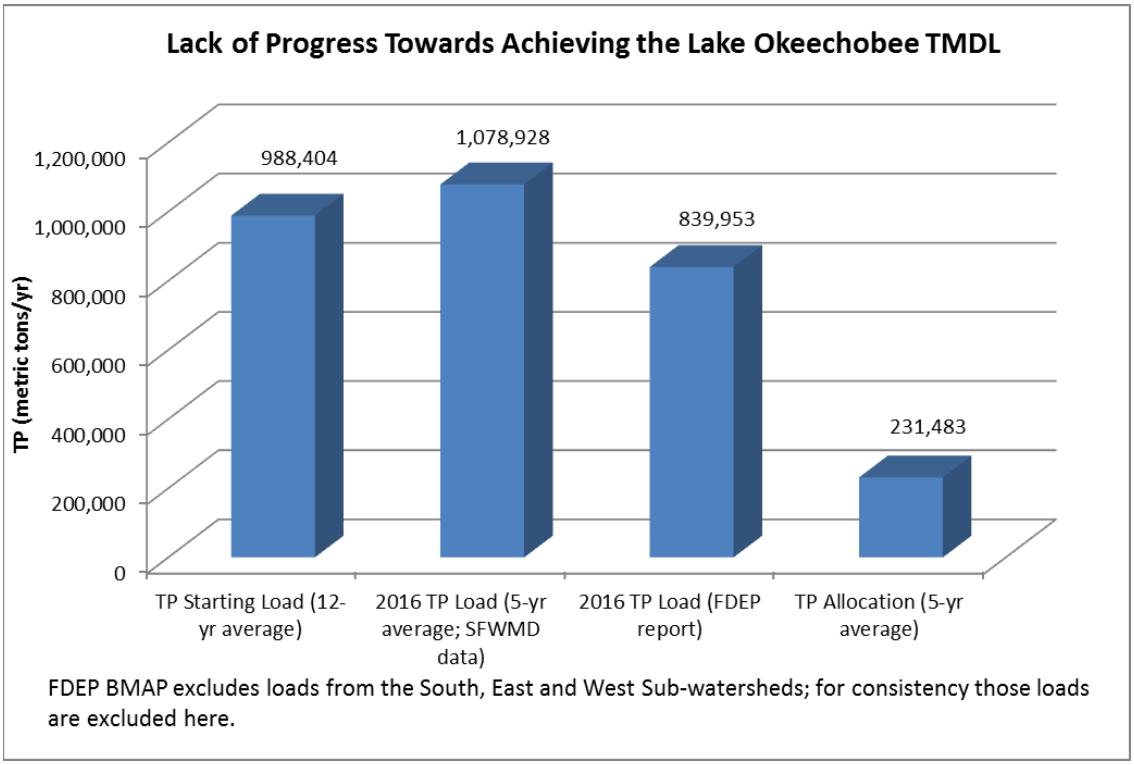


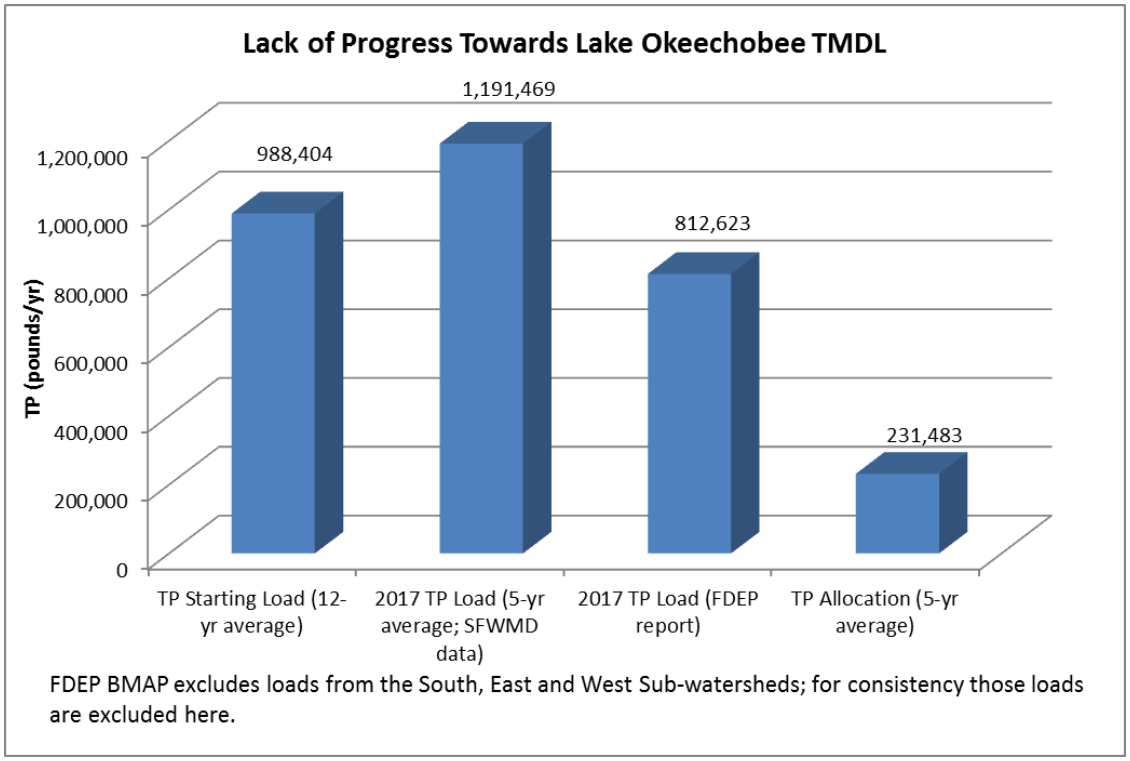
Figure 8B-25. Timelines of inflow and lake average TP concentrations (five-year moving average trend lines) calculated from the P budget of Lake Okeechobee.
(Note: ppb – parts per billion, which is equivalent to µg/L.)

Figure 9. Comparison of 2016 measured loads to the lake with FDEP estimate.



FDEP BMAP excludes loads from the South, East and West Sub-watersheds; for consistency those loads are excluded here.

Figure 10. Comparison of 2017 measured loads to the lake with FDEP estimate.



FDEP BMAP excludes loads from the South, East and West Sub-watersheds; for consistency those loads are excluded here.

Partial 2018 Inflows to Lake Okeechobee

While total nitrogen data are not yet available for all the inflow locations to the lake, the following is a preliminary summary of partial 2018 flows and phosphorus loading for the period January 1 – July 31, 2018.

Direct rainfall on the lake has been about 18 percent greater than last year for this same period, however the inflows to the lake have increased by almost 50 percent (**Figure 11**). The Upper and Lower Kissimmee sub-watersheds have contributed about 2 percent of the total inflows so far this year. Basins showing the greatest increase in 2018 compared to 2017 include the Indian Prairie, Lake Istokpoga and Taylor Creek / Nubbin Slough sub-watersheds (**Figure 12**). The basins contributing the largest phosphorus loads are Indian Prairie, Lake Istokpoga and Fisheating Creek / Nicodemus Slough (**Figure 13**). Loading from the Upper and Lower Kissimmee sub-watersheds have been minimal to date.

Figure 11. Distribution of 2018 Inflows to Lake Okeechobee.

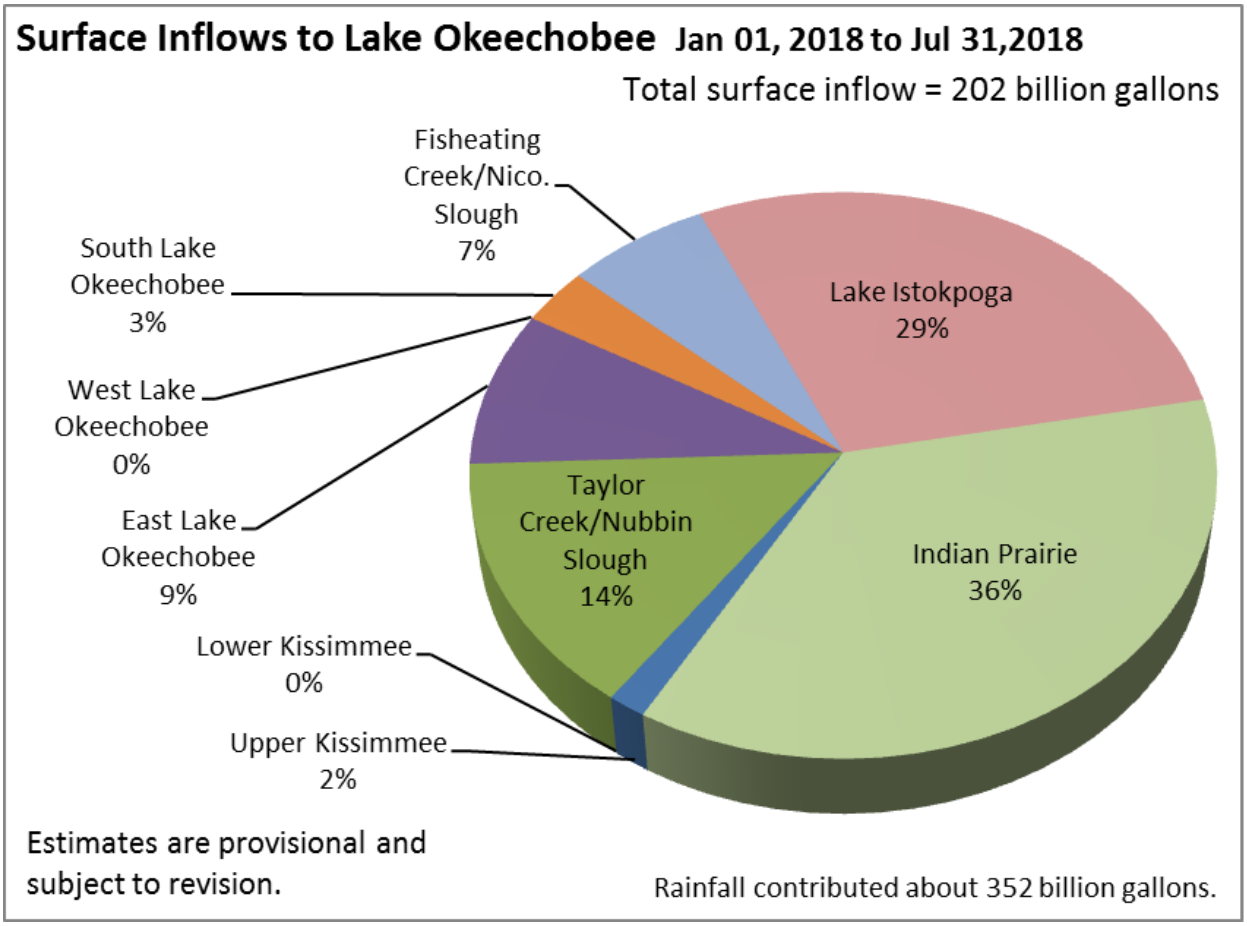


Figure 12. Comparison of Inflows to Lake Okeechobee.

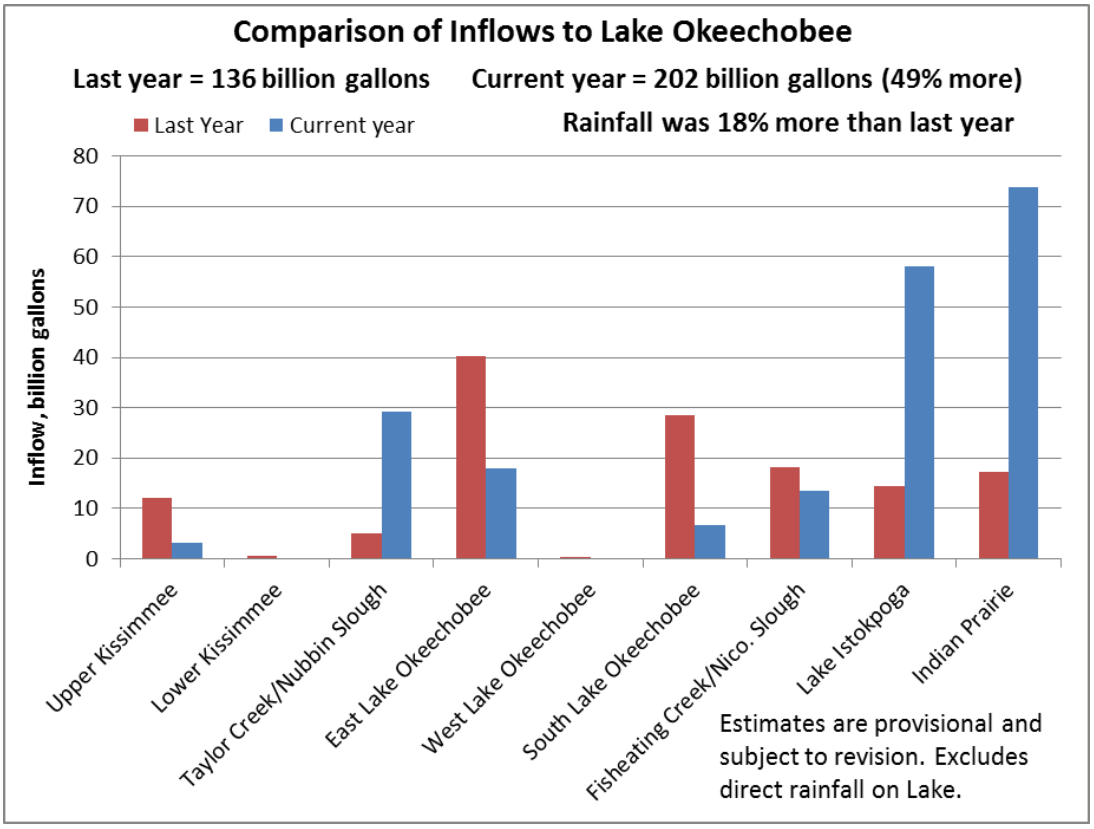
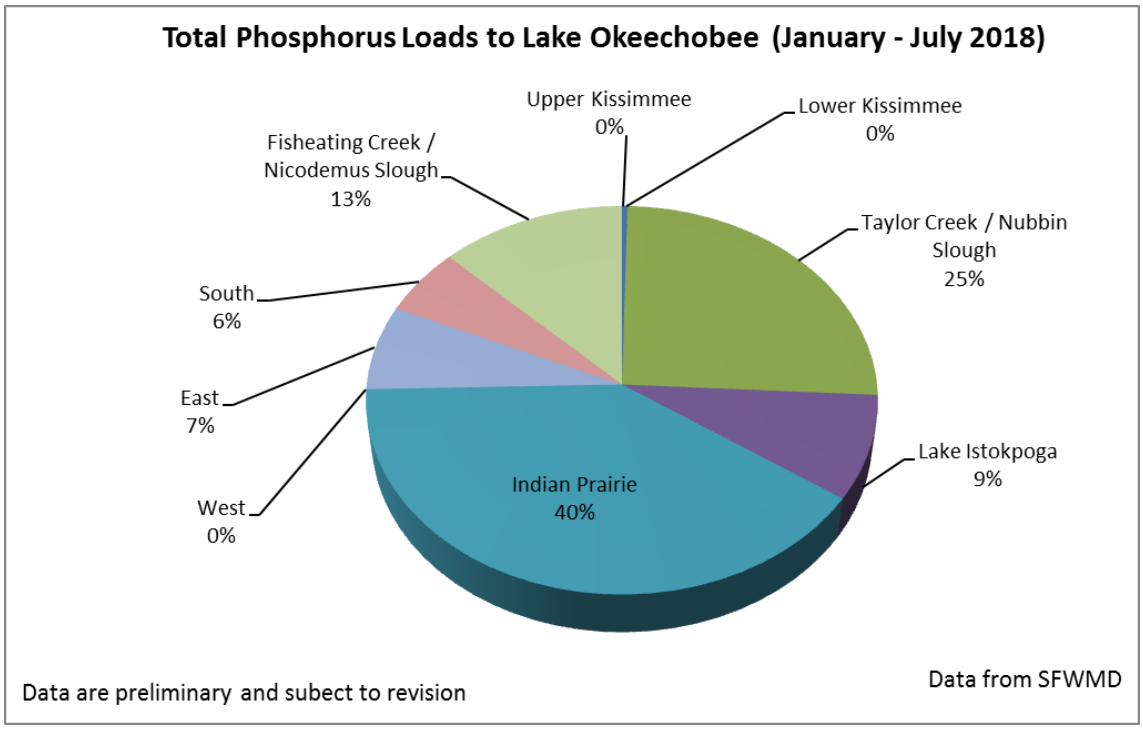


Figure 13. Preliminary Phosphorus Loads to Lake Okeechobee (partial 2018)



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