Final Report

for project entitled

Phosphorus Budget Update for the Northern Lake Okeechobee Watershed

Contract Number C-11683
October 2002

for the

South Florida Water Management District

by the

MOCK • ROOS TEAM
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The MOCK•ROOS TEAM

ACKNOWLEDGMENTS

The Mock•Roos Team, consisting of Mock, Roos & Associates, Inc., Soil and Water Engineering Technologies, Inc. and Dr. Carolyn Boggess, would like to thank the following individuals for their contribution to this project.

Dr. Joyce Zhang	Project Manager, South Florida Water Management District
Dr. Susan Gray	South Florida Water Management District
Dr. Todd Tisdale	South Florida Water Management District
Dr. Odi Villapando	South Florida Water Management District
Ms. Benita Whalen	South Florida Water Management District
Mr. Gregory White	South Florida Water Management District
Mr. Gary Ritter	South Florida Water Management District
Ms. Steffany Gornak	South Florida Water Management District
Mr. Joe Albers	South Florida Water Management District
Ms. Linda Crane	Florida Department of Agriculture and Consumer Services
Mr. John Folks	Florida Department of Agriculture and Consumer Services
Ms. Kim Shugar	Florida Department of Environmental Protection

The Mock•Roos Team would also like to thank many others that have answered questions and provided comments including all of those individuals that attended the project presentations at the Lake Okeechobee Watershed CERP PDT meeting in July 2002 and at the Lake Okeechobee Interagency Committee meeting in August 2002.

ENGINEER'S CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Florida, that the information in this Final Report for project entitled Phosphorus Budget Update for the Northern Lake Okeechobee Watershed was assembled under my direct responsible charge. The information provided herein was based on the information that was available and obtained from the South Florida Water Management District and other sources identified herein**.** The certifying Engineer cannot be responsible for added or deleted information once distributed. This report is not intended or represented to be suitable for any reuse without specific verification or adoption by the Engineer. This Certification is provided in accordance with the Florida Board of Professional Engineers' Rule on Certification under Chapter 61G15-29.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

LIST OF APPENDICES

EXECUTIVE SUMMARY

This study is an update of the original phosphorus budget for the northern Lake Okeechobee watershed compiled in 1991 (Fonyo et al., 1991) and published in 1995 (Boggess et al., 1995). The original phosphorus budget was performed to estimate the amount of net phosphorus entering the basins that discharge to Lake Okeechobee based on land use practices and hydrologic factors. This phosphorus budget update re-evaluates the different land uses to determine if their impact on the lake has changed.

This study helps to assess the effectiveness of best management practices (BMPs) and strategies implemented since 1991 and helps evaluate ways of reducing pollutant loads to the lake by refining related strategies of the Surface Water Improvement and Management (SWIM) plan water quality objective and meeting Total Maximum Daily Load (TMDL) goals. Relationships between basin characteristics and net phosphorus imports were analyzed based on current information collected in this study.

Approach

Phosphorus budgets were developed through integration of Geographic Information System (GIS) data sets, satellite imagery, landowner surveys/research, and field reconnaissance. Both tabular and graphical landowner and basin level phosphorus budgets and data structures were used in the analysis. A Graphical User Interface (GUI) was created to view and modify input data (farms, drainage basins, hydrographic features, land uses, and soil types) and phosphorus budget results (import and export) using Environmental Research System Institute (ESRI™) GIS software entitled ArcView™. A table has been included in Appendix A that shows a correlation from the Florida Land Use Cover Classification System (FLUCCS) code and the current study corresponding land use. See Appendix E (User's Manual) for a complete description of the user interface.

Net phosphorus imports for each basin were estimated as the sum of phosphorus mass in materials imported to the basin minus the mass of phosphorus in materials exported out of the basin. This study showed net phosphorus imports are dominated by anthropogenic activities. The onsite phosphorus storage was calculated as the sum of net phosphorus imports, including rainfall, minus phosphorus surface runoff. Phosphorus land use coefficients were determined and applied to each respective land use area and summed for each basin based on a revised GIS land use data set.

The Soil Conservation Service (SCS) curve number method was utilized to estimate the runoff volumes based on recent rainfall data and the percent impervious surface estimated in the original study. The Event Mean Concentration (EMC) represents the average total phosphorus concentration (mg/L) of runoff for a specific land use. EMC values were based on literature review that determined the EMC in various sampling programs, including multiple-year bi-weekly samplings of sites with various land uses. EMC values and runoff estimates were used to calculate the amount of phosphorus in runoff for each land use.

Phosphorus Budget Coefficients by Land Use

Since 1991, there has been an increase in the areal extent of several land uses including truck crops, improved pasture, sugarcane and dairies. While the areal extent of some land uses truly did change, some changes may be the result of previous mapping errors or changes in assigned land use categories.

For example, dairies have been redefined to include their pasture areas. Dairy as a land use has not actually increased. The spatial increase reported in the exhibits for dairies primarily reflects the redesignation of areas that were previously designated as improved pasture. Improved pasture area increased despite the redesignation of some of this area to dairy.

The net phosphorus import coefficients represent the average annual amount of net phosphorus imported per acre of a specific land use. Most land uses have shown a decrease from the last study in net phosphorus import per acre. The EMC value for truck crops, dairy, and improved pasture decreased from the original study, while the citrus EMC increased.

The notable changes in land use and land use practices during the past ten years have been rapid urbanization and related landscape fertilizer use. The FDEP indicated that no landowners in the northern Lake Okeechobee watershed are currently land applying sludge. According to the FDEP, sludge application has not been allowed in the Lake Okeechobee watershed since July 1, 2001, unless the applier of the sludge developed a Phosphorus Management Plan. The following is a comparison of original and current phosphorus imports:

<u>Improved Pasture</u>. The improved pasture land use has shown one of the most considerable changes in phosphorus loading. The net import of phosphorus decreased as a consequence of phosphorus fertilizer imports decreasing by 69% and the live weight phosphorus exports

increasing by 40%.   The net phosphorus import decreased by 75% from the original budget, from 12.23 kg P/ha-yr (10.91 lbs P/ac-yr) to 3.04 kg P/ha-yr (2.71 lbs P/ac-yr).

The original study approach involved assumptions of feed supplements and live weight exports according to the Institute of Food and Agricultural Sciences (IFAS) Standards and Study (IFAS, 2001). IFAS Standards are the general collection of publications for various agricultural practices and standards. The current approach involved more survey information in determining a representative feed supplement and export live weight value. The revised phosphorus budget accounted for hay and sod exports as commonly done whereas the original budget did not consider these exports.

Unimproved Pasture. Current net phosphorus imports decreased by 80% from the original budget, from 0.06 kg P/ha-yr (0.05 lb P/ac-yr) to 0.01 kg P/ha-yr (0.01 lb P/ac-yr). The approaches between the original and current unimproved pasture phosphorus budget are similar and only vary by the current supplement averages. In general, the existing supplement phosphorus decreased by 20% from the original budget.

Dairy. In contrast to the original study, the boundaries of dairies now include the high intensity areas, milking pastures, dry cow pastures, forage areas, and hay production areas. The total net import of phosphorus to dairies was calculated as 79.90 kg P/ha-yr (71.3 lbs P/ac-yr) based on values in the original study. Based on the current information, the total net import to the dairies is calculated to be 53.72 kg P/ha-yr (47.9 lbs P/ac-yr). This reduction of net import of phosphorus to the basin is mainly a result of less phosphorus being fed to the cows.

Citrus. Citrus land use currently has a lower phosphorus concentration in applied fertilizer, and a higher percentage of mature groves versus new and reset groves. Mature groves take less than one-fourth the amount of phosphorus that new and reset groves require.

The phosphorus concentrations in oranges and grapefruits were lower than reported in the original study. In addition to the overall lower phosphorus concentrations, the fruit production decreased almost 25%, from 809 boxes/ha (327 boxes/acre) to 619 boxes/ha (250 boxes/acre), thereby further reducing the amount of phosphorus exported.

The net import of phosphorus decreased because the reduced fertilizer phosphorus application more than accounted for the lower phosphorus export in fruit. The net phosphorus import decreased by approximately 27% from the original budget, from 9.92 kg P/ha-yr (8.85 lbs P/ac-yr) to 7.23 kg P/ha-yr (6.45 lbs P/ac-yr). The current citrus budget involves each approach used in the original budget. In addition, the current budget breaks out citrus harvest into oranges and grapefruits.

Sugarcane. Sugarcane net phosphorus import decreased due to the fact that total phosphorus imports decreased slightly while total phosphorus exports increased considerably. The dominating factor influencing this trend is increased sugarcane production. The current net import decreased by 88% from the original budget, from 8.09 kg P/ha-yr (7.22 lbs P/ac-yr) to 0.99 kg P/ha-yr (0.88 lb P/ac-yr). The sugarcane phosphorus budget approaches are similar in the current and original study.

Truck Crop. Truck crops include vegetable crops such as corn, potato, and cabbage. Although not included in the original study, a new land use, field crop, was created to describe areas where mostly hay is grown. Truck crop net import of phosphorus increased primarily because the farming intensity of the acreage has increased. Double cropping was not previously considered in the process approval, so phosphorus use intensity was underestimated for truck crop land usage. The net phosphorus import increased by 20% from the original budget, from 158 kg P/ha-yr (141 lbs P/ac-yr) to 190.09 kg P/ha-yr (169.6 lbs P/ac-yr).

The current and original phosphorus budgets utilized two very different approaches. The original approach estimated phosphorus import by assuming lettuce as a "typical" crop and utilized IFAS fertilizer recommendations associated with that crop. The current approach involved a more rigorous pursuit of specific land use practices such as crop types grown and crop rotations. The original study assumed a harvest amount based on Florida agricultural statistics whereas the current phosphorus budget used actual crop harvest data to determine phosphorus export.

Sod. Sod net export of phosphorus increased due to a combination of lower phosphorus loadings and higher phosphorus harvested and removed with the sod. The net phosphorus export increased from 11.4 kg P/ha-yr (10.2 lbs P/ac-yr) to 48.87 kg P/ha-yr (43.6 lbs P/ac-yr).

Commercial Forestry. Commercial forestry had no change in the net phosphorus coefficient.

Ornamental. Despite a 27% decrease in ornamental total exports, there has been a decrease of net phosphorus imports from the original phosphorus budget because imports are 44% lower. The existing net phosphorus import decreased by 60% from the original budget, from 23.81 kg P/ha-yr (21.24 lbs P/ac-yr) to 9.5 kg P/ha-yr (8.5 lbs P/ac-yr). The current and original phosphorus budget approaches for ornamentals were the same. Caladium is still considered the "typical" ornamental crop.

Residential. Residential net areal phosphorus imports have increased since the original study from 28% to 120%, depending on the housing density. A change in the methodology for estimating phosphorus food and detergent imports account for most of this change. If the methodology of the original study was utilized, the net phosphorus import coefficient would not have changed. The current study directly estimates the amount of food and detergent consumed, while the original study assumed the phosphorus waste effluent was equal to the food and detergent import phosphorus. Septic tank phosphorus removal was considered in the current study, but not in the original study.

Phosphorus Budget by Land Use

Gross Phosphorus Imports. The total gross phosphorus import to the northern Lake Okeechobee watershed is 2,961 t P/yr (3,264 tons P/yr). The four most noteworthy land uses with regard to percentage of gross phosphorus imports, listed in order of magnitude, are improved pasture (29%), dairy (22%), truck crops (20%), and citrus (9%). Fertilizer import accounts for 69% of gross phosphorus imports of which 33% is for improved pasture, 30% is for truck crops, and 13% for citrus. Approximately 31% of gross phosphorus imports are from feed imports of which dairy accounts for 63%, improved pasture accounts for 20%, and all residential accounts for approximately 15%.

Gross Phosphorus Exports. The total gross phosphorus exported from the northern Lake Okeechobee watershed is 1,245 t P/yr (1,372 tons P/yr). The four most noteworthy land uses with regard to percentage of gross phosphorus exports, listed in rank order are sod (26%), improved pasture (24%), dairy (15%), and sugarcane (12%). Harvest exports from sugarcane, citrus, field crop, ornamentals, truck crops, and forests account for approximately 34% of gross phosphorus exports from the northern Lake Okeechobee watershed. Sod exports, live weight sales, and milk exports account for 29%, 22%, and 14% of gross phosphorus exports, respectively.

Net Phosphorus Import by Land Use. The overall net import to the watershed based on land use practices is 1,717 t P/yr (1,888 tons P/yr). The land uses with the most influence within the northern Lake Okeechobee watershed in terms of net phosphorus import are improved pasture

(33%), truck crop (32%), and dairy (27%). Other noteworthy land uses in terms of percent of net watershed phosphorus import (positive or negative) are sod farm (-14%) and citrus (11%).

Phosphorus Budget by Basin

Net Phosphorus Import by Basin. The C-40 basin is a net phosphorus exporter of 24 t P/yr (26 tons P/yr) because of the amount of sod grown and harvested in that basin. Basin S-65D contributes the highest net phosphorus import of any tributary basin with 418 t P/yr (460 tons P/yr). A dominant land use was assigned to each tributary basin based on the land use that contributed the largest value of net phosphorus imports to that basin. For example, truck crop is the dominant land use in terms of net phosphorus import to basin S-65D. Not including basin S-65D, the highest phosphorus importing tributary basins in order of decreasing magnitude are S-191 (dairy dominant), S-65E (truck crop dominant), Fisheating Creek (improved pasture dominant), and S-154 (dairy dominant). These five basins account for 75% of the total net phosphorus imports to the northern Lake Okeechobee watershed.

Phosphorus Runoff. The total amount of phosphorus runoff is 488 t P/yr (537 tons P/yr). The most noteworthy tributary basins with regard to phosphorus runoff loading are Fisheating Creek with 80 t P/yr (88 tons P/yr) or 16%, S-191 with 79 t P/yr (87 tons P/yr) or 16%, S-65D with 54 t P/yr (59 tons P/yr) or 11%, and C-41 with 43 t P/yr (48 tons P/yr) or 9%. The three primary land uses contributing to phosphorus runoff in terms of metric tons of phosphorus or percent of total phosphorus runoff were improved pasture with 283 t P/yr (311 tons P/yr) or 58%, citrus with 45 t P/yr (50 tons P/yr) or 9%, and dairy with 38 t P/yr (42 tons P/yr) or 8%.

Phosphorus Storage. The onsite phosphorus storage was calculated as the sum of net phosphorus imports, including rainfall, minus phosphorus in surface runoff. Wetlands storage is calculated as the amount of uplands phosphorus in runoff minus the amount of phosphorus lake loading. Approximately 74% of the total net phosphorus import is stored on site in upland soils and vegetation, 1,413 t P/yr (1,554 tons P/yr), while 26% is lost in runoff, 488 t P/yr (537 tons P/yr). Approximately 32% of that runoff phosphorus is stored in wetlands, 156 t P/yr (172 tons P/yr), while approximately 68% is loaded to Lake Okeechobee, 332 t P/yr (366 tons P/yr). Overall, 8% of the total phosphorus imports to the northern Lake Okeechobee watershed end up being stored in wetlands and 17% is loaded to the lake. Table ES-1 below summarizes the northern Lake Okeechobee watershed phosphorus budget by basin.

Table ES-1. Summary of Phosphorus Budget Results per Basin (Metric tons used)

Basin	Net P Import	P in Rainfall	P in Runoff	On site P Storage	P to Lake	Wetland P Storage	P to Lake %
C_40	(23.5)	6.36	17.0	(34)	8.5	8.4	2.6
C_41	44.8	13.72	43.3	15	24.4	19.0	7.3
C_41A	27.3	8.46	22.2	14	19.1	3.1	5.8
FISHEATING	150.3	40.80	80.4	111	64.1	16.3	19.3
L_48	29.1	3.00	10.3	22	7.5	2.8	2.3
L_49	12.4	1.75	4.9	9	1.6	3.2	0.5
L_59E	10.7	2.08	6.5	6	1.4	5.1	0.4
L_59W	4.0	0.93	2.5	2	2.4	0.1	0.7
L_60E	1.9	0.73	1.5	1	0.3	1.2	0.1
L_60W	1.6	0.47	1.1	1	0.1	1.1	0.0
L_61E	7.2	2.07	4.6	5	1.4	3.2	0.4
L_61W	5.1	1.96	3.3	4	1.3	2.0	0.4
LAKE_ISTOK	34.4	6.99	11.0	30	3.2	7.8	1.0
NICODEMUS_	13.4	3.52	7.8	9	0.3	7.5	0.1
S_131	9.0	1.04	2.9	7	1.2	1.7	0.4
S_133	46.9	3.71	15.4	35	4.3	11.0	1.3
S_135	17.8	2.61	6.7	14	2.4	4.3	0.7
S_154	119.2	4.57	21.1	103	31.8	(10.7)	9.6
S_154C	2.1	0.32	1.1	1	0.3	0.8	0.1
S_65A	91.4	14.94	29.1	77	5.5	23.5	1.7
S_65B	34.2	18.55	24.1	29	5.5	18.5	1.7
S_65C	48.9	7.29	20.6	36	10.0	10.6	3.0
S_65D	418.1	16.85	53.5	381	37.7	15.8	11.3
S_65E	231.0	4.21	18.1	217	24.1	(6.0)	7.2
S-191	379.4	17.38	78.9	318	73.8	5.1	22.2
TOTAL	**1,717**	**184**	**488**	**1,413**	**332**	**156**	**100**

Regression Analysis Results

Although the previous study indicated that physical basin characteristics had no considerable influences on phosphorus lake loading, various tributary basin characteristics were reviewed. Area, perimeter, and shape were found to have some correlation to phosphorus loading. Each basin was considered as a data point for basin characteristic and annual phosphorus lake loading. Regression analysis utilized all basin data points to determine correlations.

The variables with the highest correlations with lake loading in order of rank include runoff phosphorus ($r^2 = 0.88$), developed land ($r^2 = 0.82$), and net phosphorus input to the basin ($r^2 = 0.80$). Other variables with fair correlations to lake phosphorus loading were on site phosphorus storage ($r^2 = 0.75$), tributary basin perimeter ($r^2 = 0.72$), and total basin phosphorus storage ($r^2 = 0.72$). Fair correlations with lake loading were found for rainfall phosphorus import ($r^2 = 0.68$), tributary basin area ($r^2 = 0.68$), area of Myakka soil type ($r^2 = 0.67$), and length of streams ($r^2 =

0.66). A fair correlation was also determined between areal lake loading and areal net imports (r^2 = 0.60). This relationship was previously poor (r^2 = 0.36).

The strongest single relationship was found between the fraction of runoff phosphorus stored in streams and wetlands with phosphorus export intensity (r^2 = 0.90). Phosphorus export intensity refers to the lake phosphorus loading per basin area. Using multiple linear regression; net phosphorus import intensity, stream and canal density, and percent of wetlands correlated well with the total annual change in phosphorus retention per acre (r^2 = 0.99) and net phosphorus imports and length of canals and streams correlated well with lake loading (r^2 = 0.80).

Changes in the Phosphorus Budget

The previous phosphorus budget (Fonyo et al., 1991; Boggess et al., 1995) was compared to the current phosphorus budget. Net phosphorus imports decreased by 28% from the original budget, from 2,380 t P (2,618 tons P) to 1,717 t P (1,888 tons P), primarily due to changes in four land uses (Table ES-2). Land uses with the largest change in net phosphorus import amount include dairy from 1,170 t P (1,287 tons P) to 458 t P (503 tons P), or –61%, improved pasture from 1,010 t P (1,111 tons P) to 559 t P (613 tons P), or –45%, truck crops from 72 t P (79 tons P) to 545 t P (600 tons P), or 657%, and sod pasture from -70 t P (–77 tons P) to -239 t P (-259 tons P), or –236%. Dairy net phosphorus imports changed primarily due to fewer dairies and also as a result in change in management practices. Improved pasture net phosphorus imports decreased due to a lower net phosphorus import coefficient, which resulted from lower fertilizer application and higher live weight export. Truck crop net phosphorus imports changed due to a five-fold increase in truck crop area, and an increase in the phosphorus import coefficient, which reflects an increased farming intensity. Sod farm net phosphorus import decreased due to lower fertilizer application on this land use.

The improved pasture land use remains a considerable contributor of net phosphorus imports (33% currently, 49% previously); truck crops have become a more influential land use (32% currently, 3% previously); and dairy has decreased in contribution significance (27% currently, 42% previously). With regards to phosphorus management, improved pasture and dairy land uses should continue to be land uses of focus, but truck crops should receive increased attention.

Table ES-2 summarizes the land use changes in area and net phosphorus import.

Table ES-2. Change in Land Use Area and Net Phosphorus Import from 1995 to 2001

	Area (ha)		Net Import (t P/yr)		
Landuse	Previous	Updated	Previous	Updated	% Change
RANGELAND	74,000	46,641	-	1	N/A
IMP PASTURE	181,000	183,778	1,010	558	(45)
WETLANDS	78,000	95,423	-	-	N/A
FOREST UPLANDS	49,700	49,887	NA	(8)	N/A
DAIRY	18,000	8,525	1,170	458	(61)
BARREN LAND	N/A	4,611	NA	-	N/A
FIELD CROPS	N/A	2,276	NA	16	N/A
OTHER URBAN	N/A	5,274	NA	-	N/A
UNIMP PASTURE	62,000	33,453	4	0	(91)
TRUCK CROPS	450	2,868	72	545	657
CITRUS	13,000	25,392	130	184	41
WATER BODIES	N/A	14,910	-	-	N/A
GOLF COURSE	N/A	377	3	4	29
SOD FARM	6,400	4,816	(70)	(235)	236
ORNAMENTALS	730	3,212	18	30	69
COMM FOREST	N/A	13,299	(8)	(2)	(74)
WASTE TREAT PNT	N/A	64	NA	-	N/A
SUGARCANE	370	8,755	3	9	188
AQUACULTURE	N/A	336	NA	-	N/A
POULTRY	N/A	20	NA	-	N/A
ABAND DAIRY	N/A	2,344	NA	7	N/A
RESIDENTIAL	7,800	9,740	48	151	214
RESIDENTIAL**	7,800	9,740	48	102	112

**Adjusted value to reflect original methodology of previous study

Basins that have the largest decrease in net phosphorus import in terms of percent reduction are C-40 (-101 t P/yr or-121 %), L-59E (-43 t P/yr or –80%), S-135 (-46 t P/yr or -72%), and C-41 (-133 t P/yr or -71%). Basins that have the largest decrease in net phosphorus import in terms of amount of reduction are S-191 (-403 t P/yr or -51%), C-41 (-133 t P/yr or -71%), Fisheating Creek (-116 t P/yr or -44%), and C-40 (-101 t P/yr or –121%). Reduction in basin net phosphorus imports result from a decrease in the phosphorus intensive land uses such as dairy and truck crop, a decrease in dairy and other land use aerial net phosphorus import coefficients, and an increase in sod production area. Only four basins have an increase in net phosphorus import: S-65E (151 t P/yr or 189%), S-65D (104 t P/yr or 33%), S-65A (37 t P/yr or 69%), and S-154 (13.3 t P/yr or 12%).

Basins L-59W and L-60E were previously part of C-40, basins L-60W and L-61E were previously part of C-41, basin L-61W was previously part of Nicodemus Slough, and S-154C was previously part of S-154. See Table ES-3 below for a summary of changes in net phosphorus import by basin.

Table ES-3. Change in Basin Net Phosphorus Import from 1995 to 2001

	Area (ha)		Net Import (t P/yr)		
Basin	**Previous**	**Updated**	**Previous**	**Updated**	**% Change**
C-40, L-59W, L-60E	22,400	22,441	83	(18)	(121)
C-41, L-61E, L-60W	45,500	45,515	187	54	(71)
S-84	23,700	23,673	63	27	(57)
FISHEATING_CREEK	118,000	114,230	267	150	(44)
L-48	8,300	8,407	48	29	(39)
L-49	4,900	4,896	17	12	(27)
L-59E	5,800	5,828	54	11	(80)
LAKE_ISTOKPOGA	19,600	19,560	34	34	1
NIC, L-61W	10,200	15,347	21	19	(12)
S-131	2,900	2,898	15	9	(40)
S-133	10,400	10,386	77	47	(39)
S-135	7,300	7,319	64	18	(72)
S-154, S-154C	12,800	13,677	108	121	12
S-65A	41,800	41,825	54	91	69
S-65B	51,900	51,932	44	34	(22)
S-65C	20,400	20,409	67	49	(27)
S-65D	47,200	47,187	314	418	33
S-65E	11,600	11,800	80	231	189
S-191	48,700	48,671	782	379	(51)

In terms of phosphorus loading and percent of total lake loading, three basins account for over 50% of lake loading: S-191 with 74 t P/yr (81 tons P/yr) or 22%, Fisheating Creek with 64 t P/yr (71 tons P/yr) or 19%, and S-65D with 38 t P/yr (42 tons P/yr) or 11%. These three basins should receive a proportional amount of attention with regards to phosphorus management.

Lake loading can be decreased most effectively by decreasing net phosphorus imports in each tributary basin. Anthropogenic activities of phosphorus import have the largest correlation to lake phosphorus loading. The relationship between net phosphorus imports and lake loading data correlated more strongly than previously estimated.

1.0 INTRODUCTION

The purpose of this study is to update the existing phosphorus budget for the northern Lake Okeechobee watershed that was compiled in 1991 (Fonyo et al., 1991) and published in 1995 (Boggess et al., 1995). The original study was performed to estimate the amount of net phosphorus entering the basins that discharge to Lake Okeechobee based on land use practices and hydrologic factors. This study update re-evaluates the different land uses to determine if their impact on the lake has changed. The following tasks were performed to accomplish the project objective:

1. Develop a Project Work Plan that will document farm-level and basin-level mass balance modeling approaches and identify specific task objectives, deliverables, and methodologies to be used.
2. Update the previous phosphorus budget study by:
    a. Reviewing the phosphorus content of import and export materials.
    b. Creating farm-level materials and phosphorus mass balance models for an array of land use and land management practices.
    c. Aggregating farm-level data by sub-basin.
3. Conduct a mass balance analysis of phosphorus for each land use at the watershed level.
4. Analyze possible relationships between lake phosphorus levels and basin characteristics, such as land use type, soils, and tributary type for each basin.
5. Develop a simple graphical user interface (GUI) to view input data (farms, drainage basins, hydrographic features, land uses, and soil types) and phosphorus budget results (import and export) using ArcView®.
6. Write final documentation that describes work done for this contract. A manuscript will be drafted for submission to a peer-reviewed scientific journal.

Lake Okeechobee is centrally located in the southern portion of the state of Florida. It is fed from the north by the Kissimmee River and discharges to the south through the Caloosahatchee and various tributaries that connect to the Everglades. Over the years the impacts from farming have increased the total phosphorus content within the lake. According to the South Florida Water Management District, recent changes in technology and agricultural practices have helped to reduce the amount of phosphorus entering the lake, but the problem still exists.

By determining which land uses contribute the most phosphorus to the land, solutions can be derived to help eliminate this problem. The use of Geographic Information Systems (GIS) directly with phosphorus loading characteristics provides a flexible tool that can be readily used to perform updates.

This study is important to understanding how recent best management practices (BMPs) and strategies implemented have affected lake phosphorus loading. Also, determining how land use practices and basin characteristics have recently affected lake phosphorus loading will help assess methods of achieving goals and refining related strategies of the SWIM Plan water quality objective (SFWMD, 1997).

The spatial extent of this study and the original study is the same (Figure 1). However, the original study included 19 tributary basins whereas the current study involves 25 basins. Basins L-59W and L-60E were previously part of C-40, basins L-60W and L-61E were previously part of C-41, basin L-61W was previously part of Nicodemus Slough, and S-154C was previously part of S-154. See Figure 1 for locations of the 25 tributary basins.

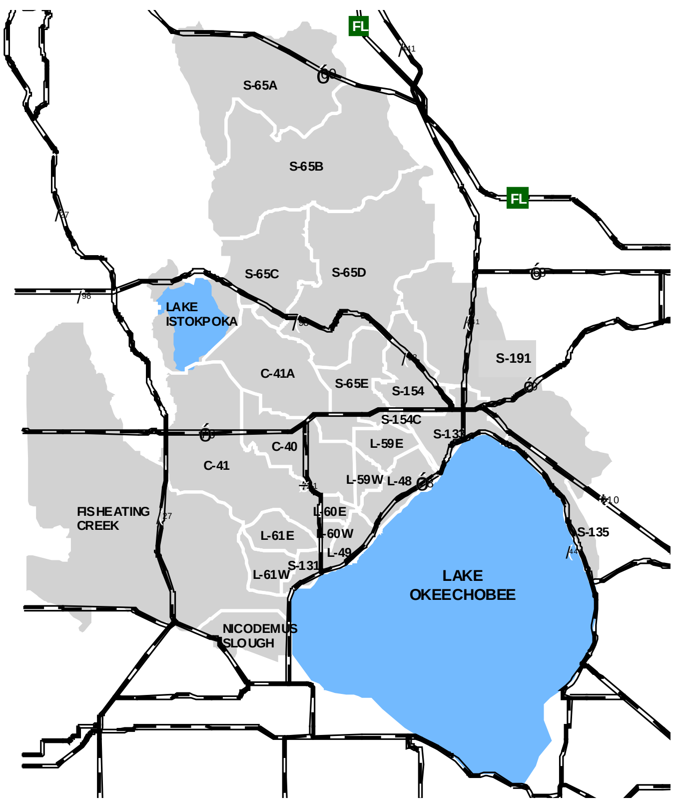

Figure 1. Tributary Basins of the Northern Lake Okeechobee Watershed

2.0 LAND USE CHANGES

Mock, Roos & Associates, Inc. (Mock•Roos) coordinated with landowners and staff at the South Florida Water Management District (SFWMD) Okeechobee Service Center to determine recent changes in land use in the northern Lake Okeechobee watershed. Satellite imagery was also utilized along with limited ground-truthing. District staff was extremely helpful in determining the "moving target" land uses such as row or truck crops.

All land use changes between 1995 and present were determined and entered into a GIS. GIS and spreadsheet software were used to compile Exhibit No. 1 through Exhibit No. 6 maps, tables, charts and graphs that help illustrate the extent of each land use change. Exhibit No. 1 illustrates the 1995 northern Lake Okeechobee watershed land uses. Exhibit No. 2 identifies the areas that have changed land uses since 1995. Finally, Exhibit No. 3 illustrates the 2001 land uses by incorporating each of those changed areas. Wetlands and water features were not changed. Exhibit No's. 4, 5, 5A, and 6 present tables and graphs quantifying land use changes by land use basin, and area.

These exhibits show that, overall, there has been an increase in the areal extent of several land uses including improved pasture, sugarcane, and dairies. An extensive review of truck crops resulted in a considerable spatial reduction of that land use. It should be noted that while some land uses did increase or decrease, the changes to some land uses may be the result of original mapping errors or newer and better-defined land uses. For example, dairies have been redefined to include their pasture areas. Dairy as a land use has not actually increased. The spatial increase reported in the exhibits for dairies primarily reflects the redesignation of areas that were previously designated as improved pasture. It is interesting to note that improved pasture still increased, despite the redesignation of some of its area as dairy.

3.0 PHOSPHORUS SURVEYS

3.1 Survey Distribution Determination

Each land use was ranked in accordance with its basin area and its potential for phosphorus loading. A value from 1 to 10 for phosphorus loading potential was assigned for each land use based on the relative magnitude of phosphorus containing material flow anticipated based on original phosphorus budget findings. The land use ranking was the product of the areal percentage of a given land use in the watershed and the phosphorus loading potential. Based on the ranking, a target number of interviews were developed per land use that were achieved based on the project resources. Mock•Roos met with the District staff at the Okeechobee Service Center to discuss and determine the final quantity of each land use to be interviewed. The available budget allowed for a certain quantity of interviews to be done. All parties agreed that more attention would be given to improved pasture (beef ranches) and dairy ranches because of their relatively high phosphorus loading potential. The target number of interviewed/surveys per land use and the actual number obtained are shown in Table 1.

Table 1. Survey Distribution

Land Use	Target Number	Number Obtained
Improved Pasture	4	17
Dairy Ranches	3	2
Citrus	1	1
Residential	1	0
Sod Farming	1	1
Truck Crop	1	2
Sugarcane	1	1
Ornamentals	0	1
Water Treatment	1	1
Fertilizer/Feed	1	4
Septic Tank	1	3
Golf Course	0	2

Later correspondences with county agents indicated that residential fertilizer was a considerable source of phosphorus that should be investigated. As a result, local fertilizer retailers were interviewed. A better trend for fertilizer use could be determined from fertilizer retailers, who supply fertilizer to a large number and variety of individuals, instead of attempting to find individuals at home. According to information from personal interviews with fertilizer suppliers, no considerable changes in fertilizer demand or sales have occurred since the 1991 study.

The golf course land use ranked very low for phosphorus impact due to its low spatial extent in the watershed. Although no golf courses were originally targeted for survey, two such surveys were obtained. In general, a greater focus was placed on land uses with the highest phosphorus loading potential. See Appendix A for “Land Use Assessment for Interview Selection” and Appendix B for a summary list of those contacted during the Phosphorus Budget Research.

3.2 Survey Questionnaires

Mock•Roos coordinated with Dr. Carolyn Boggess, author of the original phosphorus budget study (Boggess et al., 1995) and member of the project team, to determine what information was needed on the surveys. Mock•Roos then conducted three draft revisions and quality control reviews with feedback from Ms. Linda Crane (former District Okeechobee Service Center employee) and Dr. Boggess. Drafts of the surveys were transmitted via email with multiple phone conference calls to discuss content as well as format. The surveys were re-fined to minimize redundant questions and respondent’s time while still asking the pertinent questions. Appendix C includes one blank survey form utilized for each land use.

Procedures on how to most efficiently obtain survey data were discussed during the meetings with the District where it was agreed that obtaining data in person was the preferred method, but mailing and calling for survey data would also be required considering budget and time constraints. Initial contact with a follow up contact method, using a combination of in-person and/or phone call was recommended as the most effective way to secure better survey responses.

3.3 Survey Contacts

3.3.1 Improved Beef Pasture

Rangeland and unimproved pasture were considered as one category. Rangeland and unimproved pasture were not divided into separate categories because they have similar phosphorus characteristics such as low cow density and little or no fertilizer application. Those contacted throughout the study interchanged the terms rangeland and unimproved pasture when describing the same property. The stocking rate for improved pasture was 1 cow per 3 acres where the stocking rate for unimproved pasture was 1 cow per 16 acres.

The major differences between rangeland/unimproved pasture and improved pasture are the fertilizer rates and stocking rates. Ranches with little or no fertilizer applications and a low cow density are considered rangeland/unimproved pasture. Ranches that apply higher amounts of fertilizer and have higher cow densities (one cow per three acres) are considered improved pasture.

District staff recommended that of the four beef operations surveyed, two of them should be buy-out dairies (land previously used for dairies but now used for beef ranches). This was to obtain a representative sample of both buyout and non-buyout dairies and to account for any differences in management practices between the two.

Ms. Crane suggested that she first deliver the surveys to the beef ranchers in person. The initial hand delivery of the survey would give the rancher time to research the phosphorus information while providing a personal contact through the hand delivery by Ms. Crane. A follow-up meeting with Mock•Roos, Ms. Crane, and the rancher would then be scheduled to review the surveyed information and obtain any additional information. The rancher's preparation would make the meetings more productive.

A number of interviews were scheduled and later cancelled because the beef operators were not ready to meet. As the beef operators completed the surveys, they delivered them back to Ms. Crane, who in turn, delivered the surveys to Mock•Roos for review. Follow-up survey interviews, either in person or over the phone, were conducted for clarification and additional information. The beef ranchers that were contacted included Wes Williamson, Eugene Stokes, Daniel Chandler, a representative from Golden Land, Chuck Syfrett, and Ralph Palaez.

In addition to obtaining the standard surveys from each ranch, most of the ranchers submitted additional information that included their own phosphorus reports and/or copies of past phosphorus monitoring well data.

Ten additional surveys with data collected by the Okeechobee Service Center in 1998 were obtained from Steffany Gornak with SFWMD.

- Wes Williamson submitted the standard survey that was compiled for this project. While completing the survey, Mr. Williamson submitted a list containing the amount and content of fertilizer applied to his land in the past year. Included with his fertilizer reports were the quantity, type and phosphorus make up and composition of all the feed used on his ranch. A later meeting and follow-up survey with Williamson Ranch revealed that 10 million gallons of gray water a month are applied to the ranch.
- Eugene Stokes submitted the standard survey along with a report that highlighted all aspects of his farm operation. The report contained a map of his property that showed the different types of soil that were present on his property and a description of each type of soil. Mock•Roos obtained, along with the soils map, a farm conservation plan, a nutrient management plan, a livestock forage inventory, and soil test results from 1993 to present.
- Daniel Chandler submitted the standard survey along with his current SFWMD permit. This permit contained information pertaining to phosphorus collection data from 1992 to 1996 at various locations throughout his property.
- Golden Land Ranch submitted the standard survey along with a current report of their operation. The report listed the current and original site conditions and practices, gave a general site description, and contained phosphorus-monitoring data from 1990 to 1995.
- Charles Syfrett submitted the standard survey along with a report that was similar to the one submitted by Golden Land. The report contained information pertaining to past and present conditions and practices. Included in this report was phosphorus monitoring data from 1986 to 1995 at different locations.
- Ralph Palaez submitted the standard survey.

3.3.2 Dairy

A report for all Dairies was obtained from the FDEP report (see Appendix F). Interviews for the dairies were conducted by Ms. Crane, who combined the Mock•Roos questionnaires with the other surveys that she was conducting. It was discussed and decided that this approach would minimize the burden on the dairy operators. Prior to conducting the interviews, Ms. Crane contacted and met with some dairy ranchers to discuss the purpose of this phosphorus study and obtained their cooperation.

Mock•Roos reviewed the dairy survey format with Ms. Crane who offered many suggestions based on her knowledge. Ms. Crane then met with the dairy operators and obtained the information requested on the survey. The dairy ranches submitted similar information as the beef ranches and in both cases they submitted more information than was requested.

McArthur Farms submitted the standard dairy survey and also provided a copy of the 1999 Florida Department of Environmental Protection (FDEP) annual operation report for all four of their barns. This report contained information pertaining to the amount of fertilizer, lagoon water, and other such phosphorus-containing items that were applied to the individual fields.

Larson Dairy submitted the standard survey and a copy of their 2001 FDEP annual operation report. The FDEP report contained information similar to that of the McArthur FDEP report. In addition to the FDEP report, another report was submitted that described previous and current practices and contained phosphorus-monitoring data for different areas from 1990 to 1998.

3.3.3 Citrus

The information regarding the citrus industry was obtained from Duda and Sons and is intended to act as a general benchmark for all citrus groves in the area. Duda supplied the information that was requested on the standard citrus survey.

3.3.4 Sod Farming

At Ms. Crane's recommendation, Daniel's Sod Farm was asked to participate. Ms. Crane felt that Daniel's Sod Farm represented a typical sod farm of the region. She also felt that the owner would be cooperative with the survey. A standard survey was submitted.

3.3.5 Sugarcane

The information obtained from the sugarcane industry was difficult to acquire. Most of the sugarcane that is produced in the state of Florida comes from Palm Beach and Hendry counties because the soil in these counties is composed largely of muck. Muck soil is the preferred soil to grow sugarcane, with some sugarcane grown in sandy soils (IFAS, 2001). The information that was obtained came from IFAS, the

Sugarcane Growers Association and a University of Florida graduate student who has conducted research in many aspects of the sugarcane industry.

3.3.6 Truck Crops

Mr. Joe Hall with Eagle Island Farms and Mr. Perry Smith with Queen Bee Farms were contacted over the phone and gave information to questions on the truck crop survey. This information was used to revise the phosphorus budget assumptions to reflect current truck crop farming practices.

After reviewing the preliminary results of Task 3, some additional research was conducted for Truck Crops to verify the spatial extent, types of crops and number of rotations. Further research indicated that while the largest truck crop operation double crops, all other truck crop farms single crop. As a result, the original assumption of two crops per year was reduced. An additional land use, field crop, was created to describe areas previously designated as row crop where mostly hay is grown.

3.3.7 Ornamentals

Although this land use was not originally targeted for research or surveying, the basin’s considerable increase in this land use acreage prompted additional research to determine any changes in phosphorus loading. The primary ornamental crop in the basin is the caladium plant. Therefore, information from a caladium grower was sought to estimate the typical ornamental phosphorus loadings. Research on the Internet was conducted, and a phone survey was completed by Caladium World in Highlands County.

3.3.8 Golf Course

A golf course survey from Okeechobee Golf and Country Club, located in the northern Lake Okeechobee watershed, was received. This survey included information pertinent to developing a phosphorus budget for a typical local golf course.

3.3.9 Commercial Retailers

Mock•Roos researched several local businesses. After making several contacts, it was apparent that this industry did not have a large dealing with phosphorus products and therefore this industry was not pursued any further. The businesses that were contacted included: Lextron Animal Health, Miller Machinery and Supply, Southeast Milk, Fast track, and Feed Medicine. These businesses deal with various farming operations on a daily basis. However, they deal more with farming equipment and have little to do with phosphorus import or export.

3.3.10 Manufacturers of Phosphorus Products

Many feed, fertilizer, and spreader services were contacted. Jimmie Hortman Spreader Service and Diamond R. Fertilizer were contacted but did not have enough information to complete a survey. Through numerous correspondences, interviews were set up with five feed companies in Okeechobee City. Mock•Roos scheduled times and dates for in-person interviews with these companies. The feed stores that were scheduled were Gator Feed, United Feed Company, Syfrett Feed, Okeechobee Feed, and Walpole Feed. Site visits were conducted to the feed companies' supply houses, and in-person interviews were conducted. Four of the five feed companies were able to provide the needed information. Walpole Feed was not able to provide any information. The remaining feed companies that participated in the survey provided the information that was requested in the standard survey.

3.3.11 Sludge Haulers

Categories not associated with a particular land use, such as sludge haulers were identified from discussions with landowners and District staff familiar with the Okeechobee area, and from research on handlers of phosphorus containing material. Key West Sludge was the only sludge hauler that could be identified as bringing in sludge to the study area. The Key West Sludge System was contacted and provided the requested information. They completed the standard survey via a phone interview. At the time of the interview, they indicated that all of their waste is trucked to the Kirton Ranch in Okeechobee where it is land applied. Key West Sludge System was contacted again in early 2002, and they indicated that Kirton Ranch no longer applies sludge.

3.3.12 Sludge Applier

Kirton Ranch was the only ranch that was reported to have applied bio-solids. Kirton Ranch was not contacted because all of the required information was obtained from their sole source sludge hauler, Key West Sludge System. After the initial sludge hauler interview, it was verified that Kirton Ranch has stopped applying sludge. The

FDEP was contacted and stated that no landowner in the northern Lake Okeechobee watershed is currently land applying sludge. According to the FDEP, sludge application has not been allowed in the Lake Okeechobee watershed since July 1, 2001, unless the applier of the sludge developed a Phosphorus Management Plan.

Although other operations have applied sludge in the past, values that reflect the current land use practices for sludge application were incorporated in the phosphorus budgets. Therefore, ranches that were previously but no longer applying sludge were not counted as sludge appliers. The sludge moratorium affects the current sludge application practices and defines a trend for future sludge usage in the Lake Okeechobee watershed. The current land use phosphorus budgets reflect the current practices.

3.3.13 Septic Plant and Companies

The wastewater treatment plant for the City of Okeechobee was contacted in an attempt to ascertain some information regarding human waste. The plant provided some information regarding the inflow and outflow of the plant and what is done with the byproducts. All of the by-products are land applied to an orange grove near the plant itself; however, the plant did not know the details of the procedures for land applying the waste. They were able to provide the amount that was applied and the phosphorus content of the by-products.

Three local septic companies were contacted in the greater Okeechobee area, namely Roto Rooter, Mid Florida, and Boswell Septic Tank. Mid Florida treats the waste with lime at their plant in Sebring off of Highway 98 (near the airport) and is currently storing their waste on site. This waste handled by these septic companies is exported out of the watershed because the FDEP mandated that by July 1, 2001 no waste may be disposed of in the Lake Okeechobee watershed.

3.3.14 County Agents

In order to investigate all possible sources of information on the imports and exports of phosphorus from the northern Lake Okeechobee watershed, the University of Florida Cooperative Extension Service agents in the six counties that contain land contributory to Lake Okeechobee were contacted. The agents were asked some specific questions (see Appendix C), and were then asked to provide any general observations that could be helpful.

Unfortunately, none of the agents had any quantitative data on land use and levels of BMP implementation, but they have an excellent qualitative understanding of activities in their respective counties. In general, the agents indicated a limited amount of change in agricultural activities, particularly in cow/calf production. The notable changes in land use and land use practices during the past ten years have been rapid urbanization and related landscape fertilizer use. Based on discussions with county agents, vegetable production has increased by approximately 5,000 acres in Okeechobee County alone and phosphorus fertilizer usage by cow/calf operations has dropped by over 50%. There was a bio-solid spreading moratorium in three counties (Okeechobee, St. Lucie, and Martin), however, Okeechobee County lifted this ban in January 2002. Spreading may be applied in that county as permitted by FDEP.

The most rapid urban growth in the northern Lake Okeechobee watershed is occurring for the City of Okeechobee with single residential housing and commercial development representing the primary types of development. Though much of the new growth is being connected to sewage treatment systems, some offsite septic systems are still being installed. The primary concern with the urban sector is the use of home fertilizers, particularly phosphorus fertilizer. The agents did not have a good feel for the amount being applied, but felt it could be considerable.

The new vegetable production is potatoes, cabbage, pepper, and watermelon. Though the acreage is not substantial, these lands are primarily replacing less phosphorus intensive cow/calf operations. The exception is that one dairy has converted its spray field to potato production. The trend of increasing vegetable production is expected to continue. This was a buyout dairy that was converted in the early 1990’s to improved pasture before being converted to potatoes.

In general, cow/calf operations have not changed acreage or practices during the past ten years, except for phosphorus fertilization. Ranchers have essentially stopped phosphorus fertilization in many cases and have been estimated to have reduced their phosphorus usage by over 50%.

3.3.15 Trailer Park/Mobile Home

The SFWMD land use coverage refers to this land use as mobile homes. Examination of the coverage revealed that subject areas might be better described as recreational vehicle parks. The original study referred to these areas as trailer parks, which were determined to have a relatively small phosphorus impact to the northern Lake Okeechobee watershed. The trailer park phosphorus budget (Boggess et al., 1995) was reviewed, and, as with the residential land use, research indicated that the previous assumptions such as raw sewage effluent generation are still valid. From various phone interviews, the assumption of no phosphorus export was still valid. Everyone interviewed indicated that the typical mobile home was hooked to a municipal treatment facility. Based on current study investigations, the assumption that net phosphorus imports are equal to the amount of phosphorus in sewage effluent was maintained.

3.4 Other Research

3.4.1 SFWMD Files

Files compiled by Dr. Boggess from the original study were obtained from the District. The files included notes, old reports and miscellaneous information. Mock•Roos visited the SFWMD Okeechobee Service Center to search the files for useful information. The information was reviewed, and current versions of old reports were sought. Mock•Roos made copies of the pertinent information and sent the information to Dr. Boggess as she requested.

The District's files were researched online in an attempt to obtain more recent reports regarding this project. No reports could be located online, however some reports were obtained from Dr. Joyce Zhang and Ms. Linda Crane.

3.4.2 IFAS Data

The Internet was used extensively as a research tool in acquiring information. The following is a list of reports and information acquired from the IFAS web site (IFAS, 2001):

- The Poultry Manure Report breaks down the amount of nitrogen, phosphorus, and potassium found in different types of poultry production. This area was not heavily researched because of the limited amount of poultry production in the northern Lake Okeechobee watershed.

- The Sugarcane Report discusses the importance of soil and plant tissue testing to maintaining the appropriate levels of nutrients in the soil. The report also provides guidelines for the proper concentrations for each major nutrient and how to identify nutrient deficiencies in the soil.
- The Tomato Report gives a general overview of the requirements in rearing a commercial crop of tomatoes. It describes the nutrient requirements for tomatoes from seedling to fruit production.
- The Sod Production Report is an all-inclusive report dealing with most aspects of sod production. The report covers topics including what to look for in selecting a site, starting a sod farm, and installation practices used when installing sod. The report contains some valuable information pertaining to fertilizer use, pesticide application rates, and weed control.
- The report titled “Phosphorus Nutrition and Excretion by Dairy Animals” provides detailed information regarding phosphorus uptake and excretion by dairy cows. The tables included in the report show the mineral requirements for all ages of dairy cows, the mineral breakdown of various types of feed and the amount of phosphorus contained in the byproduct of dairy cows.
- The Dairy Manure Management Report explains the imports and exports of dairy cows in an effort to come up with a nutrient budget to better understand what is being applied to the land. The report describes different ways to collect, handle and dispose of dairy waste. It also shows how to develop a nutrient budget for dairy operations that would help to determine the amount of minerals being applied to the land and utilized by the cattle.
- IFAS Fertilizer Recommendations give the amount of fertilizer that should be applied and the optimal soil pH range for various different crops.
- An Overview of Florida Sugarcane (Agronomy Department Florida Cooperative Extension Service, Institute of Food and Agricultural Science) was reviewed.
- The “Characterization of Selected Mineral Soils used for Sugarcane Production” report (Agronomy Department Florida Cooperative Extension Service, Institute of Food and Agricultural Science) was researched.

All of the aforementioned titles are the latest reports that IFAS has compiled and posted on its website. Besides researching the IFAS website, other searches were conducted in the areas of fertilizers and nutritional requirements for beef cattle with little success.

3.4.3 Poultry Production

At the request of Dr. Boggess, poultry information was researched from two different types of poultry production. A broiler operation was researched in north Florida because of a working relationship with Mock•Roos and the farm owner. The information obtained consisted of general farm operation statistics that included the number of birds, harvest rates, amount of feed consumed, and amount of waste generated. The same information was obtained from Okeechobee Egg, a Layer plant in the northern Lake Okeechobee watershed. The farm statistics from the boiler plant were not used within this report because of its lack of influence within the northern Lake Okeechobee watershed.

3.4.4 Florida Department of Agriculture and Consumer Services (FDACS)

FDACS was researched online in an effort to obtain any information pertaining to this land use study. After searching the site for pertinent information, Mock•Roos contacted their main office to obtain the most current information concerning fertilizer usage. The information acquired in the fertilizer search included the 1999 and 2000 reports for the amount and type of fertilizer consumed per county in the state of Florida.

3.4.5 Census

The 2000 census for the entire State of Florida was obtained from an online source at the request of Dr. Boggess. Although this information listed the population of the entire State, it did not break down the population of each county as Dr. Boggess was seeking. An estimate of population per county was obtained from the Census Bureau which was based on the birth and mortality rates. Even though this was not an exact count of the population, it would provide the needed information until the exact population count could be obtained.

3.4.6 Florida Department of Environmental Protection (FDEP)

The FDEP indicated that no landowner in the northern Lake Okeechobee watershed is currently land applying or accepting sludge. According to the FDEP, sludge application has not been allowed in the Lake Okeechobee watershed since July 1, 2001, unless the applier of the sludge develops a Phosphorus Management Plan.

The FDEP has also been obtaining phosphorus information from dairies located within the study area and has issued annual reports summarizing the phosphorus budgets for each dairy.

3.4.7 Florida Fertilizer and Agri-chemical Association (FFAA)

The FFAA was contacted because of a lead that they had recently published a fertilizer use report. However, after two or three calls it was determined that they had no information that would be applicable to this study.

3.4.8 Palm Beach County Solid Waste Authority (SWA)

The SWA compost facility was researched after it was suggested that it may be selling sludge mixed with compost to landowners in the study area. It was found that the East Central Regional Wastewater Treatment Plant does give their sludge to SWA, which then processes it with the compost to make an enriched soil that is relatively low in nutrients. The compost quality is expected to be similar to potting soil, but little technical information was readily available. The soil generated by the compost facility is exported and sold as potting soil and soil blenders to groves, nurseries, golf courses, and landscape operations in the surrounding counties, but not to landowners in the northern Lake Okeechobee watershed. The practice is guided by the FDEP 62.709 rule.

4.0 PHOSPHORUS BUDGET BY LAND USE

The sub-sections below discuss the assumptions and results related to the current phosphorus budgets for each land use. The budget computation for each land use including assumptions and sources is located at the end of this section. This section of the report utilizes the english system of units because the survey information collected was entirely reported in english units, land owners utilize english units, and the original study utilized english units for calculating each phosphorus component of each land use budget. The use of english units allowed for direct comparison between the current and original studies. Table 2 below compares the phosphorus (P) import and export by land use type for the current and original studies.

Table 2. Phosphorus Import, Export, and Net Import Comparison by Land Use

	P Import (lbs P/ac-yr)		P Export (lbs P/ac-yr)		Net Import (lbsP/ac-yr)		
Land use	**Previous**	**Updated**	**Previous**	**Updated**	**Previous**	**Updated**	**% Change**
RANGELAND	0.19	0.15	0.14	0.14	0.05	0.01	-80%
IMP PASTURE	11.80	4.17	0.89	1.46	10.91	2.71	-75%
WETLANDS	0.00	0.00	0.00	0.00	0.00	0.00	0%
FOREST UPLANDS	0.00	0.00	0.00	0.14	0.00	-0.14	n/d
DAIRY*	95.69	66.90	24.38	18.97	71.30	47.93	-33%
BARREN LAND	0.00	0.00	0.00	0.00	0.00	0.00	0%
FIELD CROPS	0.00	35.20	0.00	29.04	0.00	6.16	n/d
OTHER URBAN	0.00	0.00	0.00	0.00	0.00	0.00	0%
UNIMP PASTURE	0.19	0.15	0.14	0.14	0.05	0.01	-80%
TRUCK CROPS	154.00	186.50	13.00	16.90	141.00	169.60	20%
CITRUS	13.85	9.24	5.00	2.79	8.85	6.45	-27%
WATER BODIES	0.00	0.00	0.00	0.00	0.00	0.00	0%
GOLF COURSE	0.00	9.17	0.00	0.00	0.00	9.17	n/d
SOD FARM	44.00	16.83	54.16	60.47	-10.16	-43.64	330%
ORNAMENTALS	42.24	23.76	21.00	15.30	21.24	8.46	-60%
COMM FOREST	0.00	0.00	0.14	0.14	-0.14	-0.14	0%
WASTE TREAT PNT	0.00	0.00	0.00	0.00	0.00	0.00	0%
SUGARCANE	16.34	15.84	9.12	14.96	7.22	0.88	-88%
AQUACULTURE	0.00	0.00	0.00	0.00	0.00	0.00	0%
POULTRY	0.00	0.00	0.00	0.00	0.00	0.00	0%
ABAND DAIRY	0.00	4.17	0.00	1.46	0.00	2.71	n/d
RES - TRA/TRAILER	30.30	36.90	0.00	0.00	30.30	36.90	22%
RES - LOW DEN	2.82	6.22	0.00	0.03	2.82	6.19	120%
RES - MED DEN	17.60	24.07	0.00	0.13	17.60	23.94	36%
RES - HIGH DEN	40.03	51.43	0.00	0.14	40.03	51.29	28%

n/d : percent change is “not defined” since the original value was zero.* : The 1991 dairy phosphorus coefficients were adjusted reflect both high intensity areas and outer pastures.

4.1 Improved Pasture

4.1.1 Imports

The improved pasture budget was updated based upon surveys conducted throughout the course of this study, phone interviews conducted in 2001 by Mock•Roos, and survey information collected in 1998 by the District's Okeechobee Service Center. A major source of imported phosphorus is fertilizer. Fertilizers with adequate nitrogen and potassium concentrations are still being applied, but the concentration of phosphorus in fertilizers currently being used has substantially decreased. The average beef operation uses approximately 40% of the fertilizer phosphorus indicated in the original budget, and all seven operations surveyed apply less than the original average. Three operations apply none or less than half a pound of phosphorus per acre-year.

A fourth operation applies fertilizer with no phosphorus. However, poultry manure is applied which contributes 11.66 lbs P/ac-yr for that operation. This operation was the only one found that applied poultry manure. It was also determined that the poultry manure was applied in lieu of phosphorus fertilizer and that if the manure was not land-applied, a phosphorus fertilizer would have been used in its place. Literature review was conducted to verify the phosphorus content in poultry (ASAE, 1995). Another supplement to phosphorus fertilizer is gray water land application by one of the beef ranches. The operation that applied gray water phosphorus (0.40 lb P/ac-yr) also applied fertilizer phosphorus (0.36 lb P/ac-yr). The combined fertilizer and gray water phosphorus import for this operation was still below the average fertilizer phosphorus import for improved pasture. A separate land use category was not created for chicken manure or gray water applicators since the phosphorus application rate from the poultry manure was in the same order of magnitude as what other operations could typically apply through fertilizer.

The operation that applies the highest rate of phosphorus fertilizer applies at a rate close to what was typical from the original study. The application of phosphorus fertilizer varies from 0 lb P/ac-yr to 10.5 lbs P/ac-yr. The original budget had a typical rate of 10.6 lbs P/ac-yr. The beef operators have made an intentional effort to reduce the amount of phosphorus applied through fertilizers. Fertilizer currently accounts for 79% of gross phosphorus import for improved pasture.

Supplement sources include mineral, molasses, minozal, protein and dry supplements, and silage. Supplements account for approximately 21% of the total phosphorus import. The average phosphorus import from supplements was calculated from surveys. Because of the variety of supplements and the inconsistency of distribution of these supplements, a single table is not shown on the phosphorus budget. Instead, budgets for each individual operation were performed from which the average supplement phosphorus was calculated.

A confidence level describes the likelihood that the same feed supplement data would be seen if all improved pasture operations were reviewed. The number of surveys taken and, therefore, the number of degrees of freedom was limited by the project budget and scope of work. The phosphorus content in feed supplements can only be determined with a certain degree of confidence without sampling each and every owner to determine a definite value.

The variance of the sampled population is unknown, and the sample size is less than thirty. Therefore, the variance is estimated using the “Student’s t-distribution,” which may deviate from that of a standard normal distribution. The “Student’s t-distribution” was used to estimate the level of confidence of feed supplement values.

The data collected has a 65% confidence level that the actual population average for feed supplements is within 18% of the calculated value, an 80% confidence level that the actual value is within 25%, and 95% confident the actual value is within 38% of the calculated value. The “Student’s t-distribution” was derived by W.S. Gosset and was based on the fundamental assumption that the samples were selected from a normal population. However, non-normal populations that have an approximate bell-shaped distribution will have values of T that are very close to the t-distribution (Walpole and Myers, 1989).

Enough surveys were completed to give a representative value of supplemental phosphorus import. Documentation of supplements imported was reviewed for some of the improved pasture operations. Phosphorus content and distribution of supplements appears to fit a normal distribution trend. The average supplement phosphorus for those surveyed appears to be a good representation of the overall watershed. Supplement phosphorus loading is decreased by 30% from the original budget. Overall, the total phosphorus import has decreased by 65% from the original budget, from 11.80 lbs P/ac-yr to 4.17 lbs P/ac-yr.

4.1.2 Exports

The largest amount of phosphorus export for improved pasture was calculated to be live weight sales. On average, live weight sales account for 86% of the total phosphorus export for improved pasture. The total average phosphorus export for all operations surveyed was 1.25 lbs P/ac-yr. This is 40% higher than the rate determined in the original survey. The phosphorus concentration of live weight was the same as the original budget. The change in live weight phosphorus export is due solely to the 40% increase in live weight production per acre.

The only data collected and referenced for improved pasture in terms of cows per acre is the stocking rate. The stocking rate has changed from 2.5 acres/cow previously to 2.78 acres/cow. However, the values given for live weight were reported in terms of pounds. Therefore, the survey information does not delineate weather the increase in live weight exports can be attributed to an increase in the number of cows and/or an increase the average cow size.

In addition, minor phosphorus exports are utilized under current practices that were not a part of the original budget. Namely, hay and sod exports contribute 0.21 lb P/ac-yr to the phosphorus export. These additional means of phosphorus export account for 15% of the existing total phosphorus export. Overall, the total phosphorus export has increased by 64% from the original budget, from 0.89 lb P/ac-yr to 1.46 lbs P/ac-yr.

4.1.3 Net Imports

The improved pasture land use category has shown one of the largest changes in phosphorus loading of all the land use categories. The net import of phosphorus decreased since the phosphorus fertilizer imports have decreased by 69% and the live weight phosphorus exports have increased by 40% from the original budget. The net phosphorus import decreased by 75% from the original budget, from 10.91 lbs P/ac-yr to 2.71 lbs P/ac-yr.

The original study approach involved general assumptions of feed supplements and live weight exports based on conversations which were not cited with IFAS personnel and beef feed suppliers. The current approach involved more survey information in determining a representative feed supplement and export live weight value. The revised phosphorus budget accounted for hay and sod exports as commonly done whereas the original budget did not consider these exports.

4.2 Unimproved Pasture

4.2.1 Imports

The total phosphorus imports are supplements in the form of minerals and molasses. The feed rates of these supplements were the same for improved and unimproved pasture. In regards to the phosphorus budget, the two critical differences between improved and unimproved pasture are 1) the stocking rate of cows per acre and 2) the absence of fertilizer import for unimproved pasture. The supplement import for unimproved pasture was adjusted to reflect the same trend findings from the beef surveys. In general, the existing supplement phosphorus contributed decreased by 20% from the original budget.

4.2.2 Exports

The total phosphorus exports are due solely to live weight sales. The stocking rate and live weight production per acre were assumed to be unchanged from the last budget. There was no available information to suggest that these rates have changed.

4.2.3 Net Imports

Current net imports decreased by approximately 80% from the original budget, from 0.05 lb P/ac-yr to 0.01 lb P/ac-yr. The approaches between the original and revised unimproved pasture phosphorus budget are similar and only vary by the current supplement averages.

4.3 Dairy

In contrast to the original study, the boundaries of the dairy land use now include the high intensity areas, milking pastures, dry cow pastures, forage areas, and hay production areas. The dairies now report the amount of fertilizer they use over their whole operation, not just the high intensity area and milking pastures. For this reason, the entire acreage for dairy operation was included in the dairy land use. The estimated average size of entire dairy operations is currently 1,620 acres compared to 700 acres as calculated from the original study. The principle phosphorus imports to dairies include feed, fertilizer, and phosphorus-containing cleaners/detergents.

A summary of phosphorus reports submitted to the FDEP from each dairy in the basin was analyzed to determine the average phosphorus imports and exports from each dairy (Appendix E). Utilizing this information as well as a detailed phosphorus assessment of the four McArthur dairies in the basin, phosphorus loads were calculated. On average, the dairies in the basin have 1,390 lactating cows and 520 dry cows. Of these, approximately 350 cows are culled each year. However, the culled cows are not treated as an export from the basin, because heifers are imported to replace them. The assumption that culled cows were not treated as an export from the basin was made in an attempt to be consistent with the original study.

To directly compare the current calculated phosphorus loads (imports and exports) to the phosphorus loads of the original study, the loads must be shown with the same units. The original study calculated the net phosphorus imports in terms of phosphorus per cow per year. The 1991 dairy operation cow density was based on the Taylor Creek and Nubbin Slough basins and utilized to develop per-acre phosphorus flow values of dairy imports and exports.

The 1991 study considered only the high intensity dairy areas as part of the dairy land use, whereas the current study considers both high and low intensity land areas. Similar land use extents had to be estimated in order to consistently compare the dairy land use of 1991 with the current dairy land use. Therefore, an equivalent 1991 net phosphorus import coefficient had to be calculated to include both high and low intensity areas for 1991 dairies. An approximate ratio of 14.2:1 for the area of intense versus non-intense dairy usage was estimated from the 1991 coverage. The 1991 net phosphorus import coefficient values for dairy and improved pasture were used for the high and low intensity areas, respectively, and prorated according to the low to high intensity ratio. The discussions below compare the current study dairy values to the equivalent 1991 dairy that includes both high and low intensity areas.

4.3.1 Imports

Lactating cows and dry cows are fed different amounts of feed on a daily basis, but the phosphorus percentage of particular feed items is approximately the same.

Typical feed imports to the basin amounted to approximately 49.9 tons of phosphorus per year, which is equivalent to 50.9 lbs P/ac-yr. Purchased feed supplements (such as molasses, alfalfa cubes, and mineral supplements) are included in the above feed calculations. The assumption is made that silage and forage are grown and consumed in the basin and are therefore not included as an import to the basin. The 49.9 tons of phosphorus per year of imported feed is equivalent to approximately 52.2 lbs of phosphorus per cow each year. The original study calculated approximately 85.3 lbs of phosphorus per acre each year for feed.

Fertilizer is another major source of phosphorus import to the basin. On average, dairies in the basin apply 4.2 tons of phosphorus per year to their land from fertilizer. Values in the dairy phosphorus budget are based on area-weighted values determined from the dairies for which information was collected. This is equivalent to approximately 5.18 lbs of phosphorus per acre each year. Fertilizers are typically used on areas where forage/silage is grown for use as a feed supplement. Occasionally, fertilizers are applied to pastures where cows graze. Spray fields get nutrients from the treated wastewater that is sprayed on the grasses. However, in times of light rainfall, some fertilization is needed on spray fields as well. The original study fertilizer phosphorus amount is calculated as 9.87 lbs P/ac-yr.

Contributions from cleaners and detergents used to clean the milking parlor and the storage tanks as well as to flush the milking lines are negligible. However, on average, each dairy typically uses approximately 0.10 lb of phosphorus per acre each year from these sources. The original study cleaners phosphorus amount is calculated as 0.52 lb P/ac-yr

The equivalent total gross phosphorus import to the dairies, including both high and low intensity areas, was calculated as 95.69 lbs P/ac-yr based on the original study information. Based on the current information, the total gross phosphorus import to the dairies, including both high and low intensity areas, is calculated as approximately 66.9 lbs P/ac-yr.

4.3.2 Exports

Major exports from dairies in the basin include raw milk and live weight sales of animals. On average, the amount of phosphorus exported from the dairies in raw milk is 14.9 tons of phosphorus per year. This is equivalent to approximately 18.4 lbs of phosphorus per acre each year versus 19.4 as estimated from the 1991 study. Average live weight sales of animals account for approximately 0.6 lb of phosphorus per acre each year versus 5.0 as estimated from the 1991 study.

The total export from the dairies was calculated as 24.4 lbs P/ac-yr in the original study. Based on the current information, the total export from the dairies is calculated as approximately 19.0 lbs P/ac-yr.

4.3.3 Net Imports

The total net import of phosphorus to the dairies was calculated as 71.3 lbs P/ac-yr in the original study. Based on the current information, the total net import to the dairies is calculated as approximately 47.9 lbs P/ac-yr. The stocking rate has decreased, from 1.82 cows/ac to 0.97 cow/ac. The reduction in cow stocking rate has resulted in a corresponding reduction in feed volume as well as phosphorus amount consumed per acre.

4.3.4 Abandoned Dairies

Since the original study was conducted in 1991, several dairies have been sold via a District “Buyout” program. These areas are being managed predominantly as improved pasture but exhibit higher levels of phosphorus in their runoff discharge than improved pasture. Therefore, they were designated as a separate land use called “abandoned dairy.” These areas were assigned a net phosphorus areal loading equal to improved pasture (see Section 4.1). Water quality monitoring of these sites by the District has found that the sites still exhibit high phosphorus levels in their runoff discharge, which is assumed to be due to the residual effects of the dairy operations. Because of this, these areas were assigned an Event Mean Concentration (EMC) equal to the EMC used for dairies (see Section 5.3.2). This may be reduced over time and can be re-assessed at any time using the GIS user interface (Appendix E) developed for this restudy.

4.4 Citrus

4.4.1 Imports

The citrus budget was updated based on more recent surveys and phone interviews conducted in 2001. The only source of imported phosphorus is fertilizer. A lower phosphorus loading per acre-year was calculated, with a 33% decrease from the original budget. This is due to the lower phosphorus application rates and the higher percent of mature groves versus new and reset groves. Mature groves take less than one-fourth the amount of phosphorus that new and reset groves require.

4.4.2 Exports

The only means of exported phosphorus remains exported boxes of citrus fruit harvested and removed from the site. The phosphorus concentration of oranges and grapefruits was determined from the USDA Nutrient Database, revised in 1998 (USDA, 1998). The new budget accounts for the phosphorus export contributions from oranges and grapefruit separately whereas the original budget assumed all export was in the form of oranges. Grapefruit production accounts for approximately 30% of total production as determined from the most recent surveys.

The phosphorus concentrations in oranges and grapefruits were lower than reported in the original study. The phosphorus concentration of oranges and grapefruit is approximately 20% and 50% of what the original budget assumed, respectively. Since the new budget accounts for production of grapefruits which have a much lower phosphorus content, the amount of phosphorus exported given the same fruit production per acre has decreased.

In addition to the overall lower phosphorus concentrations, the fruit production decreased almost 25%, from 327 boxes/acre to 250 boxes/acre, thereby further reducing the amount of phosphorus exported. The total phosphorus exported decreased by approximately 44% from the original budget.

4.4.3 Net Imports

The net import of phosphorus decreased because the reduced fertilizer phosphorus application more than accounted for the lower phosphorus export in fruit. The net phosphorus import decreased approximately 27%, from 8.85 lbs P/ac-yr to 6.43 lbs

P/ac-yr. The current citrus budget involves each approach used in the original budget. In addition, the current budget breaks out citrus harvest into oranges and grapefruits.

4.5 Sugarcane

4.5.1 Imports

The sugarcane budget was updated based on more recent surveys and phone interviews conducted in year 2001. The only source of imported phosphorus remains to be fertilizer. A higher percentage of the land is in sugarcane production and less land is fallow which contributes to a higher phosphorus fertilizer application. However, new surveys also suggest that only sugarcane and rice are produced on site and corn is not currently grown. Rotating rice with sugarcane crops helps reduce certain types of harmful insects and prevents soil stress. The absence of corn production in the current study reduces the overall areal phosphorus fertilizer import since the per acre fertilizer phosphorus for corn is more than three times the rate for sugarcane. The original study utilized IFAS recommendations for plant sugarcane (17.6 lbs P/ac-yr) and corn (62.7 lbs P/ac-yr). The area indicated for corn production in the original study is designated as sugarcane production, thereby reducing the phosphorus fertilizer import by 3%.

4.5.2 Exports

The means of exported phosphorus is currently sugarcane and rice exports. Since corn is no longer grown on site, it is no longer a means of phosphorus export. The primary change from the original budget is a 50% increase in sugarcane production per acre. It could be speculated that the value for sugarcane production in the original study based on literature review may have been lower than what is actually occurring in the study area. Changes in rotation methods could also contribute to increased sugarcane production. Sugarcane production accounted for a 6.48 lbs P/ac-yr increase in exports while rice phosphorus export remained the same, and the loss of corn production accounted for a 0.75 lb P/ac-yr decrease in exports. Since phosphorus export from rice production was considered negligible compared to sugarcane export and land owners did not have or supply values for rice production, the per acre rice production was assumed to be the same as originally determined through literature review.

4.5.3 Net Imports

The net import of phosphorus decreased due to the fact that total phosphorus imports decreased slightly while total phosphorus exports increased greatly. The dominating factor influencing this trend is the increased sugarcane production. The current net import decreased by 88% from the original budget, from 7.22 lbs P/ac-yr originally to 0.88 lb P/ac-yr currently. The sugarcane phosphorus budget approaches are similar in the current and original study.

4.6 Truck Crops

4.6.1 Imports

The truck crop budget was developed based on current practices per interviews conducted in 2002. The sole source of phosphorus imports is the fertilizer applied during the planting of each crop. The original study assumed lettuce as a “typical” truck crop. Current practices include crop rotation of corn, potato, cabbage, and silage corn.

Eagle Island Farms was initially the only truck crop operation that had responded to survey inquiries and phone calls. Eagle Island represents approximately half of the total truck crop acreage in the northern Lake Okeechobee watershed. However, this farm is very intense in its phosphorus usage, and double crops most of the time.

The net phosphorus import based on Eagle Island Ranch is 235 lbs P/ac-yr, which is an increase from the 150 lbs P/ac-yr originally determined.

With the assistance of District staff in the Okeechobee Service Center, Queen B Farms was contacted and provided valuable additional phosphorus budget information. Queen B Farms is much less intensive than Eagle Island and is considered by District staff to be a more “typical operation” in terms of usage. Based on conversations with agricultural agents and District staff familiar with truck crop land owners and practices, Eagle Island Ranch was considered to be one of the few if not the only operation which utilizes the intense double cropping method of farming. However, Eagle Island Ranch is the largest truck crop farmer by area. It is speculated that land and soil capabilities, economics, management preferences, and farm manager familiarity with certain cropping methods influence the psychological reasons for differences in management practices.

A phosphorus budget was completed for truck crops with Eagle Island and Queen B operation practices averaged as agreed to with staff familiar with the truck crop land owners and practices in the study area. Phosphorus imports increased by 21% from the original budget, from 154 lbs P/ac-yr to 186.5 lbs P/ac-yr. This increase is due solely to the increase in fertilizer phosphorus as a result of double cropping considerations. Note that on a per crop basis, the actual fertilizer phosphorus import has declined from 154 lbs P/ac-yr to 122 lbs P/ac-yr.

4.6.2 Exports

Phosphorus export is achieved by harvesting crops, thereby removing the phosphorus contained in the yield. On a per crop basis, harvest phosphorus exports have decreased from 13 lbs P/ ac-yr-crop to 11.34 lbs P/ ac-yr-crop. Due to double cropping, a higher annual areal yield is realized. The total phosphorus export increased by 30% from the original budget, from 13.0 lbs P/ac-yr to 16.9 lbs P/ac-yr. This is due in part by the increased yield volume caused by double cropping and also in part due to increased yield per crop.

Multiple factors contribute to the difference in the harvested pounds of potatoes between the two farms surveyed in the restudy. For example, the fertilizer techniques vary greatly between farms. One farm applies fertilizer once per planting while the other uses multiple applications throughout the crop growth. The balance of N-P-K, especially nitrogen, in the fertilizers used greatly influences potato growth. Also, the differences in soils, watering techniques, potato variety, use of insecticide/herbicide, local groundwater hydrology, planting timing, harvest timing, and maturity of potatoes at harvest greatly influence pounds of potato yield.

4.6.3 Net Imports

The net import of phosphorus increased solely due to the increase in farming intensity. Double cropping was not originally considered in the process approval, so phosphorus use intensity was under estimated for truck cropland usage. The net phosphorus import increased by 20% from the original budget, from 141 lbs P/ac-yr to 169.6 lbs P/ac-yr.

The current and original phosphorus budgets utilized two very different approaches. The previous approach estimated phosphorus import by assuming lettuce as a "typical" crop and utilized IFAS fertilizer recommendations associated with that crop. The current approach involved a more rigorous pursuit of specific land use practices such as crop types grown and crop rotations. The original study assumed a harvest amount based on Florida agricultural statistics whereas the current phosphorus budget estimates multiple crop types based upon the extrapolation of two farms' production records to determine phosphorus export.

4.7 Sod

4.7.1 Imports

The phosphorus budget was updated based on more recent surveys and phone interviews conducted in 2001. The original study considered three types of sod crops – St. Augustine on mixed muck and sand, Bahia on sand, and St. Augustine on muck. The average phosphorus import for these three sod types was used for comparison to the current phosphorus import. The only source of imported phosphorus remains fertilizer. The phosphorus loading per acre-year is currently 43% lower than the original budget averages or the original study.

4.7.2 Exports

The only source of exported phosphorus remains exported sod and the soil harvested with it. Average phosphorus content of harvested sod for St. Augustine (mixed muck and sand), Bahia (sand), and St. Augustine (muck) is 0.074%, 0.012%, and 0.068%, respectively (Fonyo et al., 1991). The average phosphorus content for sod for the overall watershed was assumed to be that of St. Augustine grass grown in muck at 0.00068 lbs P/lb sod harvested. The St. Augustine phosphorus concentration was utilized since it was the median and approximately average number of different sod phosphorus concentrations. The average dry weight of sod per acre was assumed to remain the same as sod harvested from a muck and sand mix at 45.86 tons per acre (Fonyo et al., 1991). An increase in the phosphorus export was caused by an increase of the percent of the field in production over the original study. The phosphorus export increased 35% from 44.7 lbs P/ac-yr to 60.4 lbs P/ac-yr.

Sod contains 60.47 lbs P/ac-yr (100% of total harvested sod with soil) based on the current sod phosphorus budget. Grass content of phosphorus was calculated to be 29 lbs P/ ac-yr (48% of total harvested sod with soil), based on 0.0022 lb P/lb grass (Rayburn, 1997) and based on a dry matter yield of 6.6 tons/ac (Overman, 2001). Soil phosphorus content was estimated as the difference between the total phosphorus in sod including soil minus the amount of phosphorus in the grass harvested, which equals 31.03 lbs P/ac-yr (52% of total harvested sod with soil).

The current approach of the phosphorus budget to include soil phosphorus exported is consistent with the original study as well as with the general mass balance approach utilized in any phosphorus budget. All primary phosphorus exports as well as imports should be accounted for regardless of the form and mechanism. Phosphorus export due to soil export is critical to the reliability of the phosphorus budget methodology. Phosphorus in the soil may or may not end up in Lake Okeechobee depending on soil particle transportation and fate. However, the important fact is that the change in soil storage of phosphorus reflects any exporting of soil phosphorus that isn't accounted for in the land use phosphorus runoff.

4.7.3 Net Exports

The net export of phosphorus increased due to a combination of lower phosphorus loadings and higher phosphorus harvested and removed with the sod. The net phosphorus export increased from 15.4 lbs P/ac-yr to 43.64 lbs P/ac-yr.

4.8 Commercial Forestry

Because of the low amount of commercial forestry in the basin, this land use was not targeted for research. Discussions with local agricultural agents and District staff familiar with the industry did not indicate any changes in the original assumptions for commercial forestry from the original study. There also has been a decline of approximately 2,400 acres in this land use, which further reduces the significance of commercial forestry relative to other northern Lake Okeechobee watershed land uses. Therefore, the original assumptions were utilized without further pursuit of land use surveys.

These original assumptions were that all commercial forestry is pine and that the phosphorus content of the harvested biomass is 0.02% phosphorus on a dry basis. The average harvest age was assumed at 20 years with 18.5 cubic feet per acre-year, and 77 lbs per cubic foot. The fertilizer rates were assumed negligible over the life of the tree (Fonyo et al., 1991).

4.9 Ornamentals

Similarly, because of the low amount of ornamental land use in the basin, this land use was also not targeted for research. However, the land use coverage update has found a large increase (over 7,000 acres) in this land use in the basin. Attempts were therefore made to acquire additional information to update the original budget for this land use. The original budget addressed caladium bulbs only, which is still the primary ornamental. Information was obtained from Caladium World in Highlands County. The average ornamental grower is now applying 400 lbs. of 6-6-6 per ac-yr.

4.9.1 Imports

The total phosphorus imports are 44% lower than the original study because of a 25% reduction in fertilizer usage, and a 25% lower concentration of phosphorus is found in the fertilizer currently being used. Both changes mentioned were made to reduce operational costs.

4.9.2 Exports

The total phosphorus exports are 27% lower than the original budget of the original study because the harvest has decreased by 27% from the original budget. This lower harvest yield is speculated to be a consequence of reduced plant growth due to a reduced fertilizer application. The phosphorus concentration of bulbs was assumed to be unchanged.

4.9.3 Net Imports

Despite 27% decrease in total exports, there has been a decrease of net phosphorus imports from the original budget of the original study because imports are 44% lower. The existing net phosphorus import is 60% lower than the original budget, from 21.24 lbs P/ac-yr to 8.5 lbs P/ac-yr. The current and original phosphorus budget approaches for ornamentals were the same. Caladium is still considered the "typical" ornamental crop.

4.10 Residential

4.10.1 Imports

Residential net areal phosphorus imports have increased since the original study from 30% to 120%, depending on the housing density. A change in the methodology for estimating phosphorus in food and detergent imports account for this change. The current study directly estimates the amount of food and detergent consumed where the original study assumed the phosphorus waste effluent was equal to the food and detergent import phosphorus. The amount of feed for animals such as horses, dogs and cats was included in the current study but was not considered in the original study. The assumptions and values from the original study were used unless otherwise noted in the text or phosphorus budget of each residential land use.

The total phosphorus imports due to fertilizer could not be determined without a random door-to-door survey to determine the percent of homeowners that fertilize, and what type of fertilizer is typically used. The assumption that 25% of all homeowners fertilize is reduced from 50% which was used by Fonyo et al., 1991. Residential fertilizer consumption was obtained by FDACS and used to verify the assumption that 25% of homeowners fertilize. Review of total phosphorus fertilizer trends reported for the study area suggests that 30% more phosphorus was being consumed during the time of the original study as compared to existing. Also, the assumption of 50% of land owners fertilize may still have been overestimated. The assumptions from the original survey have been reviewed and appear to be unchanged with the exception of that originally mentioned.

4.10.2 Exports

Total exports are a function of the sewage effluent hook up for each class of urban residential. For example, units that are hooked to the Okeechobee municipal treatment facility have no sewage effluent export. This is because the municipal treatment plant land applies the dry solids locally, in the northern Lake Okeechobee watershed. Phosphorus handled by municipal treatment facilities remains in the local area and does not leave the watershed. Such material is not considered an export. Units that are hooked to septic tank systems have a certain percentage of their phosphorus loading exported. This is because the septic tanks are cleaned out and the contents are hauled out of the northern Lake Okeechobee watershed. It was determined by review of septic tank product literature that 2% of effluent will settle in the septic tank and be removed out of the basin via vacuum trucks. The remainder of the effluent will leach into the local region of each septic tank field.

A GIS analysis was conducted to estimate the percentages of each residential land use that are assumed to be utilizing septic tanks. A service area map of the City of Okeechobee's wastewater treatment plant was not readily available when requested. Therefore, an estimated service area was developed based on proximity to the City limits. Large residential developments within or near the City limits were considered to be within the service area of the City's wastewater treatment plant. Overall percentages of residential areas outside of the service area were then calculated.

For low density urban residential, it was estimated that 95% of the units are on septic. Therefore, the total phosphorus export for low density is a factor of (0.95) * (0.02), or 0.02 of the total sewage effluent for this land use. This factor is called the effluent removal factor.

Medium density urban was estimated to have 42% of the residents on septic system. Therefore, the total phosphorus export for medium density is a factor of (0.42) * (0.02), or 0.008 of the total sewage effluent for this land use.

High density urban was estimated to have 18% of the residents on septic system. Therefore, the total phosphorus export for high density is a factor of (0.18) * (0.02), or 0.004 of the total sewage effluent for this land use. As the residential density increases, the percentage of sewage effluent remaining in the basin increases.

Research indicated that the original assumptions such as raw sewage effluent generation are still valid. The assumptions made in the original report were consistent with current Health Department and Florida Administrative Code Standards. The net phosphorus import coefficients from the original study were determined with 100% of the effluent staying in the basin, and did not account for any export of phosphorus through septic system content removal. The amount of phosphorus removed through septic tank cleaning was only 1% of the total phosphorus import.

4.10.3 Net Imports

The net phosphorus import coefficient increased from the original budget by 22%, 120%, 36%, and 28% for Travel Trailers, High Density, Medium Density, and Low Density land uses, respectively.

4.11 Golf Course

4.11.1 Imports

Although not included in the original study, a golf course phosphorus budget was prepared under the current study based on information obtained from Okeechobee Golf and Country Club in the Lake Okeechobee watershed. The fairways account for the largest area, the most concentrated phosphorus fertilizer, and therefore the majority of phosphorus loading (660 lbs P/yr). The greens account for the highest phosphorus loading intensity but the smallest area on the golf course site. Approximately 200 lbs P/yr is applied in greens areas. Approximately half of the golf course site does not have fertilizer applied. The total phosphorus import over the entire golf course site is 9.17 lbs P/ac-yr.

4.11.2 Exports

No phosphorus exports are known for the golf course land use.

4.11.3 Net Import

The net import of phosphorus is simply equal to the import due to fertilizers.

4.12 Field Crops

4.12.1 Imports

Although not included in the original study, a field crop survey was created to describe areas originally designated as row crops where mostly hay is grown. Row crops were also referred to as vegetable crops or truck crops. The import of phosphorus was based on the IFAS recommended fertilizer rates. The total phosphorus import was estimated to be 35.20 lbs P/ac-yr.

4.12.2 Exports

Phosphorus exports were estimated based on the dry matter yield and phosphorus concentration of bermuda grass. The total phosphorus export was estimated to be 29.04 lbs P/ac-yr.

4.12.3 Net Imports

The net import of phosphorus for field crops is 6.16 lbs P/ac-yr.

4.13 Phosphorus Budget Computations

IMPROVED PASTURE PHOSPHORUS BUDGET

ASSUMPTIONS

Herd size and distribution (Mock•Roos Beef survey, 2001)

- Average pasture size = 3,225 acres, cow density = 2.78 acres/cow; (Mock•Roos Beef Surveys, 2001 combined with SFWMD Beef Surveys, 1999)
- Hay phosphorus concentration = 0.0022 lb P/lb hay (Mock•Roos Beef Surveys, 2001)
- Live weight phosphorus concentration = 0.0067 lb P/lb live weight (Fonyo et al., 1991)
- 0.44 lb phosphorus in 1 lb of P_2O_5 as per the chemical formula molecular weight breakdown

IMPORTS

Feed supplements

Mock•Roos beef surveys 2001: 19,338 lbs P/yr over 22,570 acres
SFWMD Beef Surveys (Gornak and Zhang, 1999): 18,237 lbs P/yr over 20,146 acres

Total phosphorus import in supplements =
(19,338 lbs P/yr + 18,237 lbs P/yr)/(22,570 ac + 20,146 ac) = 0.88 lb P/ac-yr

Sample numbers 1 through 7 in the following fertilizer and acreage table summarizes the fertilizer phosphorus values obtained from the Mock•Roos beef surveys, 2001, while sample number 8 is the total fertilizer and acreage amount from the SFWMD beef surveys (Gornak and Zhang, 1999).

Fertilizer

Sample No.	Fertilizer, lbs P_2O_5/yr	Acres
1.	15,611	8,775
2.	31,226	1,310
3.	834	1,551
4.	161,756	6,104
5.	0	3,000
6.	5,006	420
7.	5,880	1,410
8.	99,360	20,147
Total	**319,673**	**42,717**

IMPROVED PASTURE PHOSPHORUS BUDGET (Continued)

Total P_2O_5 import per acre = (319,673 lbs P_2O_5)/42,717 acres = 7.48 lbs P_2O_5
Total phosphorus import per acre = 7.48 lbs P_2O_5 * 0.44 lb P/lb P_2O_5
= 3.29 lbs P/ac-yr

Total phosphorus import per acre = 0.88 lbs P/ac-yr + 3.29 lbs P / ac-yr = 4.17 lbs P/ac-yr

EXPORTS

Live weight

The following summarizes the net live weight export values obtained from the beef survey, 2001:

	Live weight Export, lbs	Acres
1.	1,897,514	8,775
2.	293,000	1,310
3.	220,000	1,551
4.	932,000	6,104
5.	550,000	3,000
6.	47,250	420
7.	269,180	1,410
Total	**4,208,944**	**22,570**

Live weight export = (4,208,944 lbs live weight)/22,570 acres * 0.0067 lb P/lb live weight
= 1.25 lbs P/ac-yr

Hay Export

	Hay Export, lbs	Acres
1.	547,000	8,775
2.	95,000	1,310
3.	0	1,551
4.	0	6,104
5.	22,000	3,000
6.	28,000	420
7.	0	1,410
Total	**692,000**	**22,570**

Hay export = (692,000 lbs hay)/22,570 acres * 0.0022 lb P/lb hay
= 0.07 lb P/ac-yr

IMPROVED PASTURE PHOSPHORUS BUDGET (Continued)

Sod Export

	Sod Export, ac	Acres
1.	35	8,775
2.	0	1,310
3.	0	1,551
4.	0	6,104
5.	0	3,000
6.	40	420
7.	0	1,410
Total	**75**	**22,570**

Sod export = (75 ac. hay)/22,570 acres * 43.6 lbs P/ac. Sod-yr (Mock•Roos Sod Survey, 2001)

= 0.14 lb P/ac-yr)

Total phosphorus export per acre = 1.25 lbs P / ac-yr (live weight exports) + 0.07 lb P / ac-yr (hay exports) + 0.14 lb P / ac-yr (sod export)

= 1.46 lbs P / ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR IMPROVED BEEF PASTURE
= 4.17 – 1.46 = 2.71 lbs P / ac-yr

*SFWMD beef surveys (Gornak and Zhang, 1999) include the following Ranches:

1. X-Bar Ranch
2. J. F. Ranch, Inc.
3. Hen Scratch Ranch
4. Eugene Stokes
5. Prescott Ranch
6. Gloria Farms
7. El Rancho Corp.
8. Palaez
9. C-Farr Ranch
10. Coker Cattle Company
11. Grassy Island Ranch

UNIMPROVED PASTURE PHOSPHORUS BUDGET

ASSUMPTIONS

Herd size and distribution (IFAS, 2001 and Fonyo et al., 1991)

- Average pasture = 1,600 acres
- Cow density = 16 acres/cow; 100 cows @ 1,100 lbs
- Assume number of bulls imported = number of bulls exported
- 10% of cows culled annually = 10 cows
- 69% calves sold = 48 calves @ 470 lbs each at time of sale
- Mineral and molasses values from the 1991 study were adjusted by a factor of 0.77 based on the ratio of current to previous feed ratio for improved pasture

IMPORTS

Feed supplements

Mineral: average 15.4 lbs/cow-yr @ 8% phosphorus = 1.23 lbs P/cow-yr (beef feed suppliers, Fonyo et al., 1991 with adjustments.); 1.23 lbs P / cow-yr * 1 cow/16 acres = 0.08 lb P / ac-yr

Molasses: 231.3 lbs/cow-yr @ 0.5% phosphorus = 1.16 lbs P / cow-yr * 0.06 cows/ac = 0.07 lb P / ac-yr (Fonyo et al., 1991 with adjustments)

Total phosphorus import per acre = 0.08 + 0.07 = 0.15 lb P /ac-yr

EXPORTS

Live weight

Average phosphorus concentration of live weight = 0.67 % (Khasawneh et al., 1980)

10 cows culled @ 1,100 lbs each =	73.7 lbs P
48 calves sold @ 470 lbs each =	151.2 lbs P
	224.9 lbs P/yr

Total phosphorus export per acre = 225 lbs P/yr / 1,600 acres = 0.14 lb P / ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR UNIMPROVED BEEF PASTURE
= 0.15 – 0.14 = 0.01 lb P / ac-yr

DAIRY PHOSPHORUS BUDGET

ASSUMPTIONS

Herd size and distribution (dairy personnel, county agents)

- Average dairy size = 21,065 acres/13 dairies = 1,620 ac/dairy
  (FDACS nutrient management reports)
- Number of cows = 1,390 milking cows and 520 dry cows
- Cull cows are not treated as an export since heifers are imported to replace them

IMPORTS (Mock•Roos Dairy Surveys, 2001 and FDEP annual reports)

Feed

	Avg. Quantity	Avg. Annual Phosphorus Consumption
All cows:	49.9 tons P / year	61.6 lbs P/acre-yr*(1,620 acres/1,910 total cows) = 52.2 lbs P / cow-yr

Purchased feed supplements (i.e. molasses, energy cubes, salt licks) are negligible in comparison to purchased rations. It is assumed that hay, silage and green chop are grown and consumed in the basin, and do not cross basin boundaries.

Cleaners

Detergents and cleaners: = 170 lbs P/yr / 1,620 acres = 0.10 lbs P / acre-yr *(1,620 acres/1,910 cows) = 0.09 lbs P / cow-yr

Fertilizer

On average, dairies in the basin apply 4.2 tons P/yr in fertilizer.
Fertilizer = 5.2 lbs P/acre-yr * (1,620 acres / 1910 cows) = 4.4 lbs P / cow-yr

Total Phosphorus import = 61.6 + 0.10 + 5.2 = 66.9 lbs P/acre-yr *(1,620 acres / 1,910 cows) = 56.7 lbs P/cow-yr

EXPORTS (Mock•Roos Dairy Surveys, 2001 and FDEP annual reports)

Milk

Average milk production = 14.9 tons P/yr * 2,000 lbs/ton / 1,620 acres = 18.4 lbs P / acre-yr *(1,620 acres/1910 cows) = 15.6 lbs P / cow-yr

Live Weight

Average phosphorus concentration of live weight = 0.67% (Khasawneh et al., 1980)
Calves: (1,390 animals/yr)*(100 lbs/animal)*0.0067 = 931.3 lbs P/yr / 1,620 acres = 0.57 lb P/acre-yr

(0.48 lbs P / acre-yr) *(1,620 acres/1910 cows) = 0.48 lb P / cow-yr

DAIRY PHOSPHORUS BUDGET (Continued)

Total phosphorus export = 18.4 + 0.57 = 19.0 lbs P/acre-yr *(1,620 acres / 1,910 cows) = 16.1 lbs P / cow-yr

ANNUAL NET PHOSPHORUS IMPORT FOR A DAIRY OPERATION WITHOUT HEIFERS AND CALVES
= 66.9 – 19.0 = 47.9 lbs P / acre-year
= 56.7 – 16.1 = 40.6 lbs P / cow-year

CITRUS PHOSPHORUS BUDGET

ASSUMPTIONS

- Mature groves = 80 % of acreage (Mock•Roos Citrus Surveys, 2001)
- Reset groves = 6 %, and new groves = 14 % (Mock•Roos Citrus Surveys, 2001)
- New and reset groves start to bear fruit after four years and are then classified as mature groves
- One-fourth of the total new and reset grove area is newly planted in any given year.
- Average citrus grove size = 10,000 acres (Mock•Roos Citrus Surveys, 2001)
- 0.44 lb phosphorus in l lb P_2O_5
- Since new and reset groves consist of trees between 1 to 4 years of age, and assuming that, on average, equal amounts of trees are newly planted each year, it can be deduced that one-fourth of new and reset groves are newly planted in any given year. This deduction is the same as that of Boggess et al., 1995.
- Additional literature review was conducted for sugar cane fertilizer rates (Anderson, 1998).

<u>Fertilizer use</u>

Mature groves: 300 lbs/ac-yr * 4% P_2O_5 = 12 lbs P_2O_5/ac·yr = 5.3 lbs P/ac yr (Mock•Roos Citrus Surveys, 2001)

New groves and reset: Average annual fertilizer application rate for new groves for the first three years = 0.33 lb P_2O_5/tree·yr (Taylor et al., 1989). Rate assumed for year four based on Koo (1984) recommendations = 0.56 lb P_2O_5/tree, therefore the average fertilization rate for young trees during the first four years = 0.39 lb P_2O_5/tree yr. Assuming new groves are planted at a density of 140 trees/acre, the average annual fertilizer application rate for the first four years = 54.25 lbs P_2O_5/ac-yr = 23.87 lbs P/ac-yr.

Approximately 10 percent of the growers apply an additional 500 lbs super phosphate (9% P) (Fonyo et al., 1991) to new and reset groves prior to planting = 45 lbs P/ac.

IMPORTS

<u>Fertilizer</u>

Weighted average fertilizer input: mature groves (80 %) + new groves and reset (20 %) + addition super phosphate application to 10% of new and reset groves (20%) = (0.80 * 5.3 lbs P/ac-yr) + (0.20 * 23.87 lbs P/ac-yr) + (0.1 * 0.05 * 45 lb P/ac) = 9.24 lbs P / ac-yr

Total phosphorus import per acre = 9.24 lbs P / ac-yr

CITRUS PHOSPHORUS BUDGET (Continued)

EXPORTS

<u>Harvested citrus</u>

Oranges

1,700,000 boxes (Mock•Roos Citrus Surveys, 2001) * 90 lb./box * 0.00014 lb P/lb orange = 21,420 lb P/yr (USDA Nutrient Database, Release 12, March 1998)

Grapefruit

800,000 boxes (Mock•Roos Citrus Surveys, 2001) * 90 lbs./box * 0.00009 lb P/lb grapefruit = 6,480 lbs P/yr (USDA Nutrient Database, Release 12, March 1998)

Total phosphorus export per acre = (21,420 lbs P/yr + 6,480 lbs P/yr)/10,000 acres = 2.79 lbs P/ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR A CITRUS OPERATION
= 9.24 – 2.79 = 6.45 lbs P / ac-yr

SUGARCANE FIELD PHOSPHORUS BUDGET

ASSUMPTIONS (Mock•Roos Sugarcane Surveys, 2001)

- 5 % of sugarcane acreage is in rice production, one crop per year
- 5 % is fallow
- 90 % is in sugarcane production
- 0.44 lb phosphorus in 1 lb P_2O_5
- The harvest amount includes both the main crop and ratoon crop, which includes sprout growth from the previous year's roots.

IMPORTS

Fertilizer

Average fertilization rates for: (based on IFAS recommendations and grower info)
Plant sugarcane = 40 lbs P_2O_5/ac-yr (17.6 lbs P / ac-yr)
1st, 2nd, and 3rd ratoons = 40 lbs P_2O_5/ac-yr (17.6 lbs P / ac-yr)
Rice – no fertilization

Annual phosphorus fertilizer application weighted for land use =
(17.60 lbs P / ac * 0.90 acre sugarcane production / total acres) = 15.84 lbs P / ac-yr

Total phosphorus import = 15.84 lbs P / ac-yr

EXPORTS

Harvested crop

Sugarcane (net) = 50 tons / ac-yr (Mock•Roos Sugarcane Surveys, 2001) to mill
Rice = 5600 lbs / ac (main crop plus ratoon) (Izuno and Bottcher, 1987)

Average phosphorus content of harvested biomass:
Sugarcane = 0.016% (Mock•Roos Sugarcane Surveys, 2001)
Rice = 0.2% (DeDatta, 1981)

Sugarcane phosphorus harvest: (50 ton of harvested sugarcane/ac-yr) * (2,000 lbs/ton) * (0.016% lb P/lb harvested sugarcane) = 16.0 lbs P/acre-yr

Rice phosphorus harvest: (5600 lbs rice/ac-yr) * (0.2%. lb P/lb rice = 11.2 lbs P/ac-yr

Annual phosphorus removal weighted for land use =
(16.0 lbs P/ac*0.90 ac sugarcane/total ac) + (11.2 lbs P/ac * 0.05 ac rice/total ac) = 14.96 lbs P/ac-yr

SUGARCANE FIELD PHOSPHORUS BUDGET (Continued)

Total phosphorus export = 14.96 lbs P / ac-yr

ANNUAL NET IMPORT OF PHOSPHORUS FOR SUGARCANE PRODUCTION
= 15.84 – 14.96 = 0.88 lb P / ac-yr

TRUCK CROPS PHOSPHORUS BUDGET

ASSUMPTIONS

- Eagle Island Ranches represents half of truck crop operations in the northern Lake Okeechobee watershed and Queen B Farms represents the other half of the truck crop operations
- Average phosphorus content for each crop is as follows: corn at 0.089%, potato at 0.046%, cabbage at 0.023%, and silage corn at 0.070%
- 0.44 lb phosphorus in 1 lb P_2O_5
- The phosphorus concentration of each crop considered in the truck crop phosphorus budget was determined by the USDA Nutrient Database (USDA, 1998)

Per Eagle Island Ranches

- Potato, corn, cabbage, and silage corn are grown rotationally.
- Potatoes are grown single crop, and other crops are double cropped.
- 10-34-0 fertilizer is applied once during each planting for each crop.
- 50 units of fertilizer at 20 lbs/unit are applied per acre per crop.

Per Queen B Farms

- Potato, cabbage and sorghum are grown rotationally
- The above crops are not double cropped
- Sorghum is not harvested and is only used as a cover crop.
- The same amount and quantity of fertilizer is applied to both the cabbage and potatoes.
- No phosphorus is applied to the sorghum.
- There is no phosphorus in the sorghum seed.

IMPORTS

Fertilizer (per Eagle Island)

For double cropping: 50 units P/crop/ac * 20 lbs/unit * 0.34 lb P_2O_5/lb 10-34-0 fertilizer * 0.44 lb P/lb P_2O_5 * 2 crops/yr = 299 lbs P/ac-yr

For single cropping: phosphorus import = 149.5 lbs P / ac-yr

Crop	Acres	lbs P /ac-yr	lbs P/yr
Corn	800	299	239,200
Potato	950	150	142,025
Cabbage	850	299	254,150
Silage Corn	500	299	149,500
Total	**3,100**		**784,875**

Total phosphorus import = (784,875 lbs P/yr)/3100 ac = 253 lbs P/ac-yr

TRUCK CROPS PHOSPHORUS BUDGET (Continued)

Fertilizer (per Queen B)

Single crop of potato and cabbage receive 8-4-8 with an application rate of 40 lbs P /ac-yr three times a year.

Crop	Acres	lbs/ac-yr	lbs P/yr
Potato	500	120	20,000
Cabbage	200	120	8,000
Sorghum	700	0	0
Total	**700**		**28,000**

Total phosphorus import = (28,000 lbs P/yr)/700 ac = 120 lbs P/ac-yr

Average total phosphorus import = (253 lbs P/ac-yr +120 lbs P/ac-yr)/2 =186.5 lbs P /ac-yr

EXPORTS

Harvested crops (per Eagle Island)

Crop	Acres	lbs/ac/crop	Crops/yr	lbs/yr	% P	lbs P/yr
Corn	800	14,700	2	23,520,000	0.089	20,933
Potato	950	17,500	1	16,625,000	0.046	7,648
Cabbage	850	50,000	2	85,000,000	0.023	19,465
Silage Corn	500	12,000	2	12,000,000	0.070	8,400
Total	**3,100**					**56,445**

Total phosphorus export = 56,445 lbs P/3100 acres = 18 lbs P/ac-yr

Harvested crops (per Queen B Farms)

Crop	Acres	lbs/ac/crop	Crops/yr	lbs/yr	% P	lbs P/yr
Potato	500	34,000	1	17,000,000	0.046	7,820
Cabbage	200	70,000	1	14,000,000	0.023	3,220
Total	**700**					**11,040**

Total phosphorus export = 11,040 lbs P/700 acres = 15.8 lbs P/ac-yr

Average total phosphorus Export = (18 lbs P/ac-yr +15.8 lbs P/ac-yr)/2 =16.9 lbs P /ac-yr

ANNUAL NET IMPORT OF PHOSPHORUS FOR TRUCK CROP PRODUCTION
= 186.5 – 16.9 = 169.6 lbs P/acre-yr

SOD PHOSPHORUS BUDGET

ASSUMPTIONS

- Sod is harvested on a 10.5 month cycle; there are 1.14 harvests per year (Fonyo et al., 1991).
- 85 % of the field is harvested every 10.5 months (Mock•Roos Sod Surveys, 2001).
- 0.44 lb phosphorus in 1 lb P_2O_5
- Average phosphorus content of harvested sod is 0.068% P, including turf and soil (Fonyo et al., 1991).

IMPORTS

Fertilizer (Mock•Roos Sod Surveys, 2001)

Floritam 600 ac*1,500 lbs/ac-yr*6% P_2O_5= 23,760 lbs P/yr
Florona 800 ac*300 lbs/ac-yr*10% P_2O_5= 10,560 lbs P/yr
Floralta 1,000 ac*300 lbs/ac-yr*10% P_2O_5= 13,200 lbs P/yr
Total fertilizer phosphorus = 47,520 lbs P/yr

Total acres in production = 2,400 acres
Total farm acres used = 2,400 acres/85% acreage in production
= 2,825 acres

Total phosphorus import per farm acre = 47,520 lbs P/yr / 2,825 acres
= 16.83 lbs P / ac-yr

EXPORTS

Harvested sod (lab analysis)

Average dry weight of sod per acre (including turf and soil) = 45.86 tons, (Fonyo et al., 1991)
Average dry weight of harvested sod per acre = 45.86 * 0.85 = 39.0 tons,
Average phosphorus content of harvested sod = 0.068 %, (Fonyo et al., 1991)

Total phosphorus export per acre = (39.0 tons/ac)*(0.00068)*(2000 lbs/ton)*(1.14 harvests/yr)
= 60.47 lbs P / ac-yr

ANNUAL NET PHOSPHORUS EXPORT FOR SOD OPERATION OF MIXED MUCK AND SANDY SOILS
= 60.47– 16.83 = 43.64 lbs P / ac-yr

ORNAMENTALS PHOSPHORUS BUDGET

ASSUMPTIONS

- A large amount of ornamental nurseries has been realized since the last phosphorus budgets and land use maps were compiled. A large portion of this growth has been due to an increasing caladium business in the area near Sebring, FL. Therefore, caladium was used to represent a typical plant product as was done in the original phosphorus budget report.
- 0.44 lb phosphorus in 1 lb P_2O_5
- The fertilizer and harvest rates were taken from Caladium World (Caladium World, 2002)

IMPORTS

Fertilizer

Annual fertilizer application rate = 900 lbs of 6-6-6/ac * (6% P_2O_5/lb 6-6-6) = 54 lbs P_2O_5 / ac-yr * (0.44 lb P / 1 lb P_2O_5)
avg. = 23.76 lbs P / ac-yr (grower info)

Total phosphorus import per acre = 23.76 lbs P / ac-yr

EXPORTS

Harvested crop

Annual harvest = 182 bushels/ac (grower info) 42 lbs / bu.
Phosphorus content of bulbs = 0.2% (IFAS, pers. Comm.)
Annual phosphorus removal through crop harvesting = (42 lbs / bu.) * (182 bu/ac) * (0.002 lb P/lb bulbs) = 15.30 lbs P / ac-yr

Total phosphorus export per acre = 15.30 lbs P / ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR ORNAMENTALS
= 23.76 – 15.30 = 8.46 lbs P / ac-yr

COMMERCIAL FORESTRY PHOSPHORUS BUDGET

ASSUMPTIONS (Fonyo et al., 1991)

- All commercial forestland in the northern Lake Okeechobee watershed can be classified as pine
- Fertilization rates are negligible over the life of the tree

NET EXPORTS

Harvested growing stock

Average annual removal (1980 - 1986) of pine growing stock per acre of pine timberland in Glades, Highlands, and Okeechobee Counties = 18.5 cu. ft./ac-yr @ 77 lbs/cu. ft. (Brown and Thompson, 1988) = (1425 lbs green wt./ac-yr)/2 = 712 lbs dry wt./ac-yr (IFAS, pers. comm.)

Phosphorus content of harvested biomass = 0.02 % P dry wt. (Khasawneh et al., 1980)

Total annual phosphorus export per acre = (712 lbs/ac-yr) * (0.0002 lb P/lb dry wt.) = 0.14 lb P/ac-yr

ANNUAL NET PHOSPHORUS EXPORT FOR COMMERCIAL FORESTRY
= 0.14 lb P/ac-yr

LOW DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET

ASSUMPTIONS (Fonyo et al., 1991)

- Housing density: one house every 5 acres = 0.2 apartment units/ac
- (43,560 sq. ft./ac)*(1 ac/0.2 units) = 217,800 sq. ft. of yard/apartment unit
- Household population avg. = 2.5 persons/apartment unit (Shoemyen, 1988)
- Avg. house = 2,500 sq. ft.; adjust remaining acreage by 25 % to account for non-lawn areas such as sheds, driveways, etc., and non-landscaped or fertilized lawn areas
- Avg. raw sewage effluent generation = 100 gal/capita day
- Avg. phosphorus concentration of raw sewage effluent = 10 mg P/L ($8.3*10^{-5}$ lbs P/gal)
- For residential areas that are not hooked up to a municipal treatment facility (i.e. septic tanks or package treatment plants), the settled phosphorus in sewage effluent may be used to approximate total phosphorus export from the household unit, out of the basin via septic tank cleaning.
- All material handled by the municipal treatment facility stays in the basin.
- On average, 25% of homeowners fertilize their lawns at same rate as improved pasture (24.2 lbs P_2O_5/ac-yr). A 0.5 homeowner adjustment factor was utilized.
- 95% of residential units are on septic tanks, based on review of geographic layout of land use in proximity to downtown Okeechobee service area
- 0.44 lb phosphorus in 1 lb P_2O_5
- There is an average equivalent of 1 horse and 2 dogs every 5 acres.
- 1 dog consumes 1.8 lbs feed/day (Eldridge, 2002).
- There is 0.67% phosphorus in dog feed (Eldridge, 2002).
- 1 horse consumes 5.5 lbs feed/day (Eldridge, 2002).
- 0.5 % phosphorus in horse feed (Eldridge, 2002).

IMPORTS

<u>Food, detergents, and other phosphorus-containing consumables</u>

Per the Economic Research Service (ERS), 2002 and USDA, 2002:

Food Type	lbs P/yr
Fruits/Vegetables	0.35
Grains	0.18
Meats	0.46
Cheese	0.15
Cola	0.60
Milk	0.19
Miscellaneous	0.19
Total	**2.13**

LOW DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET (Continued)

Major Detergent	**Lbs/yr**	**lbs P/capita-yr**
Soap bars	6.0	0.12
Shampoo	12.0	0.24
Laundry	50.9	1.00
Dish	3.0	0.06
Miscellaneous	3.69	0.14
Total	**79.1**	**1.56**

Total food/detergent phosphorus import per capita-year = 2.13 + 1.56 = 3.69 lb P/capita-yr

Total food/detergent phosphorus import per acre-year = Housing density*population density*per capita food/detergent consumption

= (0.2 units/ac)*(2.5 capita/unit)*(3.69 lb P/capita-yr) = 1.8 lbs P/ac-yr

Pet foods

Total pet food phosphorus import in lbs P/year = Number of animals*lbs feed/day* lbs of P quantity/1 lb dog or horse feed *365 days/yr

Phosphorus requirements for 2 dogs = 2*(1.8 lbs feed/day)*(0.67% lb P/1 lb feed)*(365 days/year) = 8.8 lbs P feed/year

Phosphorus requirements for 1 horse = 1*(5.5 lbs feed/day)*(0.5% lb P)*(365 days/year) = 10.0 lbs P feed/year

Total pet food phosphorus import per acre-year

=(10 lbs P/year + 8.8 lbs P/year)/5 acres = (18.8 lb P/year)/(5 ac)

= 3.76 lbs P/ac-yr

Total pet food phosphorus import = 3.76 lbs P/ac-yr

Lawn fertilizer

(217,800 sq. ft. of yard/apartment unit – 2,500 sq. ft./home)*(0.25 non-lawn adjustment factor) = 53,825 sq. ft. = 1.24 fertilized acres/apartment unit

Fertilization rate = 24.2 lbs P_2O_5/ac-yr = 10.65 lbs P/ac-yr

10.65 * 1.24 fertilized acres/unit = 13.2 lbs P/apartment unit-yr*(0.25 homeowner adjustment factor) * 0.2 units/basin ac = 0.66 lbs P/ac-yr

Total phosphorus Import per acre = 1.8 + 3.76 + 0.66 = 6.22 lbs P/ac-yr

LOW DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET (Continued)

EXPORTS

Septic Tank Cleaning

Sewage effluent amount = Housing density*population density*per capita effluent generation*phosphorus concentration in effluent = (0.2 units/ac)*(2.5 cap/unit)*(100 gal/cap-day)*(0.000083 lb P/gal) = 0.0042 lb P/ac-day x 365 days/yr = 1.5 lbs P/ac-yr

1.5 lb P effluent/ac-yr * 95% units on septic * 0.02 lb P removed/lb P effluent
= 0.03 lb P/ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR LOW DENSITY URBAN RESIDENTIAL AREA
= 6.22 – 0.03 lbs P/ac-yr
= 6.19 lbs P/ac-yr

MEDIUM DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET

ASSUMPTIONS (Fonyo et al., 1991)

- Housing density: 2 units/ac
- (43,560 sq. ft./ac)*(1 ac/2 units) = 21,780 sq. ft./unit
- Household population avg. = 2.5 persons/unit (Shoemyen, 1988)
- Avg. house = 2,000 sq. ft.; adjust remaining acreage by 50% to account for non-lawn areas such as sheds, driveways, etc., and non-landscaped or fertilized lawn areas.
- Avg. raw sewage effluent generation = 100 gal/capita day
- Avg. phosphorus concentration of raw sewage effluent = 10 mg/l ($8.3*10^{-5}$ lb P/gal)
- For residential areas that are on septic tanks, the settleable phosphorus in sewage effluent may be used to approximate total phosphorus export from the household unit, out of the basin via septic tank cleaning.
- All material handled by the municipal treatment facility stays in the basin.
- On average, 25% of homeowners fertilize their lawns at same rate as improved pasture (24.2 lbs P_2O_5/ac-yr). A 0.5 homeowner adjustment factor was utilized.
- 42% of residential units are on septic tanks, based on review of geographic layout of land use in proximity to downtown Okeechobee service area
- 1 dog consumes 1.8 lbs feed/day (Eldridge, 2002).
- There is 0.67% phosphorus in dog food (Eldridge, 2002).
- There is an average equivalent of 1 dog every 2 household units

IMPORTS

Food, detergents, and other phosphorus-containing consumables

Per the Economic Research Service (ERS), 2002 and USDA, 2002:

Food Type	lbs P/yr
Fruits/Vegetables	0.35
Grains	0.18
Meats	0.46
Cheese	0.15
Cola	0.60
Milk	0.19
Miscellaneous	0.19
Total	**2.13**

Major Detergent	lbs/yr	lbs P/capita-yr
Soap bars	6.0	0.12
Shampoo	12.0	0.24
Laundry	50.9	1.00
Dish	3.0	0.06
Miscellaneous	3.69	0.14
Total	**79.1**	**1.56**

MEDIUM DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET (Continued)

Total food/detergent phosphorus import per capita-year = 2.13 + 1.56 = 3.69 lb P/capita-yr

Total food/detergent phosphorus import per acre-year = Housing density*population density*per capita food/detergent consumption

= (2 units/ac)*(2.5 cap/unit)*(3.69 lb P/capita-yr) = 18.45 lb P/ac-yr

Pet foods

Total pet food phosphorus import in lbs P/year = Number of animals*lbs feed/day* lbs of P quantity/1 lb dog food*365 days/yr

Phosphorus requirements for 1 dog = 1*(1.8 lbs feed/day)*(0.67% lb P/1 lb feed)*(365 days/year) = 4.4 lbs P feed/year

Total pet food phosphorus import in acre-year

= (1 dog/2 units)*(4.4 lb P feed/dog-yr)*(2 units/acre) = 4.4 lb P/ac-yr

Total pet food phosphorus import = 4.4 lbs Pac-yr

Lawn fertilizer

(21,780 sq. ft./unit – 2,000 sq. ft./home)*(0.5 non-lawn adjustment factor) = 9,890 sq. ft. * 1ac / 43,560 sq. ft. = 0.23 ac/apartment unit

Fertilization rate = 24.2 lbs P_2O_5/ac-yr * 0.44 lb P/lb P_2O_5 = 10.65 lbs P/ac-yr

10.65 * 0.23 fertilized acres/unit = 2.45 lbs P/unit-yr*(0.25 homeowner adjustment factor) * 2 units/ basin ac = 1.22 lbs P/ac-yr

Total phosphorus import = 18.45 + 4.4 +1.22 = 24.07 lbs P/ac-yr

EXPORTS

Septic Tank Cleaning

Sewage effluent amount = Housing density*population density*per capita effluent generation*phosphorus concentration in effluent = (2 units/acre)*(2.5 capita/units)*(100 gal/capita-day)*(0.000083 lb P/gal) = 0.0415 P/acre-day x 365days/yr = 15.15 lb P/acre-yr

15.15 lb P effluent/ac-yr * 42% units on septic * 0.02 lb P removed/lb P effluent

= 0.13 lb P/ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR MEDIUM DENSITY URBAN RESIDENTIAL AREA
= 24.07 - 0.13 = 23.94 lbs P/ac-yr

HIGH DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET

ASSUMPTIONS (Fonyo et al., 1991)

- Housing density: 5 units/ac
- (43,560 sq. ft./ac)*(1 ac/5 units) = 8,712 sq. ft./unit
- Household population avg. = 2.5 persons/unit (Shoemyen, 1988)
- Avg. house = 1,500 sq. ft.; adjust remaining acreage by 50 % to account for non-lawn areas such as sheds, driveways, etc., and non-landscaped or fertilized lawn areas.
- Avg. raw sewage effluent generation = 100 gal/capita day
- Avg. phosphorus concentration of raw sewage effluent = 10 mg/l ($8.3*10^{-5}$ lb P/gal)
- For residential areas that are on septic tanks, the settleable phosphorus in sewage effluent may be used to approximate total phosphorus export from the household unit, out of the basin via septic tank cleaning.
- All material handled by the municipal treatment facility stays in the basin.
- On average, 25% of homeowners fertilize their lawns at same rate as improved pasture (24.2 lbs P_2O_5/ac-yr). A 0.5 homeowner adjustment factor was utilized.
- 18% of residential units are on septic tanks, based on review of geographic layout of land use in proximity to downtown Okeechobee service area.
- 0.44 lb phosphorus in 1 lb P_2O_5
- There is 0.46% P in cat food (Muns, 2002).
- Each cat requires 280 Kcal ME (Metabolizable Energy)/kg of body weight (Muns, 2002).
- An average adult cat weighs 11 lbs (Muns, 2002).
- There is 0.65% lbs P in 1 lb cat food (Muns, 2002).
- 1 kg cat food contains 430 Kcal (Muns, 2002).
- There is an average equivalent of 1 cat every 2 household units

IMPORTS

<u>Food, detergents, and other phosphorus-containing consumables</u>
Per the Economic Research Service (ERS), 2002 and USDA, 2002:

Food Type	lbs P/yr
Fruits/Vegetables	0.35
Grains	0.18
Meats	0.46
Cheese	0.15
Cola	0.60
Milk	0.19
Miscellaneous	0.19
Total	**2.13**

HIGH DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET (Continued)

Major Detergent	lbs/yr	lb P/capita-yr
Soap bars	6.0	0.12
Shampoo	12.0	0.24
Laundry	50.9	1.00
Dish	3.0	0.06
Miscellaneous	3.69	0.14
Total	**79.1**	**1.56**

Total food/detergent phosphorus import per capita-year = 2.13 + 1.56 = 3.69 lb P/capita-yr

Total food/detergent phosphorus import per acre-year = Housing density*population density*per capita food and detergent consumption

= (5 units/ac)*(2.5 cap/unit)*(3.69/cap-yr) = 46.13 lb P/acre-yr

Pet foods

Total cat food phosphorus import = energy requirement*weight of cat*energy in cat food*quantity of feed*convert 1 kg to 2.2 lbs*lbs of P quantity/1 lb cat food*365 days/year

Phosphorus requirements for 1 cat = 1*(280 Kcal ME cat/kg body weight-day)*(5 kg/1cat)*(1 kg cat food/4300 Kcal ME)*(2.2 lb cat food/1kg cat food)*(0.0065 lb P/1 lb cat food)*(365 days/year) = 1.69 lbs P/cat-year

Total cat food phosphorus import per acre year

= (1 cat/2 units)*(5 units/1acre)*(1.69 lbs P/cat-year) = 4.23 lbs P/ac-yr

Total cat food phosphorus import = 4.23 lbs P/ac-yr

Lawn fertilizer

(8,712 sq. ft./unit – 1,500 sq. ft./home)*(0.5 non-lawn adjustment factor) = 3,606 sq. ft. = 0.08 ac

Fertilization rate = 24.2 lbs P_2O_5/ac-yr = 10.65 lbs P/ac-yr

10.65 * 0.08 ac/unit = 0.85 lbs P/unit-yr*(0.25 homeowner adjustment factor) * 5 units/ac

= 1.07 lbs P/ac-yr

Total phosphorus import = 46.13 + 4.23 + 1.07 = 51.43 lbs P/ac-yr

EXPORTS

Septic Tank Cleaning

Sewage effluent amount = Housing density*population density*per capita effluent generation*phosphorus concentration in effluent = (5 units/ac)*(2.5 cap/unit)*(100 gal/cap-day)*(0.000083 lb P/gal) = 0.104 lb P/ac-day x 365 days/yr = 37.86 lb P/acre-yr

HIGH DENSITY URBAN RESIDENTIAL PHOSPHORUS BUDGET (Continued)

37.86 lb P effluent/ac-yr * 18% units on septic * 0.02 lb P removed/lb P effluent
= 0.14 lb P/ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR HIGH DENSITY URBAN RESIDENTIAL AREA
= 51.43 – 0.14 = 51.29 lbs P/ac-yr

TRAVEL TRAILER COURT AND FISH CAMP PHOSPHORUS BUDGET

ASSUMPTIONS (Fonyo et al., 1991)

- Housing density: 10 units/ac
- Household population average: 2 persons/unit
- Population is seasonal, residing for 6 months a year. An occupancy rate of 182.5 days/365 days was used.
- Avg. raw sewage effluent generation = 100 gal/capita day
- Avg. phosphorus concentration of raw sewage effluent = 10 mg/l ($8.3*10^{-5}$ lb P/gal)
- Travel trailer courts and fish camps are generally hooked up to a municipal treatment facility.
- On average, homeowners do not fertilize their lawns.
- The typical trailer park is on sewer service

NET IMPORTS

Food, detergents, and other phosphorus-containing consumables

Per the Economic Research Service (ERS), 2002 and USDA, 2002:

Food Type	lbs P/yr
Fruits/Vegetables	0.35
Grains	0.18
Meats	0.46
Cheese	0.15
Cola	0.60
Milk	0.19
Miscellaneous	0.19
Total	**2.13**

Major Detergent	lbs/yr	lb P/capita-yr
Soap bars	6.0	0.12
Shampoo	12.0	0.24
Laundry	50.9	1.00
Dish	3.0	0.06
Miscellaneous	3.69	0.14
Total	**79.1**	**1.56**

Total food/detergent phosphorus import per acre-year = Housing density*population density*per capita food and detergent consumption*occupancy rate

= (10 units/ac)*(2 cap/unit)*(3.69 lb P/cap-yr) = 73.8 lb P/acre-yr *(182.5 days/ 365days) = 36.9 lb P/ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR TRAVEL COURTS AND FISH CAMPS ALONG LAKE OKEECHOBEE = 36.9 lbs P/ac-yr

GOLF COURSE PHOSPHORUS BUDGET

ASSUMPTIONS

- Total golf course site is 95 acres (Mock•Roos Golf Course Surveys, 2002)

IMPORT

Fertilizer

Greens/Tees (3.5 ac.): 12,000 lbs of 13-4-13 per year * 4% lbs P_2O_5/lb fertilizer * 0.44 lb P/lb P_2O_5

= 211.2 lbs P/yr

Fairways (45 ac): 15,000 lbs of 10-10-10 per year * 10% lbs P_2O_5/lb fertilizer * 0.44 lb P/lb P_2O_5

= 660.0 lbs P/yr

Rough (46.5 ac): No fertilizer applied.

Total phosphorus import per acre = (211.2 lbs P/yr + 660.0 lbs P/yr)/95 ac.
= 9.17 lbs P/ac.

EXPORTS

No exports.

ANNUAL NET PHOSPHORUS IMPORT FOR A GOLF COURSE OPERATION
= 9.17 – 0.0 = 9.17 lbs P / ac-yr

FIELD CROP PHOSPHORUS BUDGET

ASSUMPTIONS

- Typical field crop is hay
- 0.44 lb phosphorus in 1 lb P_2O_5

IMPORTS

Fertilizer

Annual fertilizer application rate = 80 lb P_2O_5/ac-yr (IFAS, 2001)
= 80 lb P_2O_5/ac-yr * 0.44 lb P/lb P_2O_5
= 35.20 lbs P/ac-yr

Total phosphorus import per acre = 35.20 lbs P / ac-yr

EXPORTS

Harvested grass

Average annual harvest = 6.6 tons/ac-yr (Overman, 2001)

Phosphorus content of grass = 0.22% (IFAS, pers. Comm.; Overman, 2001)
Annual phosphorus removal through grass harvesting = (6.6 tons/ac-yr.) * (2,000 lbs/ton) * (0.0022 lb P/lb dry matter) = 29.04 lbs P / ac-yr

Total phosphorus export per acre = 29.04 lbs P / ac-yr

ANNUAL NET PHOSPHORUS IMPORT FOR FIELD CROP
= 35.20 – 29.04 = 6.16 lbs P / ac-yr

4.14 Net Phosphorus Import Summary And Comparison

Many land use types were researched in an effort to obtain the most current information regarding their potential impacts to the northern Lake Okeechobee watershed. Many landowners, businesses and agencies were helpful in providing the pertinent information that was needed for this survey.

The net phosphorus imports for most land uses have decreased since the original study. This trend appears to be the result of several factors including public awareness, basin rules, buyout programs, and economics. Although there are considerable reductions in some of the phosphorus imports rates, there are also increases in developed land uses, which may offset the benefits. A full accounting of the areal phosphorus import will be conducted in later sections of this task report.

The 1991 study considered only the high intensity dairy areas as part of the dairy land use, whereas the current study considers both high and low intensity land areas. Similar land use extents had to be estimated in order to consistently compare the dairy land use of 1991 with the current dairy land use. Therefore, an equivalent net phosphorus import had to be calculated to include both high and low intensity areas for 1991 dairies based on the ratio of intense versus non-intense dairy usage as estimated from the 1991 coverage.

Abandoned dairies were maintained as a separate land use since the phosphorus import and runoff properties of this land use were unique. The phosphorus import coefficient for abandoned dairies was taken to be the same as for improved pasture. However, sampling on abandoned dairies still shows high phosphorus runoff concentrations as recorded by South Florida Water Management District. The runoff concentration for this land use was taken to be still the same as that of dairy land use.

Table 3 shows the phosphorus import and export coefficients by material component and land use according to the original study (Fonyo et al., 1991). A subsequent article (Boggess et al., 1995) was prepared by some of the original participants in the original 1991 study. This article reported very similar net phosphorus import coefficients to the original study with the exception of improved pasture and dairies. Table 4 shows the current phosphorus import and export coefficients by material component and land use. Table 5 shows a comparison summary of net phosphorus import coefficients as reported in the original study, the subsequent article, and the current study. The primary contributor reported in Table 5 is the phosphorus material or calculation methodology that created the greatest change in the net phosphorus import coefficient of that respective land use. Table 6 shows the percent change of phosphorus import and export coefficients by material component and land use between the original study and the current study.

Table 3. 1991 Import and Export Coefficients by Material Component and Land Use

	P Import (lbs P/ac-yr)				P Export (lbs P/ac-yr)							Net Import
LAND USE	Fert	Feed	Clnrs	Total	Harv	Livewt	Hay	Sod	Milk	Septic	Total	(lbs P/ac-yr)
RANGELAND	0.00	0.19	0.00	0.19	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.05
IMPROVED PASTURE	10.56	1.24	0.00	11.80	0.00	0.89	0.00	0.00	0.00	0.00	0.89	10.91
WETLANDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FOREST UPLANDS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DAIRY	9.87	85.30	0.52	95.69	0.00	4.98	0.00	0.00	19.41	0.00	24.38	71.30
BARREN LAND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIELD CROP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER URBAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIMPROVED PASTURE	0.00	0.19	0.00	0.19	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.05
TRUCK CROPS	154.00	0.00	0.00	154.00	13.00	0.00	0.00	0.00	0.00	0.00	13.00	141.00
CITRUS	13.85	0.00	0.00	13.85	5.00	0.00	0.00	0.00	0.00	0.00	5.00	8.85
WATER BODIES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GOLF COURSE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOD FARM	44.00	0.00	0.00	44.00	0.00	0.00	0.00	54.16	0.00	0.00	54.16	-10.16
ORNAMENTALS	42.24	0.00	0.00	42.24	21.00	0.00	0.00	0.00	0.00	0.00	21.00	21.24
COMMERCIAL FOREST	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	-0.14
WASTE TREATMENT PLANT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUGAR CANE	16.34	0.00	0.00	16.34	9.12	0.00	0.00	0.00	0.00	0.00	9.12	7.22
AQUACULTURE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POULTRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ABANDONED DAIRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RES - TRAVEL TRAILER	0.00	30.30	0.00	30.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.30
RES - LOW DENSITY	1.32	1.50	0.00	2.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.82
RES - MED DENSITY	2.45	15.15	0.00	17.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.60
RES - HIGH DENSITY	2.13	37.90	0.00	40.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.03

Table 4. 2001 Import and Export Coefficients by Material Component and Land Use

	P Import (lbs P/ac-yr)				P Export (lbs P/ac-yr)							Net Import
LAND USE	Fert	Feed	Clnrs	Total	Harv	Livewt	Hay	Sod	Milk	Septic	Total	(lbs P/ac-yr)
RANGELAND	0.00	0.15	0.00	0.15	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.01
IMPROVED PASTURE	3.29	0.88	0.00	4.17	0.00	1.25	0.07	0.14	0.00	0.00	1.46	2.71
WETLANDS*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FOREST UPLANDS	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	-0.14
DAIRY	5.20	61.60	0.10	66.90	0.00	0.57	0.00	0.00	18.40	0.00	18.97	47.93
BARREN LAND*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIELD CROP	35.20	0.00	0.00	35.20	29.04	0.00	0.00	0.00	0.00	0.00	29.04	6.16
OTHER URBAN*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIMPROVED PASTURE	0.00	0.15	0.00	0.15	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.01
TRUCK CROPS	186.50	0.00	0.00	186.50	16.90	0.00	0.00	0.00	0.00	0.00	16.90	169.60
CITRUS	9.24	0.00	0.00	9.24	2.79	0.00	0.00	0.00	0.00	0.00	2.79	6.45
WATER BODIES*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GOLF COURSE	9.17	0.00	0.00	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.17
SOD FARM	16.83	0.00	0.00	16.83	0.00	0.00	0.00	60.47	0.00	0.00	60.47	-43.64
ORNAMENTALS	23.76	0.00	0.00	23.76	15.30	0.00	0.00	0.00	0.00	0.00	15.30	8.46
COMMERCIAL FOREST	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	-0.14
WASTE TREATMENT PLANT*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUGAR CANE	15.84	0.00	0.00	15.84	14.96	0.00	0.00	0.00	0.00	0.00	14.96	0.88
AQUACULTURE*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POULTRY*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ABANDONED DAIRY	3.29	0.88	0.00	4.17	0.00	1.25	0.07	0.14	0.00	0.00	1.46	2.71
RES - TRAVEL TRAILER	0.00	36.90	0.00	36.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.90
RES - LOW DENSITY	0.66	5.56	0.00	6.22	0.00	0.00	0.00	0.00	0.00	0.03	0.03	6.19
RES - MED DENSITY	1.22	22.85	0.00	24.07	0.00	0.00	0.00	0.00	0.00	0.13	0.13	23.94
RES - HIGH DENSITY	1.07	50.36	0.00	51.43	0.00	0.00	0.00	0.00	0.00	0.14	0.14	51.29

* These land uses were not surveyed because of the minimal phosphorus areal influence in the study area

Table 5. Net Phosphorus Import Summary and Comparison

Land Use	Current Study lbs/ac-yr	1991 Report lbs/ac-yr	1995 Article lbs/ac-yr	Primary Contributor Change Description
Improved Pasture	2.71	10.91	4.52	Fertilizer
Dairy	47.93	71.3*	52.6	Stocking rate
Field Crop	6.16	N/A	N/A	N/A
Unimproved Pasture	0.01	0.05	0.05	Supplements
Truck Crops	169.6	141	129.5	Farming intensity
Citrus	6.45	8.85	8.09	Fertilizer
Golf Course	9.17	23.58	59.5	Not determined
Sod	-43.6	-10.2	-8.85	Fertilizer
Ornamentals	8.46	21.24	19.96	Fertilizer
Commercial Forestry	-0.14	-0.14	-0.13	N/A
Sugarcane	0.88	7.22	6.56	Cane production
Trailer Parks	36.90	30.3	N/A	Feed Import Computation
Low Density Residential	6.19	2.82	1.4	Feed Import Computation
Medium Density Residential	23.94	17.6	12.14	Feed Import Computation
High Density Residential	51.29	40.03	N/A	Feed Import Computation

*Estimated per acre stocking rate based on 1991 report values on a per cow basis.

Table 6. Percent Change of Phosphorus Import and Export Coefficients by Material Component and Land Use (1991 to 2001).

	P Import				P Export							Net Import
LAND USE	Fert	Feed	Clnrs	Total	Harv	Livewt	Hay	Sod	Milk	Septic	Total	
RANGELAND	0%	-21%	0%	-21%	0%	0%	0%	0%	0%	0%	0%	-80%
IMPROVED PASTURE	-69%	-29%	0%	-65%	0%	40%	n/d	n/d	0%	0%	64%	-75%
WETLANDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FOREST UPLANDS	0%	0%	0%	0%	n/d	0%	0%	0%	0%	0%	n/d	n/d
DAIRY	-47%	-28%	-81%	-30%	0%	-89%	0%	0%	-5%	0%	-22%	-33%
BARREN LAND	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FIELD CROP	n/d	0%	0%	n/d	n/d	0%	0%	0%	0%	0%	n/d	n/d
OTHER URBAN	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
UNIMPROVED PASTURE	0%	-21%	0%	-21%	0%	0%	0%	0%	0%	0%	0%	-80%
TRUCK CROPS	21%	0%	0%	21%	30%	0%	0%	0%	0%	0%	30%	20%
CITRUS	-33%	0%	0%	-33%	-44%	0%	0%	0%	0%	0%	-44%	-27%
WATER BODIES	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
GOLF COURSE	n/d	0%	0%	n/d	0%	0%	0%	0%	0%	0%	0%	n/d
SOD FARM	-62%	0%	0%	-62%	0%	0%	0%	12%	0%	0%	12%	330%
ORNAMENTALS	-44%	0%	0%	-44%	-27%	0%	0%	0%	0%	0%	-27%	-60%
COMMERCIAL FOREST	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WASTE TREATMENT PLANT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SUGAR CANE	-3%	0%	0%	-3%	64%	0%	0%	0%	0%	0%	64%	-88%
AQUACULTURE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
POULTRY	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
ABANDONED DAIRY	n/d	n/d	0%	n/d	0%	n/d	n/d	n/d	0%	0%	n/d	n/d
RES - TRAVEL TRAILER	0%	22%	0%	22%	0%	0%	0%	0%	0%	0%	0%	22%
RES - LOW DENSITY	-50%	271%	0%	121%	0%	0%	0%	0%	0%	n/d	n/d	120%
RES - MED DENSITY	-50%	51%	0%	37%	0%	0%	0%	0%	0%	n/d	n/d	36%
RES - HIGH DENSITY	-50%	33%	0%	28%	0%	0%	0%	0%	0%	n/d	n/d	28%

n/d : percent change is “not defined” since the original value was zero.

5.0 PHOSPHORUS BUDGET BY BASIN

5.1 Overview

This section only of the report utilizes the metric system of units to be consistent with the Total Maximum Daily Load (TMDL) program and the 1995 article (Boggess et al., 1995). For each tributary basin studied, a phosphorus budget was developed using the same mass balance equation as previously used by Boggess et al., 1995. The basin phosphorus budgets may be expressed by a series of simple mass balance equations:

$$\Delta S_b = \sum_{i=1}^{a} I_i - \sum_{i=1}^{a} O_{Li}$$

where:

$$I_i = I_{imports} + I_{precip}$$

and:

$$\Delta S_b = \Delta S_o + \Delta S_a$$

$$\Delta S_o = \sum_{i=1}^{a} I_i - \sum_{i=1}^{a} R_{Li}$$

$$\Delta S_a = \sum_{i=1}^{a} R_{Li} - \sum_{i=1}^{a} O_{Li}$$

where ΔS_b = basin phosphorus retention, ΔS_o = on-site phosphorus retention, ΔS_a = wetland phosphorus assimilation, I_i = phosphorus inputs, $I_{imports}$ = net phosphorus imports, I_{precip}= rainfall phosphorus load, O_{Li} = basin phosphorus load to Lake Okeechobee, R_{Li} = average annual off-site runoff phosphorus load, and the superscript "a" = the number of tributary basins within the northern Lake Okeechobee watershed. All phosphorus terms are in units of metric tons per year (t P/yr).

A matrix of variables and basin characteristics (Table 7) was used for regression analysis to determine correlations between these variables and phosphorus loading to Lake Okeechobee. Each matrix characteristic was regressed with lake loading. The best-fit line for each relationship was calculated using the least squares method of linear regression. The variables considered in this report were the same as those used in the original study. The value of LDIST (Table 7) was attained from the previous study geographic information. It should be noted that, as defined in the 1991 study, LDIST is the distance from the basin centroid to the shore of Lake Okeechobee. The LDIST as defined does not consider distance along flow lines.

The correlations analyzed in this report include:

The relation between the independent variable (ind. var) and dependent variables (dep. var.) were analyzed and listed in order of decreasing correlation coefficients (r^2) later in this report. The regression equations are written as follows:

Linear relationship: dep. var = y-intercept + coefficient * (ind.var)
Logarithmic relationship: log(dep. var) = y-intercept + coefficient * log(ind. var)

Please note that all logarithmic regressions use base ten. The information needed to make these correlations came from previous tasks and from newly researched information as described below:

Table 7. Variables Used in Regression Analysis

Phosphorus Budget Indices		
AF	=	assimilation factor ($\Delta S_a/R_L$); fraction of off-site phosphorus load assimilated in wetlands.
BPLI	=	basin phosphorus load index (O_L/I); fraction of total phosphorus inputs exported to the lake.
OPLI	=	off-site phosphorus load index (R/I); fraction of total phosphorus inputs in off-site runoff.
Basin phosphorus budget characteristics		
dS	=	total annual change in phosphorus retention, kg yr^{-1}
ΔS_a	=	wetland phosphorus assimilation in the basin along the flow path to the lake (t yr^{-1}).
ΔS_o	=	upland phosphorus retention (t yr^{-1}).
ΔS_b	=	total basin phosphorus retention (upland retention plus wetland assimilation) (t yr^{-1}).
I_{import}	=	net phosphorus imports (t yr^{-1}).
NPAC	=	net phosphorus imports per basin area (kg ha^{-1}).
R_L	=	off-site phosphorus load in runoff (t yr^{-1}).
O_L	=	basin phosphorus load to lake (t yr^{-1}).
PLAC	=	lake phosphorus load per basin area (kg ha^{-1}).
PLFW	=	flow-weighted phosphorus loading rate (ppm)
I_{precip}	=	rainfall phosphorus load (t yr^{-1}).
Basic basin characteristics		
AREA	=	basin area (ha).
PERIM	=	basin perimeter (km)
SHAPE	=	basin shape, perimeter area (m ha^{-1})
LDIST	=	distance from basin centroid to Lake Okeechobee (km).
DEVAC	=	area of land uses in the basin with associated flows of phosphorus-containing materials (ha)
INTS	=	DEVAC divided by basin area, measure of the extensiveness of phosphorus use in the basin.
STREAM1	=	total length of all naturally flowing water (except braided streams) in the basin (km).
STREAM2	=	basin stream density, STREAM 1/basin area (m ha^{-1}).
WATER1	=	total length of streams and canals in the basin (km).
WATER2	=	basin drainage density (streams and canals) (m ha^{-1})
WETLANDS	=	total area of wetlands of all types within the basin (ha).
WETPER	=	basin area in wetlands (%).
WETEMP	=	basin area in wetlands with emergent vegetation (%).
APP	=	basin area in Placid-Pamlico soil association (ha).
ABM	=	basin area in Myakka-Basinger soil association (ha).
AMD	=	basin area in Manatee-Delray soil association (ha).
APB	=	basin area in Pompano-Basinger soil association (ha).
PPSL	=	percent basin area in Placid-Pamlico soil association (%).
BMSL	=	percent basin area in Myakka-Basinger soil association (%).
MDSL	=	percent basin area in Manatee-Delray soil association (%).
PBSL	=	percent basin area in Pompano-Basinger soil association (%).
DS/AC	=	total annual change in phosphorus retention per acre, kg yr^{-1}

5.2 Soils

A detailed GIS coverage for soils was obtained from the District and analyzed to determine the four most predominant soils groups in the watershed. This coverage was developed by NRCS. The percentage value for each soil type is the percentage of the north Lake Okeechobee watershed area that is identified as each respective soil type. These groups, as shown below, comprise 80% of the watershed.

Soil Type	Area of Soil Type	Percent of Watershed
Myakka-Basinger-Immokalee-Smyrna	249,200	48%
Placid-Pamlico-Felda-Hicoria	63,500	12%
Pompano-Basinger-Charlotte-Placid	61,100	12%
Manatee-Delray-Kaliga-Tequesta	38,500	7%

These four soil associations are named after one or more major soils and one or more minor soils that consist of a distinctive proportion of the association. Soils in any given association may differ in slope, depth, stoniness, drainage, and other characteristics. Most of the soils in Okeechobee County vary in wetness, thickness, texture, and acidity.

Myakka-Basinger Soil Association.

This association consists primarily of nearly level or depressional, strongly acidic, sandy soils that are poorly drained. Approximately 80 percent of this association is Myakka soils, 10 percent is Basinger soils, and the rest is composed of minor soils. The Myakka soils occur in flat woods and prairies, and the Basinger soils occur in sloughs and isolated depressions. Much of this soil association is used for native range, with large areas in improved pasture.

Placid-Pamlico Soil Association

This association consists of strongly acidic to mildly alkaline sandy soils, and acid muck and peat soils. The Placid soils are strongly acid, sandy soils with a thick and very dark surface layer. The Pamlico soils are 30 to 91 centimeters of strongly acid black muck. Most of these soils are very poorly drained and are typical of heavily wooded swamps and pure stands of cypress. This soil association is generally left in its natural state and provides a good habitat for wildlife.

Pompano-Basinger Soil Association

Pompano soils are poorly drained, deep sandy soils that occur in sloughs and depressions. Basinger soils occur in sloughs and isolated depressions. Native vegetation on this association consists of palmetto, widely spaced cypress, gum, slash pine, and native grasses. If drained, this soil is well suited for improved pasture and can be managed for use for truck crops (USDA, 1971).

Manatee-Delray Soil Association

This association consists of slightly acid to neutral, very poorly drained sandy and organic soils. The Manatee soils are thick, black loamy fine sand. Delray soils have dark loamy fine sand surface with a gray sandy subsurface layer. This association is common in the bottom lands in the flood plains of the Kissimmee River and Taylor Creek and lowlands adjacent to Lake Okeechobee. Native vegetation on this association consists of black willow, saw grass, and other wetland grasses. Most of this soil association near Lake Okeechobee has been drained and used for improved pasture. These soils can be drained and successfully utilized for truck crop, but not for citrus.

These four soil associations are displayed in terms of acres and percent area for each tributary basin. See Table 8 for a summary of the soil coverage results by basin.

Table 8. Soil Type Distribution by Basin

	SOIL TYPE (percent)				SOIL TYPE (thousands of hectares)			
Basin	Myakka-Basinger	Placid-Pamlico	Manatee-Delray	Pompano-Basinger	Myakka-Basinger	Placid-Pamlico	Manatee-Delray	Pompano-Basinger
C-40	0.5	57.7	0.0	26.3	0.1	10.3	0.0	4.7
C-41	21.7	20.8	0.0	8.7	8.3	8.0	0.0	3.3
C-41A	43.3	21.2	0.0	20.0	10.3	5.0	0.0	4.7
FEC	43.8	20.9	9.4	17.4	50.0	23.9	10.8	19.9
L-48	9.4	1.2	10.8	11.1	0.8	0.1	0.9	0.9
L-49	0.0	25.3	3.1	12.0	0.0	1.2	0.2	0.6
L-59E	62.6	10.0	19.2	8.2	3.6	0.6	1.1	0.5
L-59W	35.7	1.0	0.0	60.5	0.9	0.0	0.0	1.6
L-60E	0.0	0.0	0.0	100.0	0.0	0.0	0.0	2.0
L-60W	0.0	50.5	0.0	49.5	0.0	0.7	0.0	0.7
L-61E	58.4	40.3	0.0	1.3	3.4	2.3	0.0	0.1
L-61W	31.0	31.2	2.8	19.0	1.7	1.7	0.2	1.0
LAKE_IST	59.4	0.0	0.0	0.0	11.6	0.0	0.0	0.0
NIC	44.0	0.0	0.2	55.7	4.3	0.0	0.0	5.5
S-131	0.0	72.0	0.2	27.8	0.0	2.1	0.0	0.8
S-133	42.1	38.6	3.5	0.0	4.4	4.0	0.4	0.0
S-135	1.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0
S-154	91.0	0.0	5.8	0.0	11.6	0.0	0.7	0.0
S-154C	82.1	0.8	17.1	0.0	0.7	0.0	0.2	0.0
S-65A	45.3	2.6	10.6	0.0	19.0	1.1	4.4	0.0
S-65B	45.5	4.8	11.9	13.8	23.7	2.5	6.2	7.2
S-65C	71.5	0.0	22.2	5.9	14.6	0.0	4.5	1.2
S-65D	81.9	3.2	7.0	1.7	38.7	0.0	0.0	0.0
S-65E	63.9	0.0	19.0	13.5	7.5	0.0	8.9	6.4
S-191	69.4	2.1	5.1	3.0	33.8	0.0	0.0	0.0
Total	48.3	12.3	7.5	11.8	249.2	63.5	38.5	61.1

5.3 Hydrography

5.3.1 Waterways

For the purpose of this update, it was assumed that canal and stream lengths have not changed since the original study. The canal and stream lengths were taken from the previous study. Basins C-40, C-41, S-154, and Nicodemus Slough were included as parts of larger basins in the original study. The lengths of streams and canals for each of these basins, therefore, were estimated according to the area-prorated amount of the larger, original basin. For example, the L-59W Basin accounts for approximately 12% of the original C-40 Basin which has 9.5 km of streams. Therefore, the length of streams in the L-59W was estimated at 12% of the 9.5 km, or 1.10 km (see Table 9).

Table 9. Prorated Lengths of Streams and Canals based on Area

	Streams (km)	Canals (km)	Area (ha)
C-40 basin (original study)			
C-40	7.5	377.5	17,795.9
L-59W	1.1	55.3	2,606.5
L-60E	0.9	43.2	2,038.2
Basin Total:	9.5	476.0	22,440.6
C-41 Basin (original study)			
C-41	15.2	482.7	38,408.7
L-60W	0.5	16.6	1,323.3
L-61E	2.3	72.7	5,782.6
Basin Total:	18.0	572.0	45,514.6
NIC Basin (original study)			
NICODEMUS_SLOUGH	1.3	72.6	9,858.0
L-61W	0.8	40.4	5,488.7
Basin Total:	2.1	113.0	15,346.6
S-154 Basin (original study)			
S-154	50.5	73.0	12,794.5
S-154C	3.5	5.0	882.5
Basin Total:	54.0	78.0	13,677.0

5.3.2 Load in Rain and Runoff

Phosphorus load and concentration in rainfall were obtained from the 1999 Lake Okeechobee Action Plan (USEPA, 1999). According to the Action Plan, the average annual rainfall phosphorus loading to the lake is 64.5 tons and concentration is 0.028 ppm. The average annual rainfall for the Lake Okeechobee watershed is 127 cm (Zhang et al., 2002). Based on this data, the average phosphorus import from rainfall is 0.36 kg P/ha-yr.

The SCS curve number method was utilized to estimate the runoff volumes based on the updated rainfall and the impervious percentages estimated in the original study. A long-term average annual runoff volume of 34.2 cm was used for pervious areas including agriculture and forests, and 63.9 cm was used for areas estimated at approximately 30% impervious including residential. Wetlands and water bodies were considered to have a runoff volume of zero as per the assumptions previously used in LOADSS (Lake Okeechobee Agricultural Decision Support System). LOADS is a GIS-based modeling tool used for assessing water quality within the Lake Okeechobee watershed.

Zero is a reasonable wetland net phosphorus import coefficient (Bottcher, 2002). There are no anthropogenic net phosphorus imports due to the wetlands land use. Wetlands refer to canals, streams, preserve areas, and other surface water conveyance systems. Phosphorus imports due to rainfall and land use runoff are accounted for in the study's phosphorus budget. The assumption of zero discharge from wetland itself was used after receiving previous comments and further discussions with the District. A portion of wetlands may contribute runoff, but a majority of wetlands are isolated as suggested by the District.

In order to be consistent with the original study and for comparison sake, the assumption of zero discharge from wetlands itself was used strictly for the sake of determining a value for phosphorus in uplands runoff. The value for uplands phosphorus runoff is needed to determine wetlands assimilation, which is an index utilized in this and the original study. Wetlands assimilation is the fraction of uplands phosphorus runoff that is not loaded to the lake. The wetlands runoff is accounted for as per the mass balance equations in Section 5.1. The distinction between uplands runoff and lake loading should be clear when reviewing the mass balance equations. Flow out of wetlands is considered as lake loading and not uplands runoff. Wetlands runoff is not a function of area, but of loadings to the wetland, i.e. the land use types surrounding the wetland. Therefore, wetlands assimilation factors are more descriptive of the physical system than an "average" wetlands areal runoff value.

All phosphorus flows into and out of the wetlands have been accounted for in the phosphorus budget. Phosphorus flows into wetlands are equal to uplands runoff. Wetlands runoff is equal to lake loading. Review of the mass balance equations identify the relation of wetlands phosphorus flows in and out in relation to other variables in the phosphorus budget.

The Event Mean Concentrations (EMC) represent the average total phosphorus concentration (mg/L) of runoff for a specific land use. EMC values and runoff estimates were used to calculate the amount of phosphorus in runoff by land use. The EMC values were taken from the original study unless otherwise noted and applied to the current runoff values and current areas for each land use. The EMC value for dairy was based on the average value of phosphorus concentration values for the period of 1991 to 1999 (Ray and Zhang, 2001). A large reduction in the phosphorus concentrations was observed during this period. The original study utilized an EMC value of 6.8 mg/L. Based on measured concentrations, an EMC value of 2.19 mg/L is more representative of phosphorus discharge from high intensity dairy areas in recent years. Review of the existing dairy coverages indicated that 50% of dairy area is outer pasture, and 50% is dairy intensive land use. The EMC value used for the dairy land use as a whole was calculated to be 1.32 mg/L, which is 50% of the 2.19 mg/L and 50% of the improved pasture value of 0.45 mg/L. This represents an 82% decrease in the dairy EMC value.

The EMC value for truck crops decreased substantially from the original study, from 6 mg/L to 0.55 mg/L (SFWMD Works of the District, 2002). Improved pasture showed a small reduction in EMC value from 0.5 mg/L to 0.45 mg/L (Gornak and Zhang, 1999) while the citrus EMC increased from 0.2 mg/L to 0.52 mg/L (SFWMD Works of the District, 2002). The improved pasture EMC value was reported as the seven-year average total phosphorus concentration from the SFWMD Works of the District samples.

See Table 10 for a summary of the runoff loading broken down by each land use. The EMC value for barren land was assumed to be the same as unimproved pasture, other urban assumed as urban residential, water bodies assumed as wetlands, mobile home assumed as rural residential, and all the residential land types were assumed as urban residential. The distinction between rural residential and urban residential is reflected in the EMC values of each land use as defined in the previous study. Land uses such as waste treatment, aquaculture, poultry, did not have a determined EMC value. The EMC values for these land uses were assumed to be the same concentration of rainfall phosphorus, at 0.028 mg/L since phosphorus containing materials were assumed to be contained on site or non-existent.

Table 10. Event Mean Concentrations

Land Use	EMC(mg/L)
RANGELAND	0.04
IMPROVED PASTURE (1)	0.45
WETLANDS	0.04
FORESTED UPLANDS	0.16
DAIRY (2)	1.32
BARREN LAND	0.10
FIELD CROPS	0.55
OTHER URBAN	0.39
UNIMPROVED PASTURE	0.10
TRUCK CROPS (3)	0.55
CITRUS (3)	0.52
WATER BODIES	0.04
GOLF COURSE	0.21
SOD FARM	0.21
ORNAMENTALS	0.41
COMMERCIAL FORESTRY	0.16
WASTE TREATMENT / DISPOSAL	0.03
SUGARCANE	0.10
AQUACULTURE	0.03
POULTRY	0.03
ABANDONED DAIRY	1.32
RESIDENTIAL - MOBILE HOME UNITS	0.16
RESIDENTIAL - LOW DENSITY	0.39
RESIDENTIAL - MEDIUM DENSITY	0.39
RESIDENTIAL - HIGH DENSITY	0.39

Source: 1. Gornak and Zhang, 1999; 2. Ray and Zhang, 2001;
3. SFWMD Works of the District/SWIM Plan, 2002.

The phosphorus runoff load was determined based on the area, runoff, and EMC value for each specific land use. For example, the land use of forested uplands has a much smaller runoff phosphorus concentration than many of the other land uses in the watershed. However, forested uplands accounts for almost ten percent of the overall watershed area and, as a result, is one of the top five land uses in terms of amount of annual phosphorus runoff. Forested upland runoff phosphorus load changed very little from the original study because it’s area, runoff, and EMC value did not change much since.

5.3.3 Load to Lake Okeechobee

Updated loads to the lake and flow weighted total phosphorus loading rate by basin were taken from data in the 2002 SWIM Plan (SFWMD, 2002), and from 2001 values obtained from SFWMD. The 2002 SWIM Plan reported average values for each basin in english tons of phosphorus per year. A five-year average was calculated for 1997-2001. The original study utilized average annual phosphorus load and flow-weighted areal phosphorus loads from the 1985-89 period. A six-year lake loading average from years 1995-2000 was used for basins C-40, C-41, L-48, L-49, S-154C, and S-65A through E. The phosphorus lake loading from all other basins in the study was obtained using the five-year average from years 1997-2001.

The SWIM Plan included only one combined value for phosphorus loading for basins S-65A, B, C, D, and E. Since this update includes each of the S-65 basins separately, a separate phosphorus loading value for each basin needed to be assigned. The distribution of the phosphorus loading for the S-65 basins from the original study was utilized to determine the phosphorus lake loading proration for each S-65 sub-basin. Considering that phosphorus load distribution in the S-65 basin may have changed slightly since the previous study, the assumption of prorating by area may not be completely accurate. However, this assumption is reasonable for the purposes of this study. This phosphorus loading ratio was applied to the current total basin loading to attain an estimated revised value for each S-65 basin.

The loads reported from Lake Istokpoga were prorated to account for the fact that there are additional areas draining through the Lake that are not in the study area. Based on USGS basin information, only 12.4 percent of the actual watershed is within the study area.

5.4 On-site Phosphorus Storage

The onsite phosphorus storage was calculated as the sum of net phosphorus imports ($I_{imports}$) and rainfall phosphorus loading (I_{precip}) minus phosphorus runoff (R_L). This value relates to the phosphorus accumulated in the tributary basin and stored in the soils and native vegetation. Wetland phosphorus storage was estimated as the difference in runoff phosphorus and lake loading. This amount represents the phosphorus that is filtered out and removed from flows before lake loading occurs. The total basin phosphorus storage was the sum of on-site and wetland phosphorus storage. These phosphorus storage values were used for the purpose of completing the phosphorus mass balance and for comparing the current values to the previous study.

5.5 Basin Geometry

Although the previous study indicated that physical basin characteristics were found to have very low correlation ($r^2 < 0.36$) and had no considerable influences on phosphorus lake loading, various physical basin characteristics were reviewed in the current study. Area, perimeter, shape, distance to Lake Okeechobee, and other characteristics were reviewed for possible correlation to phosphorus loading to the lake. Table 11 summarizes geometrical values for each tributary basin. The geometric parameters shown in Table 11 are as previously defined in Table 7 of this report.

5.6 Phosphorus Budget Basin Results

5.6.1 Gross Phosphorus Imports

Tables 12 and 13 show the values and comparative percentages of gross phosphorus imports for each land use, broken down into major phosphorus-containing materials. The phosphorus import coefficient for each land use presented in Section 4 was applied to the GIS land use coverage and summarized per basin to assess the total import based on land use practices. The total gross phosphorus import to the northern Lake Okeechobee watershed is 2,961 t P/yr (Table 12). The four most influential land uses in regards to percentage of gross phosphorus imports, listed in order of magnitude, are improved pasture (29%), dairy (22%), truck crops (20%), and citrus (9%) (Table 13). Fertilizer import accounts for 69% of gross phosphorus imports of which 33% is for improved pasture, 30% is for truck crops, and 13% for citrus (Table 13). Approximately 31% of gross phosphorus imports are from feed imports of which dairy accounts for 63%, improved pasture accounts for 20%, and all residential accounts for approximately 15% (Table 13). Dairies account for practically 100% of the phosphorus in cleaners, this material is a relatively negligible in terms of gross phosphorus import.

Table 11. Basin Geometry

	PERIM	AREA	SHAPE	DEVAC	INTS	WETLANDS	WETPER	STREAM1	STREAM2	LENGTH OF	WATER1	WATER2	LDIST
Basin	km	ha	m/ha	ha		ha	%	km	m/ha	Canals,km	km	m/ha	km
C-40	72.0	17,796	4.0	12,713.0	0.7	2236	12.6%	7.53	0.42	377.48	385.01	0.02	14
C-41	112.8	38,409	2.9	24,535.2	0.6	3978	10.4%	15.19	0.40	482.70	497.89	0.01	25
C-41A	92.3	23,673	3.9	12,506.2	0.5	3852	16.3%	21.00	0.89	159.00	180.00	0.01	30
FEC	199.3	114,230	1.7	38,327.0	0.3	27781	24.3%	288.00	2.52	467.00	755.00	0.01	31
L-48	41.6	8,407	5.0	6,533.6	0.8	1032	12.3%	16.00	1.90	238.00	254.00	0.03	3
L-49	32.3	4,896	6.6	2,797.2	0.6	413	8.4%	0.00	0.00	110.00	110.00	0.02	3
L-59E	45.0	5,828	7.7	3,436.7	0.6	877	15.1%	14.00	2.40	177.00	191.00	0.03	10
L-59W	26.2	2,607	10.1	1,345.3	0.5	108	4.1%	1.10	0.42	55.29	56.39	0.02	8
L-60E	20.9	2,038	10.3	607.7	0.3	146	7.2%	0.86	0.42	43.23	44.10	0.02	8
L-60W	16.0	1,323	12.1	542.1	0.4	40	3.0%	0.52	0.40	16.63	17.15	0.01	7
L-61E	33.2	5,783	5.7	2,325.8	0.4	872	15.1%	2.29	0.40	72.67	74.96	0.01	12
L-61W	35.7	5,489	6.5	1,480.3	0.3	1446	26.4%	0.75	0.14	40.41	41.17	0.01	8
LAKE_IST	63.9	19,560	3.3	4,958.2	0.3	2376	12.1%	4.00	0.20	42.00	46.00	0.00	48
NIC	44.9	9,858	4.6	5,772.3	0.6	1628	16.5%	1.35	0.14	72.59	73.93	0.01	6
S-131	24.5	2,898	8.4	2,257.6	0.8	225	7.8%	0.00	0.00	30.00	30.00	0.01	2
S-133	54.5	10,386	5.2	6,968.5	0.7	605	5.8%	32.00	3.08	154.00	186.00	0.02	4
S-135	62.1	7,319	8.5	5,585.1	0.8	345	4.7%	27.00	3.69	156.00	183.00	0.03	1
S-154	62.4	12,794	4.9	9,469.2	0.7	1774	13.9%	50.52	3.95	72.97	123.48	0.01	19
S-154C	13.9	882	15.7	688.2	0.8	70	7.9%	3.48	3.95	5.03	8.52	0.01	13
S-65A	111.1	41,825	2.7	14,062.3	0.3	9225	22.1%	133.00	3.18	160.00	293.00	0.01	15
S-65B	121.0	51,932	2.3	10,866.7	0.2	15166	29.2%	191.00	3.68	160.00	351.00	0.01	76
S-65C	69.5	20,409	3.4	12,069.9	0.6	4558	22.3%	116.00	5.68	67.00	183.00	0.01	56
S-65D	119.8	47,187	2.5	29,484.4	0.6	10943	23.2%	145.00	3.07	335.00	480.00	0.01	46
S-65E	59.5	11,800	5.0	8,293.5	0.7	1129	9.6%	71.00	6.02	49.00	120.00	0.01	38
S-191	135.4	48,671	2.8	34,877.5	0.7	4597	9.4%	208.00	4.27	361.00	569.00	0.01	21

Table 12. Phosphorus Imports per Land Use (Metric tons used)

LANDUSE	Fert_imp	Feed_imp	Clnrs_imp	Total_imp	Harv_exp	Livew_exp	Hay_exp	Sod_exp	Milk_exp	Septic_exp	Total_exp	Net_imp
RANGELAND	0.0	7.8	0.0	7.8	0.0	7.3	0.0	0.0	0.0	0.0	7.3	0.5
IMPROVED PASTURE	677.6	181.2	0.0	858.8	0.0	257.4	14.4	28.8	0.0	0.0	300.7	558.106
WETLANDS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FORESTED UPLANDS	0.0	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	7.8	-7.8
DAIRY	49.7	588.4	1.0	639.1	0.0	5.4	0.0	0.0	175.8	0.0	181.2	457.9
BARREN LAND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FIELD CROP	89.8	0.0	0.0	89.8	74.1	0.0	0.0	0.0	0.0	0.0	74.1	15.7
OTHER URBAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIMPROVED PASTURE	0.0	5.6	0.0	5.6	0.0	5.2	0.0	0.0	0.0	0.0	5.2	0.4
TRUCK CROPS	599.3	0.0	0.0	599.3	54.3	0.0	0.0	0.0	0.0	0.0	54.3	545.0
CITRUS	262.9	0.0	0.0	262.9	79.4	0.0	0.0	0.0	0.0	0.0	79.4	183.5
WATER BODIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GOLF COURSE	3.9	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
SOD FARM	90.8	0.0	0.0	90.8	0.0	0.0	0.0	326.3	0.0	0.0	326.3	-235.5
ORNAMENTALS	85.5	0.0	0.0	85.5	55.1	0.0	0.0	0.0	0.0	0.0	55.1	30.4
COMMERCIAL FORESTRY	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.1	-2.1
WASTE TREATMENT / DISPOSAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUGARCANE	155.4	0.0	0.0	155.4	146.8	0.0	0.0	0.0	0.0	0.0	146.8	8.6
AQUACULTURE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POULTRY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ABANDONED DAIRY	8.6	2.3	0.0	11.0	0.0	3.3	0.2	0.4	0.0	0.0	3.8	7.1
RESIDENTIAL - MOBILE HOME UNITS	0.0	32.8	0.0	32.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.8
RESIDENTIAL - LOW DENSITY	4.9	41.6	0.0	46.5	0.0	0.0	0.0	0.0	0.0	0.2	0.2	46.3
RESIDENTIAL - MEDIUM DENSITY	2.6	49.2	0.0	51.9	0.0	0.0	0.0	0.0	0.0	0.3	0.3	51.6
RESIDENTIAL - HIGH DENSITY	0.4	19.9	0.0	20.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	20.2
TOTAL:	**2031.5**	**928.9**	**1.0**	**2961.4**	**419.5**	**278.7**	**14.6**	**355.5**	**175.8**	**0.6**	**1244.7**	**1716.7**

Table 13. Phosphorus Imports per Land Use (% of Category)

LANDUSE	Fert_imp	Feed_imp	Clnrs_imp	Total_imp	Harv_exp	Livew_exp	Hay_exp	Sod_exp	Milk_exp	Septic_exp	Total_exp	Net_imp
RANGELAND	0.0	0.8	0.0	0.3	0.0	2.6	0.0	0.0	0.0	0.0	0.6	0.0
IMPROVED PASTURE	33.4	19.5	0.0	29.0	0.0	92.4	98.7	8.1	0.0	0.0	24.2	32.5
WETLANDS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FORESTED UPLANDS	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.6	-0.5
DAIRY	2.4	63.3	100.0	21.6	0.0	2.0	0.0	0.0	100.0	0.0	14.6	26.7
BARREN LAND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FIELD CROP	4.4	0.0	0.0	3.0	17.7	0.0	0.0	0.0	0.0	0.0	6.0	0.9
OTHER URBAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UNIMPROVED PASTURE	0.0	0.6	0.0	0.2	0.0	1.9	0.0	0.0	0.0	0.0	0.4	0.0
TRUCK CROPS	29.5	0.0	0.0	20.2	12.9	0.0	0.0	0.0	0.0	0.0	4.4	31.7
CITRUS	12.9	0.0	0.0	8.9	18.9	0.0	0.0	0.0	0.0	0.0	6.4	10.7
WATER BODIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GOLF COURSE	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
SOD FARM	4.5	0.0	0.0	3.1	0.0	0.0	0.0	91.8	0.0	0.0	26.2	-13.7
ORNAMENTALS	4.2	0.0	0.0	2.9	13.1	0.0	0.0	0.0	0.0	0.0	4.4	1.8
COMMERCIAL FORESTRY	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.2	-0.1
WASTE TREATMENT / DISPOSAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUGARCANE	7.7	0.0	0.0	5.2	35.0	0.0	0.0	0.0	0.0	0.0	11.8	0.5
AQUACULTURE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POULTRY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ABANDONED DAIRY	0.4	0.2	0.0	0.4	0.0	1.2	1.3	0.1	0.0	0.0	0.3	0.4
RESIDENTIAL - MOBILE HOME UNITS	0.0	3.5	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
RESIDENTIAL - LOW DENSITY	0.2	4.5	0.0	1.6	0.0	0.0	0.0	0.0	0.0	40.1	0.0	2.7
RESIDENTIAL - MEDIUM DENSITY	0.1	5.3	0.0	1.8	0.0	0.0	0.0	0.0	0.0	50.1	0.0	3.0
RESIDENTIAL - HIGH DENSITY	0.0	2.1	0.0	0.7	0.0	0.0	0.0	0.0	0.0	9.9	0.0	1.2
TOTAL:	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Percent of import/export	69%	31%	0%	100%	34%	22%	1%	29%	14%	0%	100%	

5.6.2 Gross Phosphorus Exports

The total gross phosphorus exported from the northern Lake Okeechobee watershed is 1,244 t P/yr (Table 12). The four most influential land uses in regards to percentage of gross phosphorus exports are sod (26%), improved pasture (24%), dairy (15%), and sugarcane (12%) (Table 13). Harvest exports from sugarcane, citrus, field crop, ornamentals, truck crops, and forests account for approximately 34% of gross phosphorus exports from the northern Lake Okeechobee watershed (Table 13). Sod exports, live weight sales, and milk exports account for 29%, 22%, and 14% of gross phosphorus exports, respectively. Hay exports account for 1% and septic tank hauling accounts for less than one-tenth of one percent of gross phosphorus exports (Table 12).

5.6.3 Net Phosphorus Imports by Land Use

The overall net import to the watershed based on land application is 1,717 t P/yr (Table 12). The land uses with the most influence within the northern Lake Okeechobee watershed in terms of net phosphorus import are improved pasture (33%), truck crop (32%), and dairy (27%) (Table 13). Other influential land uses in terms of percent of net watershed phosphorus import (positive or negative) sod farm (-14%) and citrus (11%) (Table 13).

5.6.4 Net Phosphorus Imports Per Basin

The C-40 Basin is a net phosphorus exporter (24 t P/yr) because of the amount of sod grown and harvested in that basin (Table 14). Basin S-65D contributes the highest net phosphorus import of any tributary basin with 418 t per year. A dominant land use was assigned to each tributary basin based on the land use that contributed the largest value of net phosphorus imports to that basin. For example, truck crop is the dominant land use in terms of net phosphorus import to basin S-65D. The next highest phosphorus imports per basin of decreasing order are S-191 (dairy dominant), S-65E (truck crop dominant), Fisheating Creek (improved pasture dominant), and S-154 (dairy dominant). These five basins account for 76% of the total net phosphorus imports to the northern Lake Okeechobee watershed.

Appendix D includes a full set of basin tables with a breakdown of the phosphorus import and export components. Maps are also included in Appendix D for each basin illustrating the spatial distribution of the land application results side-by-side with land use for comparative purposes.

5.6.5 Phosphorus Loads to Lake Okeechobee (Obtained from 2002 SWIM Plan)

In terms of phosphorus loading and percent of total lake loading, three basins account for over 50% of lake loading: basin S-191 (74 t P/yr or 22%), Fisheating Creek (64 t P/yr or 19%), and S-65D (38 t P/yr or 11%). The S-154, C-41, and S-65E Basins account for 10%, 7%, and 7% of total lake loadings, respectively. The basins with the least percentage contribution to lake loading are L-60W (0.02%), Nicodemus Slough (0.08%), S-153C (0.08%), and L-60E (0.10%). Other basins contributed from 0.4% to 6% of the total lake loading.

5.6.6 Phosphorus in Runoff

The total amount of phosphorus in runoff is 488 t P/yr (Table 15). The three primary land use contributors to phosphorus runoff in terms of metric tons of phosphorus or percent of total phosphorus runoff were improved pasture (283 t P/yr or 58%), citrus (45 t P/yr or 9%), and dairy (39 t P/yr or 8 %).

Table 14. Summary of Basin Net Phosphorus Import in Decreasing Order (Metric tons used)

BASIN	Annual Net Import (t/yr)	Basin % of Total	Dominant Net Importer
S_65D	418.1	24.4%	Truck Crops
TAYLOR_CREEK	379.4	22.1%	Dairy
S_65E	231.0	13.5%	Truck Crops
FISHEATING_CREEK	150.3	8.8%	Improved Pasture
S_154	119.2	6.9%	Dairy
S_65A	91.4	5.3%	Truck Crops
S_65C	48.9	2.8%	Improved Pasture
S_133	46.9	2.7%	Residential - Medium Density
C_41	44.8	2.6%	Citrus
LAKE_ISTOK	34.4	2.0%	Improved Pasture
S_65B	34.2	2.0%	Improved Pasture
L_48	29.1	1.7%	Improved Pasture
C_41A	27.3	1.6%	Citrus
S_135	17.8	1.0%	Improved Pasture
NICODEMUS_SLOUGH	13.4	0.8%	Improved Pasture
L_49	12.4	0.7%	Improved Pasture
L_59E	10.7	0.6%	Improved Pasture
S_131	9.0	0.5%	Improved Pasture
L_61E	7.2	0.4%	Improved Pasture
L_61W	5.1	0.3%	Improved Pasture
L_59W	4.0	0.2%	Improved Pasture
S_154C	2.1	0.1%	Improved Pasture
L_60E	1.9	0.1%	Improved Pasture
L_60W	1.6	0.1%	Improved Pasture
C_40	-23.5	-1.4%	Sod Farm
Total	1716.7		Improved Pasture

Table 15. Phosphorus in Runoff per Land Use (Metric tons used)

	Area	Runoff	EMC	Runoff load		
Land Use	**ha**	**cm**	**mg/l**	**kg/ha/yr**	**t P/yr**	**% of Total**
RANGELAND	46,641	34.2	0.04	0.14	6.38	1.3
IMPROVED PASTURE	183,778	34.2	0.45	1.54	282.71	57.9
WETLANDS	95,423	0.0	0.04	0.00	0.00	0.0
FORESTED UPLANDS	49,887	34.2	0.16	0.55	27.29	5.6
DAIRY	8,525	34.2	1.32	4.51	38.47	7.9
BARREN LAND	4,611	34.2	0.10	0.34	1.58	0.3
FIELD CROPS	2,276	34.2	0.55	1.88	4.28	0.9
OTHER URBAN	5,274	63.9	0.39	2.49	13.14	2.7
UNIMPROVED PASTURE	33,453	34.2	0.10	0.34	11.44	2.3
TRUCK CROPS	2,868	34.2	0.55	1.88	5.39	1.1
CITRUS	25,392	34.2	0.52	1.78	45.14	9.2
WATER BODIES	14,910	0.0	0.04	0.00	0.00	0.0
GOLF COURSE	377	34.2	0.21	0.72	0.27	0.1
SOD FARM	4,816	34.2	0.21	0.72	3.46	0.7
ORNAMENTALS	3,212	34.2	0.41	1.40	4.50	0.9
COMMERCIAL FORESTRY	13,299	34.2	0.16	0.55	7.27	1.5
WASTE TREATMENT / DISPOSAL	64	63.9	0.03	0.19	0.01	0.0
SUGARCANE	8,755	34.2	0.10	0.34	2.99	0.6
AQUACULTURE	336	34.2	0.03	0.10	0.03	0.0
POULTRY	20	34.2	0.03	0.10	0.00	0.0
ABANDONED DAIRY	2,344	34.2	1.32	4.51	10.58	2.2
RESIDENTIAL - MOBILE HOME UNITS	794	63.9	0.16	1.02	0.81	0.2
RESIDENTIAL - LOW DENSITY	6,672	63.9	0.39	2.49	16.62	3.4
RESIDENTIAL - MEDIUM DENSITY	1,923	63.9	0.39	2.49	4.79	1.0
RESIDENTIAL - HIGH DENSITY	352	63.9	0.39	2.49	0.88	0.2
Total	516,000				488	100

5.7 Summary of Phosphorus Budget Basin Results

5.7.1 Anthropogenic Versus Natural Phosphorus Import

The total phosphorus budget represents the results of the land application and the hydrologic components such as rainfall phosphorus and runoff phosphorus. Values reported on the phosphorus budget are in metric tons unless otherwise noted. The overall annual phosphorus budget indicates that of the total net phosphorus imports to the watershed (1,901 t P/yr), 90% is associated with anthropogenic land use activities (1,717 t P/yr) and 10% of phosphorus input results from rainfall (184 t P/yr) (Table 16). The phosphorus import comparisons in this report are given in terms of net an-hropogenic phosphorus imports. Figure 2 illustrates the phosphorus budget schema-ically. Approximately 74% of the total net phosphorus import is stored on site in upland soils and vegetation (1,413 t P/yr) while 26% is discharged in runoff (488 t P/yr). The most influential tributary basins with regard to phosphorus runoff loading are Fisheating Creek (80 t P/yr or 16%), S-191 (79 t P/yr or 16%), S-65D (54 t P/yr or 11%), and C-41 (43 t P/yr or 9%). See Table 16 for phosphorus budget results by basin. See Table 7 for variable definitions and Section 5.1 for variable relationships.

Table 16. Summary of Phosphorus Budget Results per Basin

Basin	Net P_I I_{import}	Rainfall P I_{precip}	Runoff P R_L	Onsite P_S ΔS_O	P to Lake O_L	Wetland P_S ΔS_a	Total P Basin ΔS_b	P to Lake % total
C_40	(23.5)	6.36	17.0	(34)	8.5	8.4	(26)	2.6
C_41	44.8	13.72	43.3	15	24.4	19.0	34	7.3
C_41A	27.3	8.46	22.2	14	19.1	3.1	17	5.8
FISHEATING	150.3	40.80	80.4	111	64.1	16.3	127	19.3
L_48	29.1	3.00	10.3	22	7.5	2.8	25	2.3
L_49	12.4	1.75	4.9	9	1.6	3.2	12	0.5
L_59E	10.7	2.08	6.5	6	1.4	5.1	11	0.4
L_59W	4.0	0.93	2.5	2	2.4	0.1	3	0.7
L_60E	1.9	0.73	1.5	1	0.3	1.2	2	0.1
L_60W	1.6	0.47	1.1	1	0.1	1.1	2	0.0
L_61E	7.2	2.07	4.6	5	1.4	3.2	8	0.4
L_61W	5.1	1.96	3.3	4	1.3	2.0	6	0.4
LAKE_ISTOK	34.4	6.99	11.0	30	3.2	7.8	38	1.0
NICODEMUS_	13.4	3.52	7.8	9	0.3	7.5	17	0.1
S_131	9.0	1.04	2.9	7	1.2	1.7	9	0.4
S_133	46.9	3.71	15.4	35	4.3	11.0	46	1.3
S_135	17.8	2.61	6.7	14	2.4	4.3	18	0.7
S_154	119.2	4.57	21.1	103	31.8	(10.7)	92	9.6
S_154C	2.1	0.32	1.1	1	0.3	0.8	2	0.1
S_65A	91.4	14.94	29.1	77	5.5	23.5	101	1.7
S_65B	34.2	18.55	24.1	29	5.5	18.5	47	1.7
S_65C	48.9	7.29	20.6	36	10.0	10.6	46	3.0
S_65D	418.1	16.85	53.5	381	37.7	15.8	397	11.3
S_65E	231.0	4.21	18.1	217	24.1	(6.0)	211	7.2
S-191	379.4	17.38	78.9	318	73.8	5.1	323	22.2
TOTAL	**1,717**	**184**	**488**	**1,413**	**332**	**156**	**1,569**	**100**

Figure 2 illustrates the phosphorus budget schematically. Approximately 74% of the total net phosphorus import is stored on site in upland soils and vegetation (1,413 t P/yr) while 26% is lost in runoff (488 t P/yr).

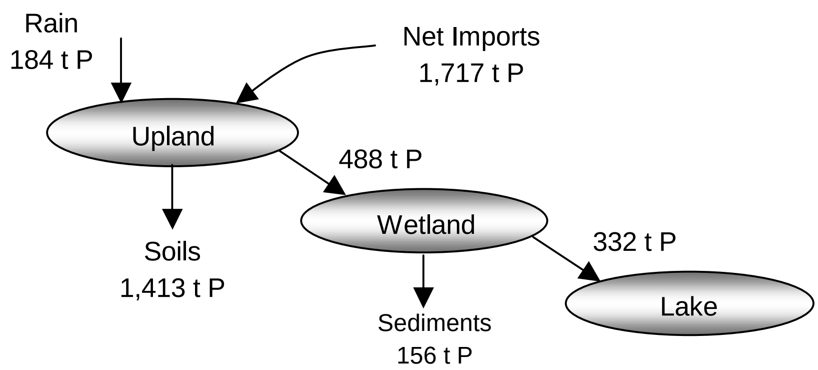

Figure 2. Average Annual Phosphorus Budget.

Approximately 32% of that runoff phosphorus is stored in wetlands (156 t P/yr) while approximately 68% is loaded to Lake Okeechobee (332 t P/yr). Overall, 8% of the total phosphorus imports to the northern Lake Okeechobee watershed end up being stored in wetlands and 17% is loaded to the lake.

5.8 Basin Result Comparison

Comparison tables have been created to assess the changes in net phosphorus import by amount and percent for each basin and land use. Table 17 shows how the current basin net phosphorus imports have changed from the previous study. Basins that have the largest decrease in net phosphorus import in terms of percent reduction are C-40 (-101 t P/yr or-121 %), L-59E (-43 t P/yr or –80%), S-135 (-46 t P/yr or -72%), and C-41 (-133 t P/yr or -71%). Basins that have the largest decrease in net phosphorus import in terms of amount of reduction are S-191 (-403 t P/yr or -51%), C-41 (-133 t P/yr or -71%), Fisheating Creek (-116 t P/yr or -44%), and C-40 (-101 t P/yr or –121%). Reduction in basin net phosphorus imports result from a decrease in the phosphorus intensive land uses such as dairy and truck crop, a decrease in dairy and other land use aerial net phosphorus import coefficients, and an increase in sod production area. Only four basins have an increase in net phosphorus import: S-65E (151 t P/yr or 189%), S-65D (104 t P/yr or 33%), S-65A (37 t P/yr or 69%), and S-154 (13.3 t P/yr or 12%).

Table 17. Net Phosphorus Import Changes by Basin (Metric tons used)

Basin	NET P IMPORTS (t P/yr)			
	Updated	Previous	Difference	Change
	(2001)	(1995)	Amount	%
C_40, L_59W, L_60E	-17.6	83.0	-100.6	-121.2
C_41, L_60W, L_61E	53.7	187.0	-133.3	-71.3
C_41A	27.3	63.0	-35.7	-56.7
FISHEATING CREEK	150.3	267.0	-116.7	-43.7
L_48	29.1	48.0	-18.9	-39.4
L_49	12.4	17.0	-4.6	-27.3
L_59E	10.7	54.0	-43.3	-80.1
LAKE_ISTOK	34.4	34.0	0.4	1.1
NIC, L_61W	18.5	21.0	-2.5	-11.7
S_131	9.0	15.0	-6.0	-39.9
S_133	46.9	77.0	-30.1	-39.1
S_135	17.8	64.0	-46.2	-72.2
S_154, S_154C	121.3	108.0	13.3	12.3
S_65A	91.4	54.0	37.4	69.2
S_65B	34.2	44.0	-9.8	-22.3
S_65C	48.9	67.0	-18.1	-27.0
S_65D	418.1	314.0	104.1	33.1
S_65E	231.0	80.0	151.0	188.8
S-191	379.4	782.0	-402.6	-51.5
TOTAL	**1,717**	**2,379**	**(662)**	**(28)**

Table 18 shows how the current land use phosphorus imports have changed from the previous study. Land uses with the largest amount of change in net phosphorus import amount include dairy (-712 t P or -61%), truck crops (473 t P or 657%), improved pasture (-452 t P or -45%), and sod (-166 t P or 236%). Dairy net phosphorus imports decreased due to a decrease in the number of dairy operations and changes in management practices that resulted in a lower computed phosphorus import coefficient. Truck crop net phosphorus imports changed due to a five-fold increase in truck crop area, and an increase in the phosphorus import coefficient. Improved pasture net phosphorus imports decreased due to a lower net phosphorus import coefficient, and sod farm net phosphorus import decreased due to a lower land use area and phosphorus fertilizer application.

Table 18. Net Phosphorus Import Changes by Land Use

LANDUSE	NET P IMPORTS (t P/yr)			
	Updated (2001)	Previous (1995)	Difference t P/yr	Change %
RANGELAND	0.5	0.0	0.5	UND
IMPROVED PASTURE	558.1	1010.0	-451.9	-44.7
WETLANDS	0.0	0.0	0.0	0.0
FORESTED UPLANDS	-7.8	N/A	N/A	N/A
DAIRY	457.9	1170.0	-712.1	-60.9
BARREN LAND	0.0	N/A	N/A	N/A
FIELD CROP	15.7	N/A	N/A	N/A
OTHER URBAN	0.0	N/A	N/A	N/A
UNIMPROVED PASTURE	0.4	4.0	-3.6	-90.6
TRUCK CROPS	545.0	72.0	473.0	657.0
CITRUS	183.5	130.0	53.5	41.2
WATER BODIES	0.0	0.0	0.0	0.0
GOLF COURSE	3.9	3.0	0.9	29.2
SOD FARM	-235.5	-70.0	-165.5	236.4
ORNAMENTALS	30.4	18.0	12.4	69.2
COMMERCIAL FORESTRY	-2.1	-8.0	5.9	-73.9
WASTE TREATMENT / DISPOSAL	0.0	N/A	N/A	N/A
SUGARCANE	8.6	3.0	5.6	187.8
AQUACULTURE	0.0	N/A	N/A	N/A
POULTRY	0.0	N/A	N/A	N/A
ABANDONED DAIRY	7.1	N/A	N/A	N/A
ALL RESIDENTIAL	150.9	48.0	102.9	214.4
TOTAL:	**1716.7**	**2380.0**	**-663.3**	**-28**

UND = Undefined; N/A = Not Applicable

6.0 BASIN CORRELATIONS

6.1 Lake Loading Regression Results

This section utilizes the metric system of units to be consistent with the Section 5.0 phosphorus budget from which the budget indices were calculated by basin. The phosphorus budget information (Table 16) developed in the previous section and basin characteristics (Table 7 and Table 11) were used to determine which basin characteristics influence lake phosphorus loading. Each basin in the study was considered as a data point for basin characteristics and annual phosphorus lake loading. Regression analysis utilized all basin data points to determine correlations. Table 19 shows values for phosphorus budget indices. These indices were compared to physical basin characteristics with linear regression analysis to find any relationships that may influence phosphorus retention and transport within the watershed.

Table 19. Phosphorus Budget Indices (Metric tons used)

Basin	Avgpload_t/yr (t P/yr)	Arealpload, PLAC (kg/ha/yr)	Flow weighted P, PLFW (ppm)	BPLI (OL/I)	OPLI (RL/I)	AF (WetlandPs/RL)
C_40	8.55	0.44	508	-0.50	-0.99	0.50
C_41	24.36	0.58	429	0.42	0.74	0.44
C_41A	19.12	0.73	149	0.53	0.62	0.14
FISHEATING	64.13	0.51	178	0.34	0.42	0.20
L_48	7.55	0.81	230	0.24	0.32	0.27
L_49	1.64	0.30	91	0.12	0.34	0.66
L_59E	1.39	0.22	238	0.11	0.51	0.79
L_59W	2.39	0.83	164	0.49	0.52	0.06
L_60E	0.32	0.14	155	0.12	0.58	0.79
L_60W	0.07	0.05	136	0.03	0.53	0.94
L_61E	1.36	0.21	147	0.15	0.49	0.70
L_61W	1.31	0.22	101	0.19	0.47	0.61
LAKE_ISTOK	3.18	0.15	59	0.08	0.27	0.71
NICODEMUS_	0.25	0.02	47	0.02	0.46	0.97
S_131	1.17	0.37	115	0.12	0.29	0.60
S_133	4.32	0.38	182	0.09	0.30	0.72
S_135	2.38	0.30	116	0.12	0.33	0.64
S_154	31.83	2.26	826	0.26	0.17	-0.51
S_154C	0.27	0.28	826	0.11	0.46	0.75
S_65A	5.55	0.12	213	0.05	0.27	0.81
S_65B	5.55	0.10	231	0.11	0.46	0.77
S_65C	9.98	0.44	231	0.18	0.37	0.52
S_65D	37.71	0.72	231	0.09	0.12	0.30
S_65E	24.07	1.85	231	0.10	0.08	-0.33
S-191	73.80	1.38	651	0.19	0.20	0.06
Total	332.25	0.58	163	0.17	0.26	0.32

A correlation was considered good if the correlation coefficient was greater or equal to 0.80 ($r^2 \geq 0.80$), fair if the correlation coefficient was less than 0.8 but greater or equal to 0.70 ($0.80 > r^2 \geq 0.70$), and marginal if the correlation coefficient was less than 0.70 but greater or equal to 0.60 ($0.70 > r^2 \geq 0.60$). A positive correlation indicates that an increase in the independent variable will correspond to an increase in the dependent variable.

The variables with the highest correlations with lake loading in order of rank include runoff phosphorus ($r^2 = 0.88$), developed land ($r^2 = 0.82$), and net phosphorus input to the basin ($r^2 = 0.80$). Other variables with fair correlations to lake phosphorus loading were on site phosphorus storage ($r^2 = 0.75$), tributary basin perimeter ($r^2 = 0.72$), and total basin phosphorus storage ($r^2 = 0.72$). Fair correlations with lake loading were found for rainfall phosphorus import ($r^2 = 0.68$), tributary basin area ($r^2 = 0.68$), area of Myakka soil type ($r^2 = 0.67$), and length of streams ($r^2 = 0.66$). A fair correlation was also determined between areal lake loading and areal net imports ($r^2 = 0.60$). This relationship was previously poor ($r^2 = 0.36$). See Table 7 for a description list of variables used in the regression analysis. Table 20 shows a ranked list of variable relationships in order of strength of correlations of each relationship.

Table 20. List of Correlations Sorted by Correlation Coefficient

Dep. Var.	Ind. Var	Relationship	R^2	Coeff	Y-int
AF	PLAC	Linear	0.90	-0.65	0.83
OL	RunoffP	Linear	0.88	0.83	-2.94
OL	RunoffP	Log	0.82	1.33	-0.75
OL	DEVAC	Linear	0.82	0.002	-3.63
OL	Net Pi	Log	0.80	1.04	-0.85
OL	DEVAC	Log	0.79	1.31	-4.32
OL	OnsitePs	Log	0.75	0.93	-0.57
OL	TotalPbasin	Log	0.72	1.01	-0.81
OL	PERIM	Log	0.72	2.23	-3.26
OL	AREA	Log	0.68	1.22	-4.31
OL	RainfallP	Log	0.68	1.22	-0.11
OL	Myakka-ac	Linear	0.67	1.21	1.26
OL	STREAM1	Log	0.66	0.75	-0.24
OL	Net Pi	Linear	0.63	0.14	3.77
OL	WATER1	Log	0.66	1.30	-2.14
OL	WATER1	Linear	0.62	0.08	-3.52
OL	PERIM	Linear	0.61	0.35	-9.76
OL	Arealpload, PLAC	Log	0.61	1.27	1.24
OL	SHAPE	Log	0.59	-2.49	2.34
PLAC, kg/ha/yr	NPAC kg P/ha	Linear	0.60	0.11	0.20
OL	WETLANDS	Log	0.57	0.82	-1.93
BPLI	OPLI	Linear	0.58	0.46	0.00
OL	STREAM1	Linear	0.58	0.19	3.09
OL	TotalPbasin	Linear	0.57	0.15	4.19
OL	OnsitePs	Linear	0.56	0.15	5.03
OL	AREA	Linear	0.56	0.00	1.17
OL	RainfallP	Linear	0.56	1.64	1.17
AF	PLAC	Log	0.57	-0.63	-0.69
OL	Canals_km	Log	0.51	1.19	-1.77
OL	Canals,km	Linear	0.44	0.09	-1.27
NPAC kg P/ha	PLAC, kg/ha/yr	Log	0.44	0.51	0.57
OL	AF	Log	0.38	-1.38	0.03
OL	low weighted P, PLF\	Log	0.43	1.79	-3.41
OL	AF	Linear	0.38	-32.26	28.90
OL	WETLANDS	Linear	0.34	0.00	6.19
OL	BPLI	Log	0.33	1.26	1.73
OL	Arealpload, PLAC	Linear	0.32	20.38	2.37
OL	WetlandPs	Log	0.31	0.82	-0.01
OL	Manatee-ac	Linear	0.31	4.25	6.91
OL	SHAPE	Linear	0.26	-2.94	30.45
OL	LDIST	Log	0.24	0.82	-0.29
OL	Placid-ac	Linear	0.25	1.92	8.22
WetlandPs	RunoffP	Linear	0.23	0.17	2.94
OL	Pompano-ac	Linear	0.23	2.31	7.88
OL	OPLI	Log	0.22	-1.57	-0.10
OL	STREAM2	Log	0.24	0.72	0.56
INTS	PLFW	Linear	0.20	0.20	0.45
OL	WETPER	Log	0.19	1.32	1.83
NPAC kg P/ha	PLFW	Log	0.17	0.17	-0.77
OL	Myakka-%	Linear	0.15	26.39	2.69
OL	low weighted P, PLF\	Linear	0.15	0.04	4.04
INTS	PLFW	Log	0.15	0.15	-0.80
OL	STREAM2	Linear	0.15	4.05	5.00
OL	LDIST	Linear	0.09	0.30	7.24
OL	WATER2	Linear	0.07	-676.16	22.71
OL	Pompano-%	Linear	0.07	-21.02	17.12
CAN1	OPLI	Linear	0.07	-113.80	194.06
OL	BPLI	Linear	0.07	26.73	9.32
NPAC kg P/ha	PLFW	Linear	0.06	0.00	1.91
OL	WETPER	Linear	0.05	57.68	5.45
OL	WATER2	Log	0.03	-0.49	-0.36
OL	Placid-%	Linear	0.04	-17.62	16.14
OL	INTS	Log	0.03	0.83	0.84
OL	WetlandPs	Linear	0.02	0.35	11.11

6.1.1 Runoff Phosphorus

One of the highest correlation determined as related to phosphorus lake loading was basin phosphorus runoff, R_L. Based on linear regression, basin runoff (R_L) accounts for 88% of the variation in lake loading (O_L) data.

$$O_L = -2.94 + 0.83 * R_L \qquad r^2 = 0.88$$

The linear relation is a slightly better fit than the log relationship. Figure 3 below shows the data and best-fit line for the relation.

$$\log(O_L) = -0.75 + 1.33 * \log(R_L) \qquad r^2 = 0.82$$

As the above equation indicates, there is a positive, logarithmic correlation between O_L and R_L.

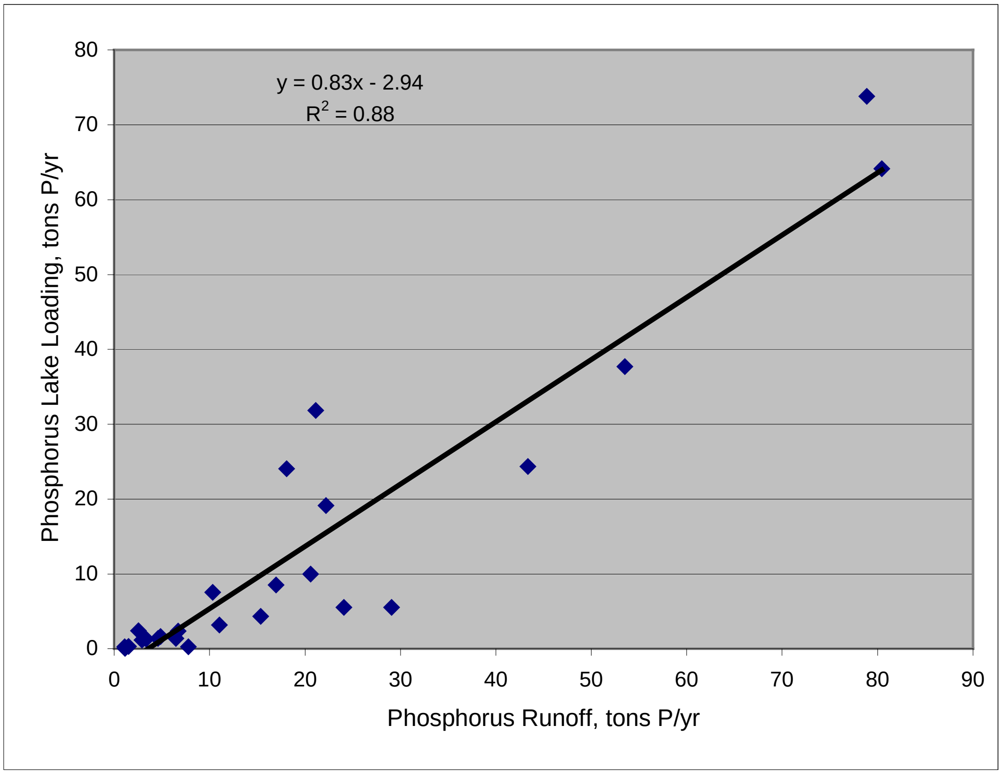

Figure 3. Phosphorus Lake Loading vs. Runoff Phosphorus

6.1.2 Developed Land

The area of developed land, DEVAC, includes the areal sum of land use types under consideration except for rangeland, wetlands, barren land, other urban, unimproved pasture, water bodies, and commercial forestry.

$$O_L = -3.63 + 0.002 * \text{DEVAC} \qquad r^2 = 0.82$$

This correlation is higher than the correlation relation previously obtained ($r^2 = 0.72$). This correlation was expected to be good since the area of developed land represents areas where phosphorus-contained materials are handled. A fairly high logarithmic relationship was also found:

$$\log(O_L) = -4.32 + 1.31 * \log(\text{DEVAC}) \qquad r^2 = 0.79$$

The DEVAC coefficient suggests that, on average, an additional hectare of developed land could correspond to approximately 0.002 of a metric ton, or 2 kg (4 lbs), of additional phosphorus lake loading per year. This correlation is not a totally accurate and complete description of system behavior but does infer a possible average order-of-magnitude relation between developed land and lake loading. The coefficient of the DEVAC term can be used to estimate the degree to which a change in developed area relates to a change in lake phosphorus loading. As suggested in the original study, the positive correlation of developed land to lake loading may represent the presence of phosphorus sources that accompany development. Figure 4 shows the data and best-fit line for the relation.

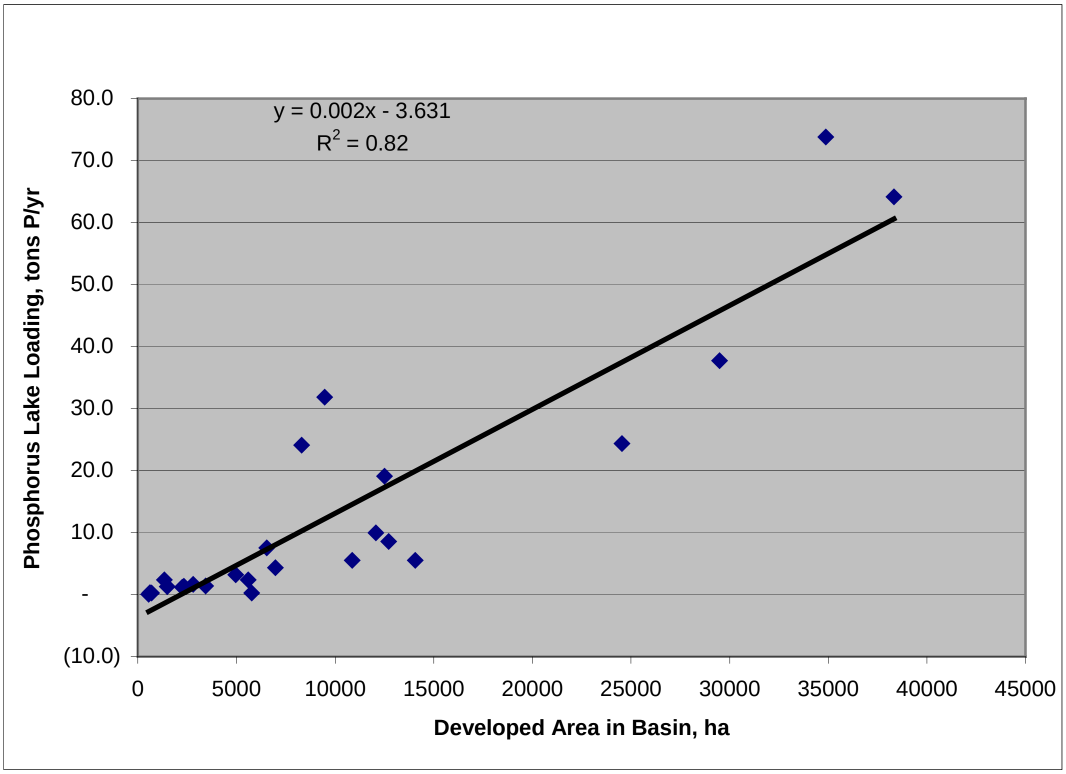

Figure 4. Lake Phosphorus Loading vs. Area of Developed Land

6.1.3 Net Phosphorus Imports

The net phosphorus imports ($I_{imports}$) account for 80% of the variation in phosphorus lake loading (O_L) data. A logarithmic relationship was found to best fit the relationship between $I_{imports}$ and lake loading. The best-fit line based on linear regression analysis is as follows:

$$\log(O_L) = -0.85 + 1.04 * \log(I_{imports}) \qquad r^2 = 0.80$$

A linear relationship was found between $I_{imports}$ and lake loading:

$$O_L = 3.77 + 0.14 * I_{imports} \qquad r^2 = 0.63$$

The correlation coefficient for the linear relationship was previously 0.70 as compared to 0.68.

Figure 5 shows the data and best fit line for the logarithmic relationship between $I_{imports}$ and lake loading. Note that the model is expressed in terms of a linear relationship between the log base ten values of lake loading and net phosphorus loading. The slope coefficient in the linear model is the coefficient value of the log base ten term of net phosphorus imports.

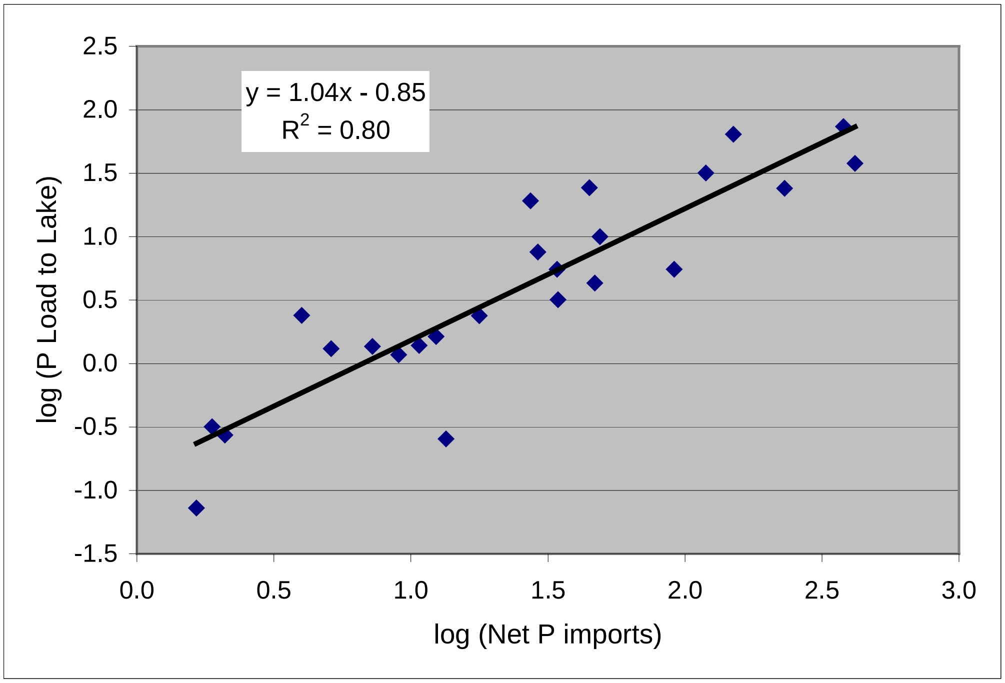

Figure 5. Phosphorus Load to Lake vs. Net Phosphorus Imports

6.1.4 Total Phosphorus Storage On Site and in the Basin

Both the total basin phosphorus storage, ΔS_b, and the on-site phosphorus storage, ΔS_o, relate to the lake phosphorus loading with good correlation.

$$\log(O_L) = -0.57 + 0.93*\log(\Delta S_o) \qquad r^2 = 0.75$$
$$\log(O_L) = -0.81 + 1.01*\log(\Delta S_b) \qquad r^2 = 0.72$$

There is a positive correlation with ΔS_b and ΔS_o with O_L. The positive coefficients for ΔS_b and ΔS_o might suggest that higher lake loading is related to higher on-site and total basin storage. The linear regression output suggests a strong trend for the entire system, including the basin on-site, wetlands, and Lake Okeechobee, to become more saturated with phosphorus as a result of increased net phosphorus import. Also, the correlation suggests that more phosphorus stored on-site and in wetlands could indicate more loading to the lake. These residual trends show why soil phosphorus testing and monitoring could be useful tools in phosphorus best management practices and in gauging lake loading. For example, when a truck crop is double cropped, phosphorus fertilizer rates should be based on soil phosphorus content. An increase in soil phosphorus suggests that an over application of phosphorus is occurring which exceeds the ability of the crop uptake on site, and that phosphorus is also being loaded to wetlands and the lake. Figure 6 shows the data and best-fit line for the logarithmic relation between on-site phosphorus storage and lake loading.

A linear relationship was found between ΔS_b and ΔS_o with O_L.

$O_L = 5.03 + 0.15 * \Delta S_o$ $\qquad r^2 = 0.56$

$O_L = 4.19 + 0.15 * \Delta S_b$ $\qquad r^2 = 0.57$

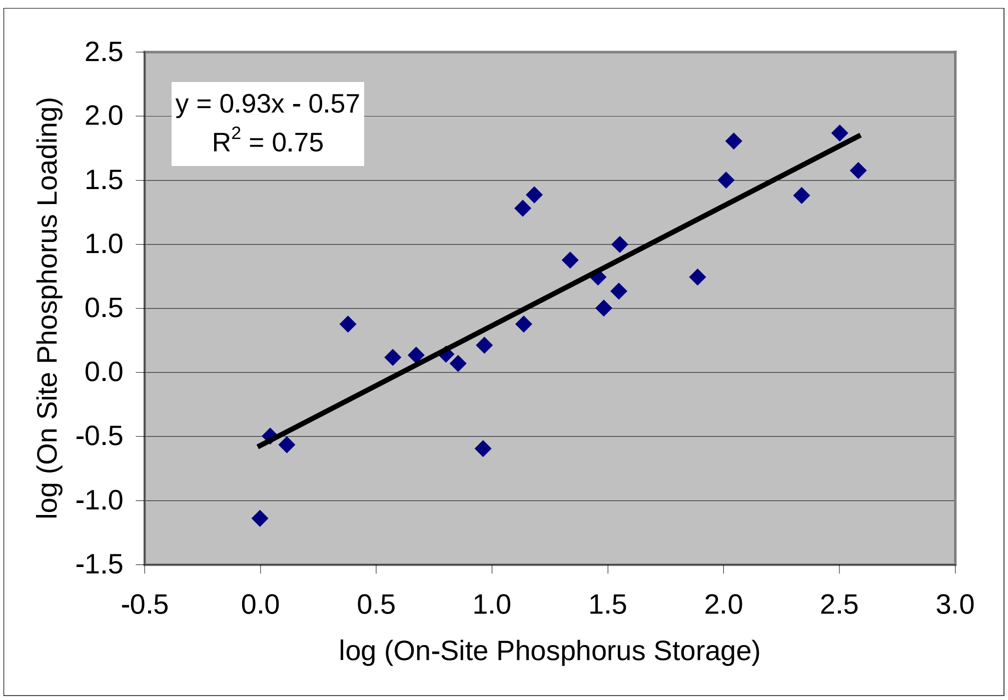

Figure 6. Phosphorus Lake Loading vs. On Site Phosphorus Storage

6.1.5 Basin Perimeter

The basin perimeter, PERIM, regression equation below accounts for 72% of the variation in phosphorus lake loading (O_L) data. The relation is as follows:

$$\log(O_L) = -3.26 + 2.23*\log(PERIM) \qquad r^2 = 0.72$$

The linear regression model for basin perimeter, PERIM, and phosphorus lake loading (O_L) is as follows:

$$O_L = -9.76 + 0.35(PERIM) \qquad r^2 = 0.61$$

The original study indicated that basin morphology was not useful in predicting phosphorus lake loading. However, this basin perimeter model indicates a correlation coefficient as high as any model in the previous study. No single linear-regressed model for lake loading in the original study had a correlation coefficient as high as this basin perimeter model. It appears that the original study's conclusions regarding basin morphology should be reconsidered.

The apparently stronger relations to lake loading and higher correlation coefficients over the previous study may have resulted from a number of factors. For example, better delineation of the watershed basins and a more accurate land use coverage may have contributed to higher correlation coefficients. Also, phosphorus net imports were determined using either the previous study assumptions or more accurate assumptions that gave a better representation of the actual land use practices. For example, the original truck crop land use budget assumed and was based on lettuce as a "typical" truck crop. The revised truck crop coefficient took a more rigorous approach for determining a more accurate coefficient value. Using the previous study as a bench mark and further improving the assumptions could have also contributed to stronger relations between associated variables.

6.1.6 Rainfall Phosphorus Import

The phosphorus import from rain, I_{precip}, accounts for 68% of the variation in phosphorus lake loading (O_L) data. The relation is as follows:

$$\log(O_L) = -0.11 + 1.22*\log(I_{precip}) \qquad r^2 = 0.68$$

The linear regression model for rainfall phosphorus import and phosphorus lake loading (O_L) is as follows:

$$O_L = 1.17 + 1.64*(I_{precip}) \qquad r^2 = 0.56$$

This indicates a relationship not as strong as the relationship of anthropogenic net phosphorus imports to lake loading.

6.1.7 Total Basin Area

The total basin area accounts for 68% of the variation in phosphorus lake loading (O_L) data. The relation is as follows:

$$\log(O_L) = -4.31 + 1.22 *\log(Area) \qquad r^2 = 0.68$$

The linear regression model for total basin area and phosphorus lake loading (O_L) is as follows:

$$O_L = 1.17 + 0.00(Area) \qquad r^2 = 0.56$$

A smaller correlation coefficient was determined between lake phosphorus loading and shape factor ($r^2 = 0.59$), which is the basin perimeter divided by its area. This suggests that physical basin characteristics such as perimeter and area more directly influence phosphorus loading to the lake than the symmetry, irregularity, or roundness of a tributary basin’s shape.

6.1.8 Total Length of Streams

The total length of streams regression equation below accounts for 66% of the variation in phosphorus lake loading (O_L) data. The relation is as follows:

$$\log(O_L) = -0.24 + 0.75*\log(Stream1) \qquad r^2 = 0.66$$

The linear regression equation between lengths of streams and variation in phosphorus lake loading (O_L) is as follows:

$$O_L = 3.09 + 0.19(STREAM1) \qquad r^2 = 0.58$$

This relationship is stronger than previously reported ($r^2 = 0.54$). This suggests that the network of streams expedites the flow of phosphorus to the lake to a certain degree. The stronger relationship puts a higher emphasis on BMPs that prevent phosphorus runoff loading to nearby streams and canals. The stronger relationship also suggests that implementing such preventative BMPs could have a more direct impact on reducing phosphorus lake loading.

6.1.9 Soil Type

The only relationship between soil type and lake loading with even marginal correlation was the area (in thousands of acres) of Myakka-Basinger-Immokalee-Smyrna (MBIS) soils ($r^2 = 0.60$). The relation of MBIS to lake loading, however, is not very strong.

$$O_L = 1.26 + 1.21 * MBIS \qquad r^2 = 0.67$$

Soil type and lake loading were correlated slightly higher based on recent phosphorus loading than the last study ($r^2 = 0.58$ previously). The same soil type, Smyrna-Immokalee, was found to have the strongest correlation with phosphorus lake loading in both studies. This association may be inferred because of the greater trend for agricultural operations on these soils.

6.1.10 Total Length of Streams and Canals

The regression model for total length of streams and canals, WATER1, accounts for 66% of the variability in lake loading data (O_L). The relation is as follows:

$$\log(O_L) = -2.14 + 1.30 * \log(WATER1) \qquad r^2 = 0.66$$

The linear regression model for the lengths of streams and canals, and variation in phosphorus lake loading (O_L) is as follows:

$$O_L = 3.52 + 0.08 * (WATER1) \qquad r^2 = 0.62$$

This relation is a positive correlation for many of the same reasons that total length of streams has a positive correlation. The previous study determined a relationship between WATER1 and O_L with $r^2 = 0.54$.

6.1.11 Areal Phosphorus Loading, PLAC

The linear regression equation based on basin export intensity, or the amount of phosphorus loading per area, accounts for 61% of the variation in phosphorus lake loading (O_L).

$$\log(O_L) = 1.24 + 1.27*\log(PLAC) \qquad r^2 = 0.61$$

It appears that basin size is more influential than basin export intensity in regards to lake loading.

6.1.12 Shape

The basin shape regression equation below accounts for 59% of the variation in phosphorus lake loading (O_L) data:

$$\log(O_L) = 2.34 + -2.49*\log(SHAPE) \qquad r^2 = 0.59$$

As discussed previously, the basin area appears to have a stronger relationship to lake loading than the shape factor.

6.1.13 Wetlands Phosphorus Import

The area of wetlands in a basin, WETLANDS, accounts for 57% of the variation in phosphorus lake loading (O_L) data. The relation is as follows:

$$\log(O_L) = -1.93 + 0.82*\log(WETLANDS) \qquad r^2 = 0.57$$

6.2 Regression Analysis Between Variables

6.2.1 Wetlands Assimilation Factor and Basin Phosphorus Export Intensity

The wetlands assimilation factor (AF), the fraction of runoff phosphorus stored in streams and wetlands, was correlated with phosphorus export intensity, PLAC. The PLAC linear regression equation accounts for 90% of the variations in AF data.

$$AF = 0.83 - 0.65*PLAC \qquad r^2 = 0.90$$

The logarithmic relation between the runoff phosphorus stored in streams and wetlands, AF, and phosphorus export intensity (PLAC) is as follows:

$$\log AF = -0.69 + -0.63*\log PLAC \qquad r^2 = 0.57$$

The negative coefficient for (PLAC) in the above equation indicates that the wetlands assimilation rate is not as efficient as the basin phosphorus usage becomes more intense.

6.2.2 Areal Net Imports (NPAC) and Areal Lake Loading (PLAC)

Phosphorus loads were evaluated as an areal loading rate (PLAC) to account for variations in basin sizes. Based on linear regression, it was determined that the areal net imports, (NPAC), regression equation below accounts for 60% of the variation in PLAC values. This correlation is much stronger than previously determined (r^2 = 0.36 previously. The revised correlation analysis suggests that areal net imports are a more considerable factor to lake loading than previously shown. Phosphorus load intensity results from more intense phosphorus import and land use practices. As phosphorus load intensity increases, areal lake loading increases proportionally.

$$PLAC = 0.20 + 0.11*NPAC \qquad r^2 = 0.60$$

As determined in the original study, it appears that the net phosphorus imports influence phosphorus loading to the lake more directly than the average of phosphorus imports averaged over the tributary basin area. This degree of influence to lake loading is suggested when comparing the 0.80 correlation coefficient of net phosphorus imports with the 0.61 correlation coefficient of PLAC with respect to lake loading. The amount of phosphorus imported plays a more influential role in lake loading than the actual size of a basin. However, the 0.68 area correlation indicates that basin size is also has a fair influence on lake loading.

6.2.3 Off-site Phosphorus Load Index, OPLI and Basin Phosphorus Load Index, BPLI

A fair to marginal correlation was determined for the influence of off-site phosphorus loading to basin phosphorus loading index. This relationship is expected to have a reasonable correlation since the runoff phosphorus were highly correlated to phosphorus lake loading.

$$BPLI = -0.00 + 0.46 * OPLI \qquad r^2 = 0.58$$

The correlation between OPLI and lake loading was poor ($r^2 = 0.23$). The original study also assessed the correlation of the off-site phosphorus loading index, OPLI, with total length of canals (CAN1), distance of the basin to the lake (LDIST), and percent of basin in emergent wetlands (WETEMP). However, the current data does not indicate any correlations between OPLI and these variables higher than $r^2 = 0.22$.

The basin phosphorus load index, BPLI, was also regressed with canal density (CAN2), percent of wetlands (WETP), and percent Felda-Riviera soils (FRSL). The current data indicates correlations $r^2 = 0.33$ or less between BPLI and each of these variables.

6.3 Multiple Regression Analysis Between Variables

6.3.1 Change in Basin Storage

Multiple linear regression analysis was performed to update the models previously examined in both the original 1991 study (Fonyo et al., 1991) and the 1995 paper (Boggess et al., 1995). Model 1 from the 1991 paper was used to examine effects of net phosphorus import intensity, stream and canal density, and percent of wetlands on the total annual change in phosphorus retention per acre, dS/AC.

$$dS/AC = 0.20 + 0.97*NPAC - 4.19*WATER2 + 0.20*WETPER$$
$$r^2 = 0.980$$

As determined before, this model has a good correlation which indicates that these are explanatory variables. As the previous Model 1 indicated and as expected, the intercept is not considerably different from zero. The positive coefficient of NPAC was expected and is the same order of magnitude, 0.97, as the 1.022 value previously determined. The positive NPAC coefficient infers that increased net phosphorus intensity leads to increased basin phosphorus storage intensity. The negative sign of the revised stream and canal density coefficient is consistent with the previous model, but much larger in magnitude. This coefficient suggests that an increase in drainage density reduces the amount of phosphorus retention in a basin. The coefficient for wetland percent suggests that an increase in wetlands in a basin would increase the phosphorus storage intensity in that basin.

Wetlands percent was regressed against basin storage intensity and found to have a very poor correlation $r^2 = 0.004$. As a result, the wetlands component of Model 1 was removed, yielding a regression equation with a correlation just as strong as the original Model 1. The revised model, Model 1a, is as follows:

$$dS/AC = 0.19 + 0.97 * NPAC - 4.11 * WATER2 \qquad r^2 = 0.990$$

6.3.2 Lake Load Intensity

Model 2 from the 1991 study was revised and assessed. Model 2 examined the relation of the same independent variables assessed in Model 1 with lake phosphorus load intensity. As with Model 1, wetland percent was found to have a very poor correlation with lake loading intensity ($r^2 = 0.02$). Wetland percent was removed from Model 2 with no resulting change in the Model 2 correlation coefficient. The multiple regression analysis yielded the following results for the revised Model 2:

$$PLAC = 0.15 + 0.11 * NPAC + 3.51 * WATER2 \qquad r^2 = 0.60$$

The previous Model 2 correlation was higher ($r^2 = 0.91$) than the updated Model 2. The positive signs of the revised NPAC and WATER2 coefficients are consistent with those previously determined. The order of magnitude of these two coefficients is much larger than previously determined (previously 0.028 and 0.011 for NPAC and WATER2, respectively).

6.3.3 Lake Loading

Model 3 from the 1991 study was similar to the Model 2 without being on a per unit area basis. As with Model 2, the wetlands factor was found to individually correlate very poorly ($r^2 = 0.23$). When the wetlands factor was removed from the multiple linear regression equation, the correlation coefficient and the independent variable coefficients did not change in the decimal places reported:

$$O_L = -3.46 + 0.08 * I_{imports} + 0.05WATER1 \qquad r^2 = 0.80$$

The previous Model 3 correlation was higher ($r^2 = 0.91$) than the updated Model 3. The positive signs of the revised phosphorus import and WATER1 coefficients are consistent with those previously determined. The order of magnitude for the revised phosphorus import coefficient is larger (0.0176 previously) and the revised WATER 1 coefficient is similar (0.046 previously) to the previous corresponding Model 3 values.

6.3.4 Off-site Phosphorus Load Index

Model 4 was assessed in the original 1995 study to assess independent variables that may relate to off-site phosphorus load index, OPLI, which is the fraction of total phosphorus inputs discharged in runoff. Variables of total length of canals, distance of basin to the lake, and percent of wetlands in a basin were regressed with OPLI. This model had a low correlation coefficient ($r^2 = 0.49$) previously. Regression analysis of the current data yielded an even lower correlation coefficient ($r^2 = 0.06$). It appears that the basin characteristics of length of canals, distance to the lake, or wetlands percentage do not highly relate to the off-site phosphorus loading of a basin.

6.3.5 Basin Phosphorus Load Index

Model 5 was assessed in the original 1995 study to suggest independent variables that may relate to basin phosphorus load index, BPLI, which is the fraction of total phosphorus inputs loaded to the lake. Variables of canal density, fraction of basin in wetlands, and basin percent of Myakka-Basinger soil type were regressed with BPLI. This model had a marginal correlation coefficient ($r^2 = 0.61$) previously. Regression analysis of the current data yielded an even lower correlation coefficient ($r^2 = 0.08$). It appears that the basin characteristics of canals density, fraction of wetlands, or soil type do not highly relate to the basin phosphorus load index. A strong relationship between BPLI and phosphorus lake loading could not be found. It appears that BPLI is not a considerable factor for relating to lake loading, or other physical basin characteristics. BPLI was found only to relate to off-site phosphorus load index because of the strong relation of phosphorus runoff and phosphorus lake loading.

6.3.6 Lake Loading with Developed Area and Soil Type.

Model 6 was assessed in the original 1995 study to suggest some interaction between the independent variables of Developed area and soil type that may relate to basin phosphorus lake loading. Multiple linear regression was originally performed using developed area and the four most dominant soil types in the watershed. Multiple linear regression was then performed with Pompano soil type and Developed land with lake loading. The relation is as follows:

$$\log O_L = -4.39 + 1.33 * \log(DEVAC) - 0.01*APB \qquad r^2 = 0.79$$

This model has a correlation coefficient slightly higher than the original study (r^2 = 0.74 previously). However, the linear regression output for developed area alone regressed with lake loading had a correlation coefficient of $r^2 = 0.82$.

6.3.7 Areal Lake Loading with Wetlands and Soil Type

Model 7 was assessed in the original 1995 study to suggest some interaction between the independent variables of basin wetland percentage and soil type that may relate to areal lake loading, PLAC. This model had a low correlation coefficient in the original study (r^2 = 0.47 previously) and an even lower correlation coefficient given the current data (r^2 = 0.21). Wetlands or soils type did not appear to considerably relate to areal phosphorus loading. Model 7 does not appear as useful as relating wetland percentage directly with lake loading.

6.3.8 Flow-weighted Areal Phosphorus Loading Rate (PLFW) with Developed Area and Soil Type

Model 8 was assessed in the original 1995 study to suggest some interaction between the independent variables of basin fraction of developed area, INTS, and soil type with PLFW. The previous study and current study both indicated low correlation (r^2 = 0.58 and r^2 = 0.42, respectively) between the variables in model 8. As concluded in the original study, this model is not as strong as Model 6 that relates developed land directly to lake loading. It is more useful to compare basin characteristics directly with phosphorus loading than trying to account for differences in basin size using areal loading rate characteristics.

7.0 CONCLUSIONS

The phosphorus budget for the northern Lake Okeechobee watershed was revised from the original study as performed in 1991 and later published (Boggess et al., 1995) using current land use areas, current land use practices, current land use net phosphorus import coefficients, and more recent rainfall and runoff values. The lake loading was taken from the 2002 SWIM Plan developed by the SFWMD. New correlations were determined from the current phosphorus budget.

Approximately 1,717 t (1,888 tons) of phosphorus are imported into the northern Lake Okeechobee watershed annually from anthropogenic land use activities. The onsite phosphorus storage was calculated as the sum of net phosphorus imports, including rainfall, minus phosphorus surface runoff. Wetlands storage is calculated as the amount of uplands phosphorus runoff minus the amount of phosphorus lake loading. Approximately 74% of the total net phosphorus import, 1,413 t P/yr (1,554 tons P/yr), is stored on site in upland soils and vegetation, while 26%, 488 t P/yr (537 tons P/yr), is lost in runoff. Approximately 32% of that runoff phosphorus, 156 t P/yr (172 tons P/yr), is stored in wetlands, while approximately 68%, 332 t P/yr (366 tons P/yr), is loaded to Lake Okeechobee. Overall, 8% of the total phosphorus imports to the northern Lake Okeechobee watershed end up being stored in wetlands and 17% is loaded to the lake.

The C-40 basin is a net phosphorus exporter of 24 t P/yr (26 tons P/yr) because of the amount of sod grown and harvested in that basin. Basin S-65D contributes the highest net phosphorus import of any tributary basin with 418 t P/yr (460 tons P/yr). A dominant land use was assigned to each tributary basin based on the land use that contributed the largest value of net phosphorus imports to that basin. For example, truck crop is the dominant land use in terms of net phosphorus import to basin S-65D. Not including basin S-65D, the highest phosphorus importing tributary basins in order of decreasing magnitude are S-191 (dairy dominant), S-65E (truck crop dominant), Fisheating Creek (improved pasture dominant), and S-154 (dairy dominant). These five basins account for 75% of the total net phosphorus imports to the northern Lake Okeechobee watershed.

The previous phosphorus budget (Fonyo et al., 1991; Boggess et al., 1995) was compared to the current phosphorus budget. Net phosphorus imports decreased by 28% from the original budget, from 2,380 t P (2,618 tons P) to 1,717 t P (1,888 tons P), primarily due to changes in four land uses. Land uses with the largest change in net phosphorus import amount include dairy from 1,170 t P (1,287 tons P) to 458 t P (503 tons P), or –61%, improved pasture from 1,010 t P (1,111 tons P) to 559 t P (613 tons P), or –45%, truck crops from 72 t P (79 tons P) to 545 t P (600 tons P), or 657%, and sod pasture from -70 t P (–77 tons P) to -239 t P (-259 tons P), or –236%. Dairy net phosphorus imports changed primarily due to fewer dairies and also as a result in change in management practices. Improved pasture net phosphorus imports decreased due to a lower net phosphorus import coefficient, which resulted from lower fertilizer application and higher live weight export. Truck crop net phosphorus imports changed due to a five-fold increase in truck crop area, and an increase in the phosphorus import coefficient, which reflects an increased farming intensity. Sod farm net phosphorus import decreased due lower fertilizer application on this land use.

The overall phosphorus budget indicates that annual amount of onsite storage of phosphorus has decreased by 26% from the original budget. Although loading to the wetlands/streams decreased by 36%, 272 t P/yr (299 tons P/yr), from the original budget, wetland/stream storage decreased by an even greater value, 66%, 304 t P/yr (334 tons P/yr), from the original budget, resulting in an increase in lake loading of 11%, 32 t P/yr (35 tons P/yr). Based on the current information, the overall wetlands assimilation factor, which is the percent of wetlands loading that is retained in the wetland, has changed from 61% to 32%. The reduction is not a result of a wetlands area, but a result of currently reduced phosphorus assimilation potential. Overall, 83% of net imported phosphorus was stored in the watershed, which was previously determined to be 90%. Wetlands assimilation is calculated as the percent of uplands runoff that is not loaded to Lake Okeechobee.

Event mean phosphorus concentrations (EMCs) were used to calculate the amount of phosphorus runoff for each particular land use. A considerable decrease in truck crop and dairy EMC values was indicated since the last study. Truck crop runoff changed from 6.0 mg/L to 0.55 mg/L while dairy runoff changed from 6.8 mg/L to 1.32 mg/L. The citrus land use EMC increased noticeably from 0.20 mg/L to 0.52 mg/L.

The variables with the highest correlations with lake loading in order of rank include runoff phosphorus ($r^2 = 0.88$), developed land ($r^2 = 0.82$), and net phosphorus input to the basin ($r^2 = 0.80$). Other variables with fair correlations to lake phosphorus loading were on site phosphorus storage ($r^2 = 0.77$), tributary basin perimeter ($r^2 = 0.72$), and total basin phosphorus storage ($r^2 = 0.72$). Fair correlations with lake loading were found for rainfall phosphorus import ($r^2 = 0.68$), tributary basin area ($r^2 = 0.68$), area of Myakka soil type ($r^2 = 0.62$), length of streams ($r^2 = 0.66$). A fair correlation was also determined between areal lake loading and areal net imports (r^2 = 0.60). This relationship was previously poor (r^2 = 0.36).

The strongest single relationship was found between the fraction of runoff phosphorus stored in streams and wetlands with phosphorus export intensity (r^2 = 0.90). Phosphorus export intensity refers to the lake phosphorus loading per basin area. Using multiple linear regression; net phosphorus import intensity, stream and canal density, and percent of wetlands correlated well with the total annual change in phosphorus retention per acre (r^2 = 0.99) and net phosphorus imports and length of canals and streams correlated well with lake loading (r^2 = 0.80).

Areal net phosphorus imports was determined to be more influential to areal lake loading (r^2 = 0.60 currently) than previously thought (r^2 = 0.36 previously). This relationship indicates that the intensity of phosphorus imports does influence lake loading.

The original study indicated that basin morphology factors such as shape, size, and perimeter were not influential to lake loading. However, these factors now appear to have some effect on phosphorus lake loading. Better information on physical characteristics, more accurate spatial data sets and delineation of watershed basins, and more representative net phosphorus import coefficients may have contributed to stronger correlations determined for basin morphology factors over the original study.

Basin factors that did not correlate, even marginally, with lake loading are percent of wetlands, wetland assimilation factor, flow weighted areal phosphorus loading, distance to the lake, off-site phosphorus load index, and the basin phosphorus load index.

Lake loading can be decreased most effectively by decreasing phosphorus runoff and decreasing net phosphorus imports in each tributary basin. The correlation between net phosphorus imports and lake loading is higher than previously determined. The net phosphorus import regression equation accounts for 80% of the variability in lake loading data whereas the best regressed equation only accounted for 70% of variability in lake loading previously. The relationship between net phosphorus imports and lake loading was the highest correlation to lake loading in the original study.

The improved pasture land use remains a considerable contributor of net phosphorus imports (33% currently, 49% previously); truck crops have become a more influential land use (32%

currently, 3% previously); and dairy has decreased in contribution significance (27% currently, 42% previously). With regards to phosphorus management, improved pasture and dairy land uses should continue to be land uses of focus, but truck crops should receive increased attention.

In terms of phosphorus loading and percent of total lake loading, three basins account for over 50% of lake loading: S-191 with 74 t P/yr (81 tons P/yr) or 22%, Fisheating Creek with 64 t P/yr (71 tons P/yr) or 19%, and S-65D with 38 t P/yr (42 tons P/yr) or 11%. These three basins should receive a proportional amount of attention with regards to phosphorus management.

Lake loading can be decreased most effectively by decreasing phosphorus runoff which means decreasing net phosphorus imports in each tributary basin. Anthropogenic activities of phosphorus import have the largest correlation to lake phosphorus loading. The relationship between net phosphorus imports and lake loading data was strongly than previously estimated. A lower wetland assimilation factor for phosphorus increases the importance of reducing phosphorus import to reduce lake loadings.

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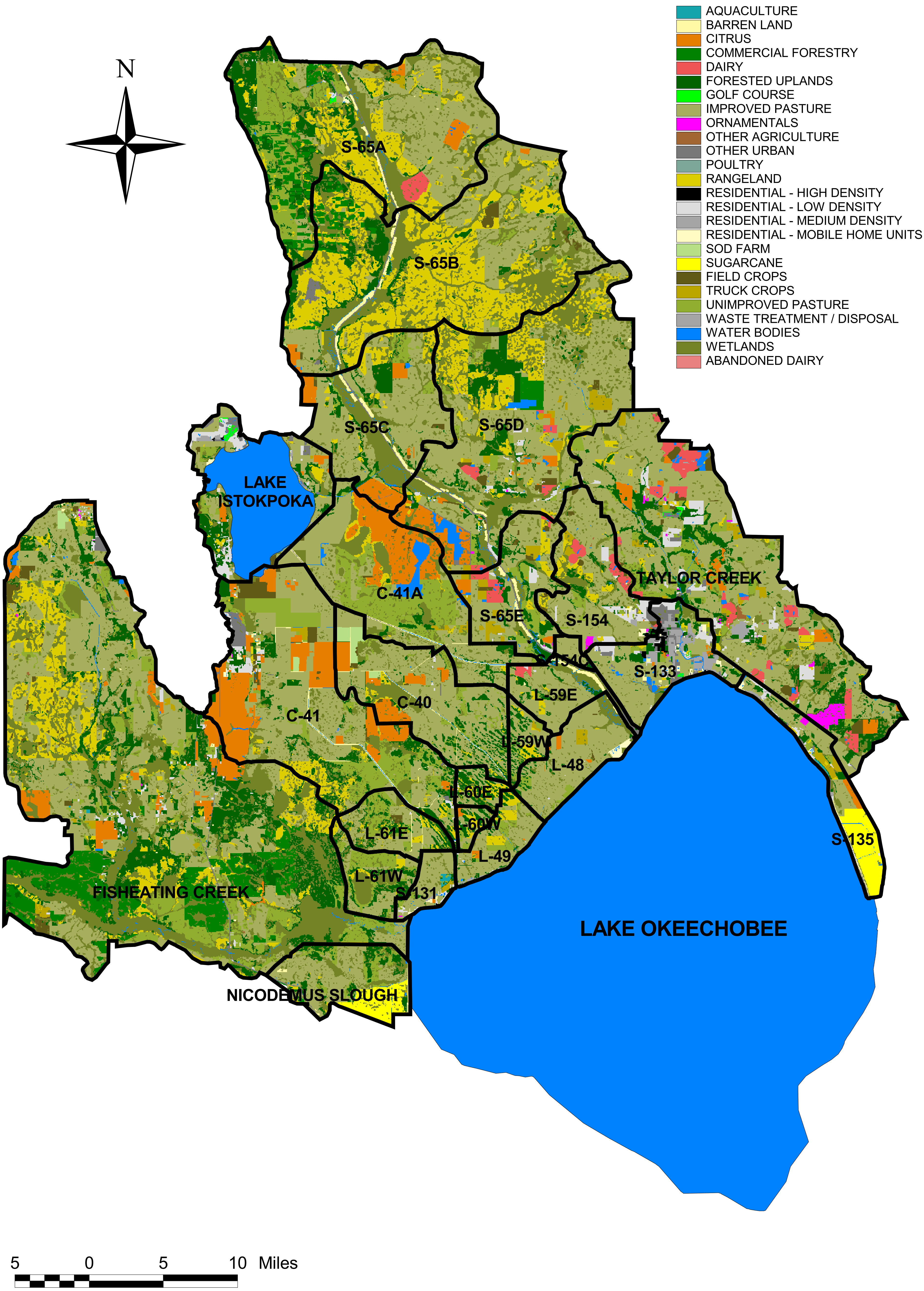
9.0 EXHIBITS

10.0 APPENDICES



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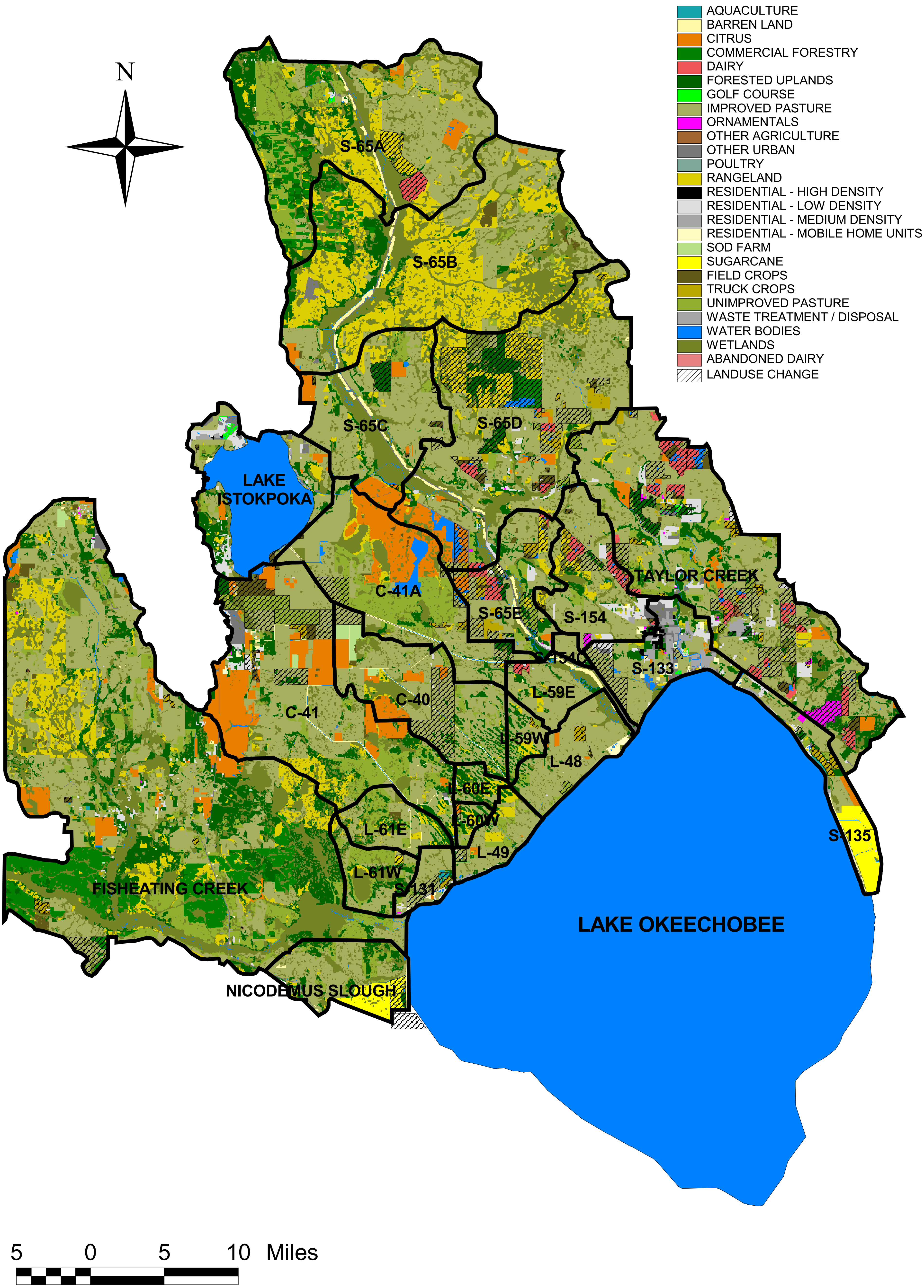
G:\sfwd\sfwdpbud\final-lu\landuse.apr:1995 Land Use

1995 Land Use in the Northern Lake Okeechobee Watershed for the SFWMD P - Budget Update

September 2002

Exhibit 1



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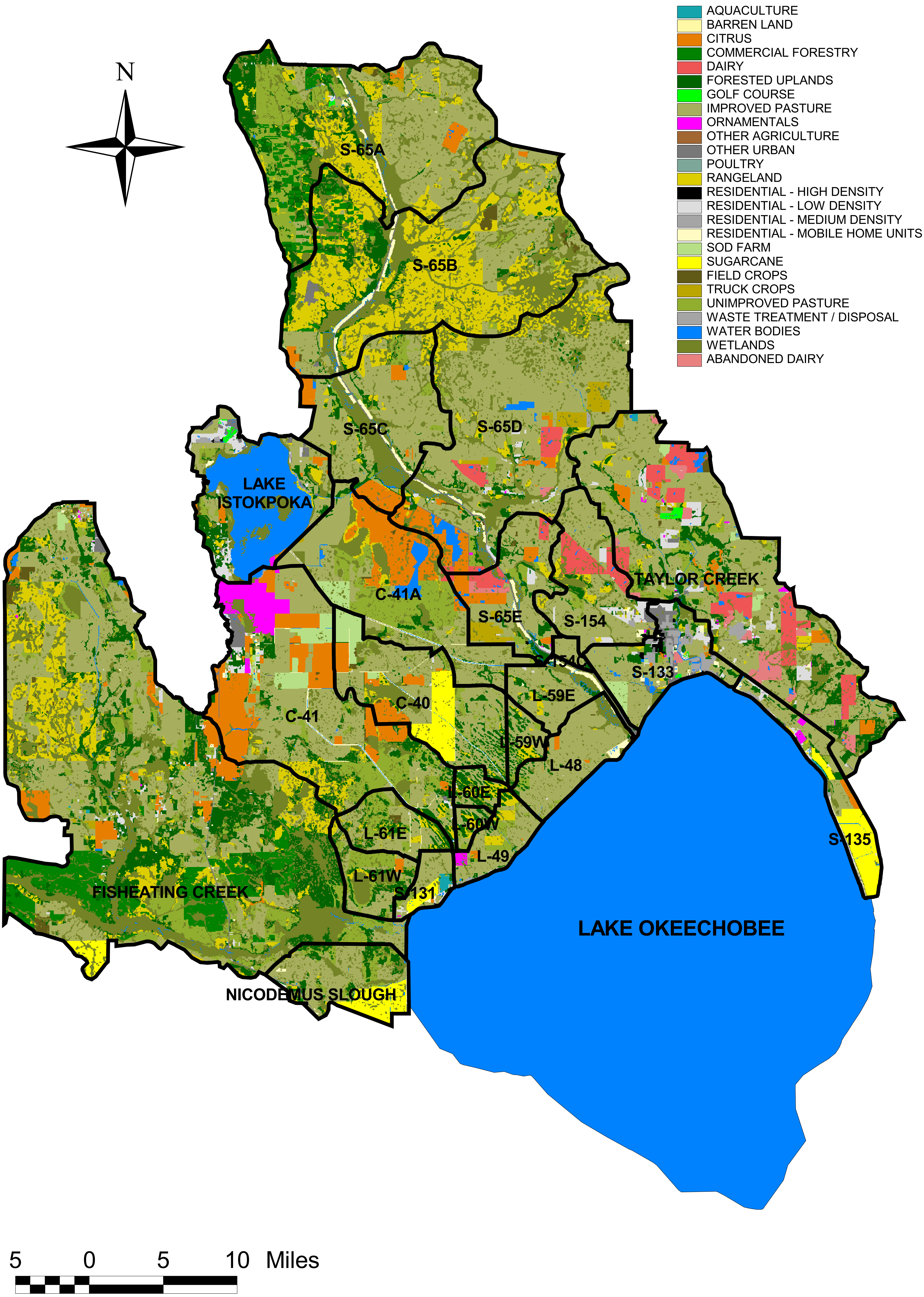
G:\sfwd\sfwdpbud\final-lu\landuse.apr:Land Use Changes

1995 - 2001 Land Use Changes in the Northern Lake Okeechobee Watershed for the SFWMD P - Budget Update

September 2002

Exhibit 2



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G:\sfwd\sfwdpbud\final-lu\landuse.apr:2001 Land Use

2001 Land Use in the Northern Lake Okeechobee Watershed for the SFWMD P - Budget Update

September 2002

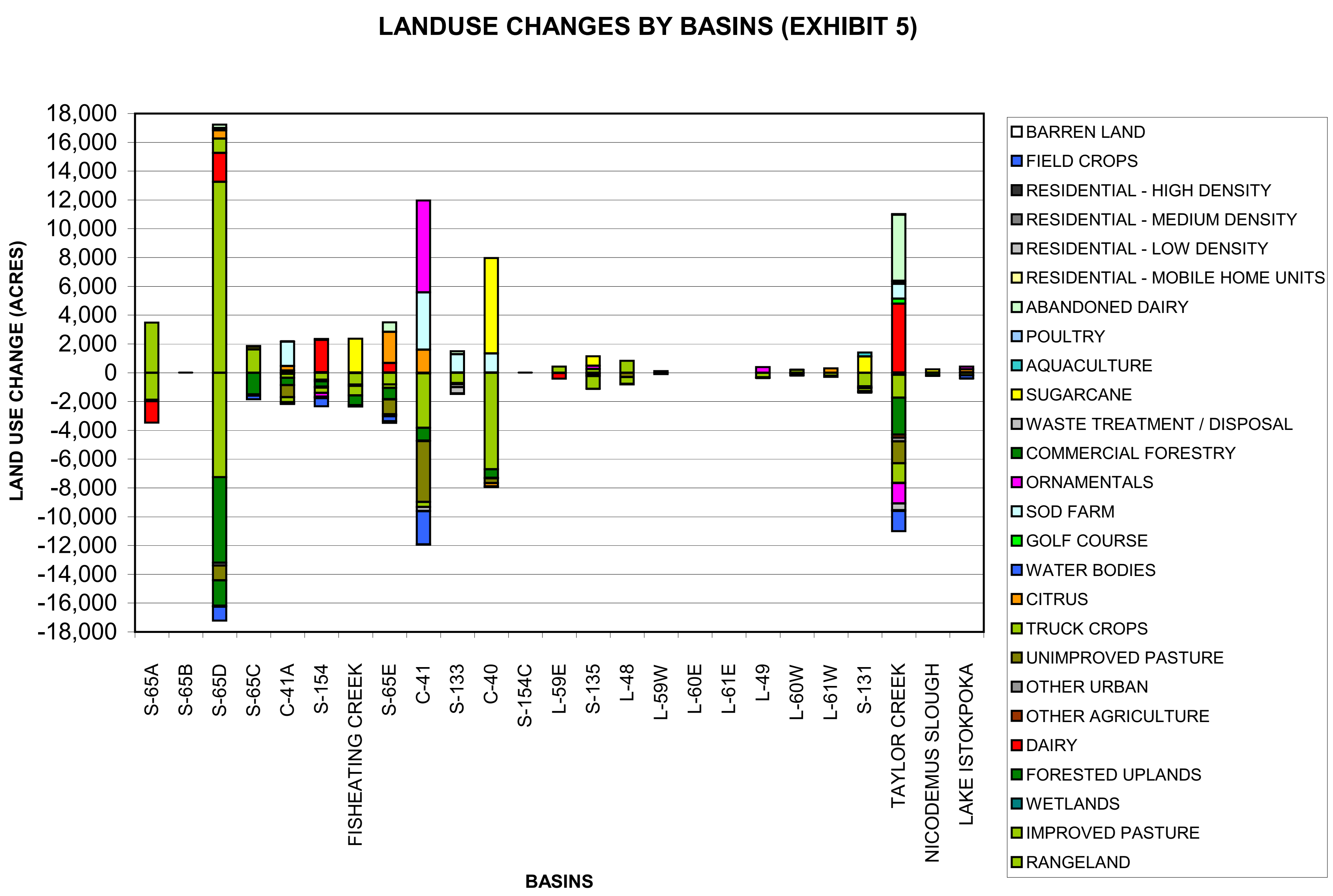
Exhibit 3

NET LAND USE CHANGES FOR THE NORTHERN LAKE OKEECHOBEE WATERSHED (EXHIBIT 4)

LAND USE	1995 Land Use (acres)	2001 Land Use (acres)	Land Use (1) Change (acres)	Percent Change
RANGELAND	126250	115250	-11000	-8.7%
IMPROVED PASTURE	449660	454120	4459	1.0%
WETLANDS	235767	235792	25	0.0%
FORESTED UPLANDS	137235	123273	-13962	-10.2%
DAIRY (2)	13098	21064	7966	60.8%
BARREN LAND	11707	11394	-313	-2.7%
OTHER AGRICULTURE	295	0	-295	-100.0%
OTHER URBAN	13766	13031	-734	-5.3%
UNIMPROVED PASTURE	91856	82664	-9192	-10.0%
TRUCK CROPS	10955	7086	-3869	-35.3%
CITRUS	58005	62745	4740	8.2%
WATER BODIES	36781	36842	61	0.2%
GOLF COURSE	585	932	347	59.2%
SOD FARM	2602	11899	9297	357.3%
ORNAMENTALS	2383	7937	5554	233.1%
COMMERCIAL FORESTRY	35301	32862	-2440	-6.9%
WASTE TREATMENT / DISPOSAL	0	159	159	-
SUGARCANE	10613	21635	11022	103.9%
AQUACULTURE	401	831	431	107.4%
POULTRY	0	50	50	-
ABANDONED DAIRY	0	5793	5793	-
RESIDENTIAL - MOBILE HOME UNITS	2001	1961	-40	-2.0%
RESIDENTIAL - LOW DENSITY	17951	16486	-1466	-8.2%
RESIDENTIAL - MEDIUM DENSITY	4908	4751	-157	-3.2%
RESIDENTIAL - HIGH DENSITY	925	869	-55	-6.0%
FIELD CROPS	12006	5624	-6382	-53.2%
Total	1275051	1275051		

NOTES:

1. A positive number symbolizes a net increase in that particular land use category, while a negative number symbolizes a net decrease in that land use. Spatially, 92965 acres (7.3% of the entire watershed) has changed from one land use to another.
2. It should be noted that the increase in dairy is due to improved mapping of the dairy pastures and not as a result increased dairy activity.
3. It is also important to note that the 1995 land use is not the land use that was used in the previous 1991 study (or subsequent 1995 paper). This 1995 land use was completed in 1997 and was utilized because it represented the most recent available GIS land use coverage.



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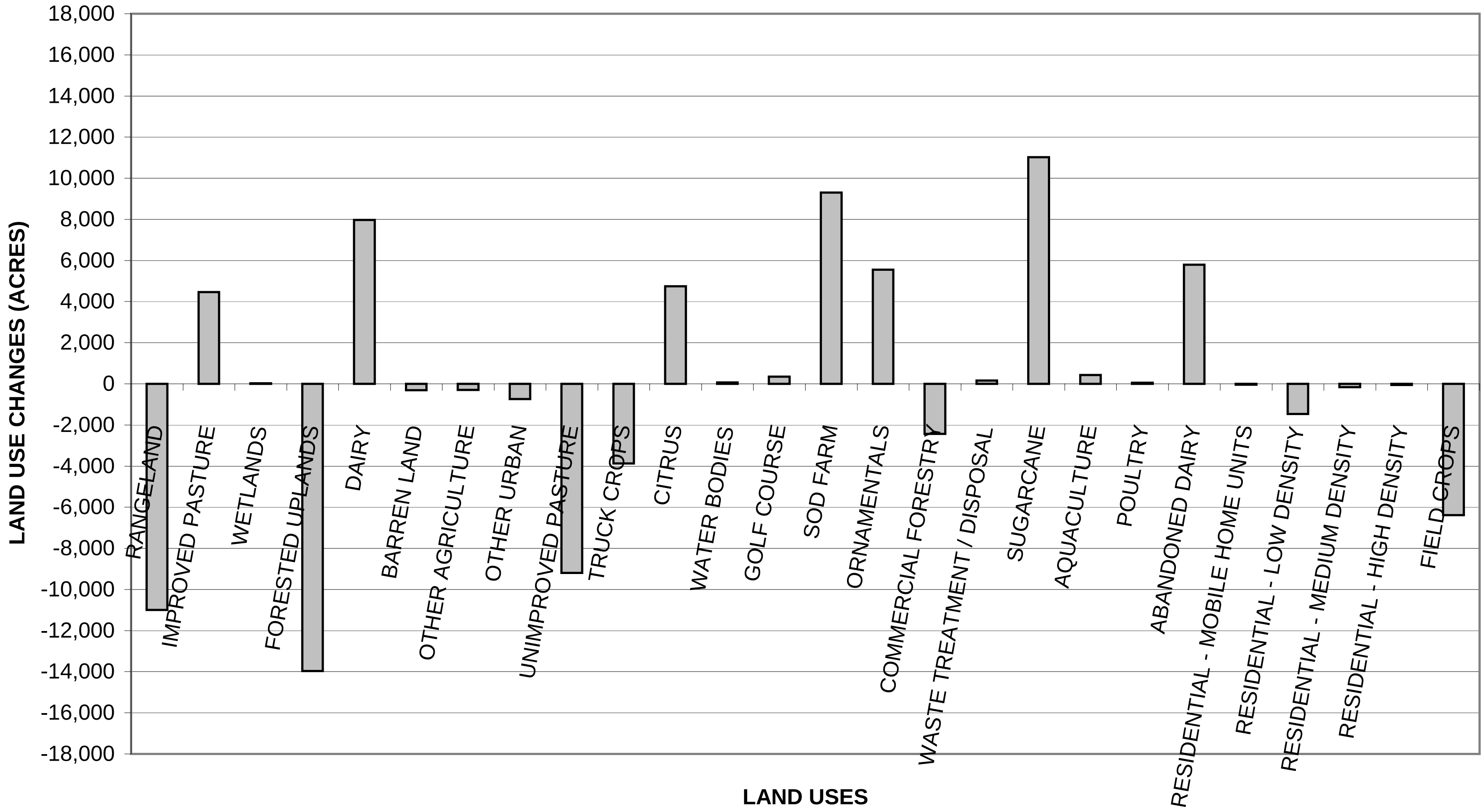
LAND USE CHANGE TOTALS (EXHIBIT 5A)



Note: The increase in dairy land use is due to improved mapping of the dairy pastures and is not a result of increased dairy activity

LAND USE CHANGES IN ACRES
(EXHIBIT 6)

LANDUSE	S-65A	S-65B	S-65D	S-65C	C-41A	S-154	FISHEATING CREEK	S-65E	C-41	S-133
RANGELAND	-1871	-1	-7257	-12	-87	-479	-21	-809	-42	0
IMPROVED PASTURE	3478	1	13253	1609	-268	-121	-801	-239	-3787	-730
WETLANDS	0	1	1	0	0	19	2	0	0	0
FORESTED UPLANDS	-115	0	-5940	-1502	-508	-363	-34	-794	-883	-47
DAIRY	-1492	0	2014	0	156	2253	0	666	0	-23
BARREN LAND	0	0	0	0	-45	-7	0	-118	-37	-49
OTHER AGRICULTURE	0	0	0	0	0	-16	-32	0	-29	0
OTHER URBAN	0	0	-191	0	0	-3	0	-24	-19	-197
UNIMPROVED PASTURE	0	0	-1034	194	-837	-49	-24	-1025	-4211	0
TRUCK CROPS	0	0	990	-16	-354	-379	-661	-51	-351	0
CITRUS	0	0	579	-70	310	0	0	2173	1599	0
WATER BODIES	0	0	0	63	0	0	0	-1	-1	0
GOLF COURSE	0	0	0	0	0	0	0	0	0	0
SOD FARM	0	0	0	0	1688	0	0	0	3968	1278
ORNAMENTALS	0	0	0	0	26	-254	0	0	6391	0
COMMERCIAL FORESTRY	0	-1	-1754	0	0	0	-684	0	0	0
WASTE TREATMENT / DISPOSAL	0	0	159	0	0	0	0	0	0	0
SUGARCANE	0	0	0	0	5	0	2371	0	5	0
AQUACULTURE	0	0	0	0	0	0	0	0	0	0
POULTRY	0	0	0	0	0	0	0	0	0	0
ABANDONED DAIRY	0	0	240	0	0	74	0	657	0	219
RESIDENTIAL - MOBILE HOME UNITS	0	0	0	0	0	0	0	-12	0	0
RESIDENTIAL - LOW DENSITY	0	0	-62	0	-2	-34	-1	-73	-284	-452
RESIDENTIAL - MEDIUM DENSITY	0	0	-13	0	-6	-11	0	-1	-11	0
RESIDENTIAL - HIGH DENSITY	0	0	0	0	0	-55	0	0	0	0
FIELD CROPS	0	0	-985	-266	-77	-573	-113	-351	-2309	0

LAND USE CHANGES IN ACRES
(EXHIBIT 6)

LANDUSE	C-40	S-154C	L-59E	S-135	L-48	L-59W	L-60E	L-61E	L-49	L-60W	L-61W
RANGELAND	-5	0	-5	-59	0	-1	0	0	0	-1	-207
IMPROVED PASTURE	-6699	0	427	244	821	107	0	0	-322	209	-6
WETLANDS	2	0	0	0	0	0	0	0	0	0	0
FORESTED UPLANDS	-597	0	-20	-159	0	0	0	0	-26	-65	-91
DAIRY	0	0	-397	0	0	0	0	0	0	0	0
BARREN LAND	-52	0	-6	0	0	0	0	0	0	0	-6
OTHER AGRICULTURE	0	0	0	0	0	0	0	0	0	0	0
OTHER URBAN	-36	0	0	-4	0	0	0	0	0	0	0
UNIMPROVED PASTURE	-336	0	0	-10	-306	-2	0	0	0	0	0
TRUCK CROPS	0	0	0	-890	-463	-103	0	0	-22	0	0
CITRUS	-222	0	0	0	0	0	0	0	0	-139	309
WATER BODIES	0	0	0	0	0	0	0	0	0	0	0
GOLF COURSE	0	0	0	0	0	0	0	0	0	0	0
SOD FARM	1333	0	0	0	0	0	0	0	0	0	0
ORNAMENTALS	0	0	0	241	0	0	0	0	391	1	0
COMMERCIAL FORESTRY	0	0	0	0	0	0	0	0	0	0	0
WASTE TREATMENT / DISPOSAL	0	0	0	0	0	0	0	0	0	0	0
SUGARCANE	6629	0	0	661	0	0	0	0	0	0	0
AQUACULTURE	0	0	0	0	0	0	0	0	0	0	0
POULTRY	0	0	0	0	0	0	0	0	0	0	0
ABANDONED DAIRY	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL - MOBILE HOME UNITS	0	0	0	-1	0	0	0	0	0	0	0
RESIDENTIAL - LOW DENSITY	-17	0	0	-23	0	0	0	0	-22	-6	0
RESIDENTIAL - MEDIUM DENSITY	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL - HIGH DENSITY	0	0	0	0	0	0	0	0	0	0	0
FIELD CROPS	0	0	0	0	-52	0	0	0	0	0	0

LAND USE CHANGES IN ACRES
(EXHIBIT 6)

LANDUSE	S-131	TAYLOR CREEK	NICODEMUS SLOUGH	LAKE ISTOKPOKA	Total
RANGELAND	0	-142	0	0	-11000
IMPROVED PASTURE	-943	-1598	0	-176	4459
WETLANDS	0	0	0	0	25
FORESTED UPLANDS	-90	-2553	-177	0	-13962
DAIRY	0	4791	0	0	7966
BARREN LAND	-5	51	-33	-6	-313
OTHER AGRICULTURE	0	-218	0	0	-295
OTHER URBAN	-4	-256	0	-1	-734
UNIMPROVED PASTURE	-34	-1519	0	0	-9192
TRUCK CROPS	-208	-1365	-24	29	-3869
CITRUS	0	-11	0	212	4740
WATER BODIES	0	-1	0	0	61
GOLF COURSE	0	347	0	0	347
SOD FARM	0	1031	0	0	9297
ORNAMENTALS	0	-1424	0	182	5554
COMMERCIAL FORESTRY	0	0	0	0	-2440
WASTE TREATMENT / DISPOSAL	0	0	0	0	159
SUGARCANE	1119	0	233	0	11022
AQUACULTURE	279	152	0	0	431
POULTRY	0	50	0	0	50
ABANDONED DAIRY	0	4603	0	0	5793
RESIDENTIAL - MOBILE HOME UNITS	-26	0	0	0	-40
RESIDENTIAL - LOW DENSITY	-29	-463	0	0	-1466
RESIDENTIAL - MEDIUM DENSITY	-60	-55	0	0	-157
RESIDENTIAL - HIGH DENSITY	0	0	0	0	-55
FIELD CROPS	0	-1419	0	-239	-6382

Appendix A

Table A-1: Land Use Assessment for Interview Selection

LAND USE	Acres	Land Share	P-Potential	Ranking	No. Interviews	Recommended
IMPROVED_PASTURE	432070.5	44.3%	5	221.3	7	4
FORESTED_UPLANDS	162510.6	16.6%	0	0.0	0	0
RANGELAND	123010.1	12.6%	2	25.2	1	0
UNIMPROVED_PASTURE	84259.4	8.6%	3	25.9	1	0
CITRUS	55148.3	5.6%	5	28.2	1	1
OTHER_URBAN	27781.9	2.8%	6	17.1	1	1
DAIRY	24147.2	2.5%	10	24.7	1	3
RESIDENTIAL	20423.6	2.1%	6	12.6	0	1
TRUCK_CROPS	15994.0	1.6%	8	13.1	0	1
BARREN_LAND	15001.6	1.5%	0	0.0	0	0
SUGARCANE	9073.7	0.9%	6	5.6	0	0
OTHER_AGRICULTURE	2455.5	0.3%	7	1.8	0	0
COMMERCIAL_FORESTRY	2184.3	0.2%	3	0.7	0	0
SOD_FARM	2148.3	0.2%	7	1.5	0	1
GOLF_COURSE	287.9	0.0%	8	0.2	0	0
ORNAMENTALS	158.4	0.0%	9	0.1	0	0
TOTALS	976655.2			378.0	12	12

Notes:

The "No. Interviews" column includes the computed distribution based on land use rankings. The 'Recommended' column takes into consideration that some improved pasture is contained in dairies. Also, truck crops is a growing land use with a high P-potential that we should try to include.

The total number of 12 interviews was selected based on an estimate of how many landowners would realistically be willing to meet with the Team. Mail-outs and hand-outs could provide additional information.

Table A-2 FLUCCS Conversion

FLUCCS Code	P Budget Code	Land Use Description	FLUCCS Code	P Budget Code	Land Use Description
1009	100	RESIDENTIAL - MOBILE HOME UNITS	1850	8	OTHER URBAN
1100	110	RESIDENTIAL - LOW DENSITY	1860	8	OTHER URBAN
1110	110	RESIDENTIAL - LOW DENSITY	1870	8	OTHER URBAN
1130	110	RESIDENTIAL - LOW DENSITY	1880	8	OTHER URBAN
1190	110	RESIDENTIAL - LOW DENSITY	1890	8	OTHER URBAN
1200	120	RESIDENTIAL - MEDIUM DENSITY	1900	8	OTHER URBAN
1210	120	RESIDENTIAL - MEDIUM DENSITY	1910	8	OTHER URBAN
1230	120	RESIDENTIAL - MEDIUM DENSITY	1920	8	OTHER URBAN
1290	120	RESIDENTIAL - MEDIUM DENSITY	1930	8	OTHER URBAN
1300	130	RESIDENTIAL - HIGH DENSITY	1940	8	OTHER URBAN
1310	130	RESIDENTIAL - HIGH DENSITY	2100	2	IMPROVED PASTURE
1330	130	RESIDENTIAL - HIGH DENSITY	2110	2	IMPROVED PASTURE
1340	130	RESIDENTIAL - HIGH DENSITY	2120	9	UNIMPROVED PASTURE
1350	130	RESIDENTIAL - HIGH DENSITY	2130	9	UNIMPROVED PASTURE
1390	130	RESIDENTIAL - HIGH DENSITY	2140	10	TRUCK CROPS
1400	8	OTHER URBAN	2140	10	TRUCK CROPS
1410	8	OTHER URBAN	2150	215	FIELD CROPS
1411	8	OTHER URBAN	2156	26	SUGARCANE
1420	8	OTHER URBAN	2200	11	CITRUS
1423	8	OTHER URBAN	2210	11	CITRUS
1430	8	OTHER URBAN	2220	11	CITRUS
1440	8	OTHER URBAN	2230	11	CITRUS
1450	8	OTHER URBAN	2300	2	IMPROVED PASTURE
1460	8	OTHER URBAN	2310	2	IMPROVED PASTURE
1470	8	OTHER URBAN	2400	22	ORNAMENTALS
1480	8	OTHER URBAN	2410	22	ORNAMENTALS
1490	8	OTHER URBAN	2420	14	SOD FARM
1500	8	OTHER URBAN	2430	22	ORNAMENTALS
1510	8	OTHER URBAN	2440	22	ORNAMENTALS
1520	8	OTHER URBAN	2450	22	ORNAMENTALS
1530	8	OTHER URBAN	2500	7	OTHER AGRICULTURAL
1540	8	OTHER URBAN	2510	2	IMPROVED PASTURE
1550	8	OTHER URBAN	2520	5	DAIRY
1560	8	OTHER URBAN	2530	7	OTHER AGRICULTURE
1590	8	OTHER URBAN	2540	28	AQUACULTURE
1600	8	OTHER URBAN	2550	7	OTHER AGRICULTURAL
1610	8	OTHER URBAN	2590	7	OTHER AGRICULTURE
1620	8	OTHER URBAN	2600	215	FIELD CROPS
1630	8	OTHER URBAN	2610	215	FIELD CROPS
1660	8	OTHER URBAN	3100	1	RANGELAND
1700	8	OTHER URBAN	3100	1	RANGELAND
1710	8	OTHER URBAN	3200	1	RANGELAND
1720	8	OTHER URBAN	3210	1	RANGELAND
1730	8	OTHER URBAN	3290	1	RANGELAND
1740	8	OTHER URBAN	3300	1	RANGELAND
1750	8	OTHER URBAN	3300	1	RANGELAND
1760	8	OTHER URBAN	4100	4	FORESTED UPLANDS
1770	8	OTHER URBAN	4110	4	FORESTED UPLANDS
1800	8	OTHER URBAN	4110	4	FORESTED UPLANDS
1810	8	OTHER URBAN	4119	4	FORESTED UPLANDS
1820	13	GOLF COURSE	4120	4	FORESTED UPLANDS
1830	8	OTHER URBAN	4120	4	FORESTED UPLANDS
1840	8	OTHER URBAN	4130	4	FORESTED UPLANDS

Table A-2 FLUCCS Conversion (Continued)

FLUCCS Code	P Budget Code	Land Use Description	FLUCCS Code	P Budget Code	Land Use Description
4140	4	FORESTED UPLANDS	6210	3	WETLANDS
4190	4	FORESTED UPLANDS	6210	3	WETLANDS
4200	4	FORESTED UPLANDS	6218	3	WETLANDS
4210	4	FORESTED UPLANDS	6219	3	WETLANDS
4220	4	FORESTED UPLANDS	6220	3	WETLANDS
4230	4	FORESTED UPLANDS	6230	3	WETLANDS
4240	4	FORESTED UPLANDS	6240	3	WETLANDS
4250	4	FORESTED UPLANDS	6300	3	WETLANDS
4260	4	FORESTED UPLANDS	6300	3	WETLANDS
4270	4	FORESTED UPLANDS	6400	3	WETLANDS
4280	4	FORESTED UPLANDS	6410	3	WETLANDS
4290	4	FORESTED UPLANDS	6410	3	WETLANDS
4310	4	FORESTED UPLANDS	6411	3	WETLANDS
4320	4	FORESTED UPLANDS	6412	3	WETLANDS
4330	4	FORESTED UPLANDS	6420	3	WETLANDS
4340	4	FORESTED UPLANDS	6420	3	WETLANDS
4340	4	FORESTED UPLANDS	6430	3	WETLANDS
4350	4	FORESTED UPLANDS	6430	3	WETLANDS
4370	4	FORESTED UPLANDS	6439	3	WETLANDS
4380	4	FORESTED UPLANDS	6440	3	WETLANDS
4390	4	FORESTED UPLANDS	6440	3	WETLANDS
4400	4	FORESTED UPLANDS	6450	3	WETLANDS
4410	23	COMMERCIAL FORESTRY	6510	3	WETLANDS
4420	23	COMMERCIAL FORESTRY	6510	3	WETLANDS
4430	23	COMMERCIAL FORESTRY	6520	3	WETLANDS
5100	12	WATER BODIES	6530	3	WETLANDS
5100	12	WATER BODIES	6530	3	WETLANDS
5200	12	WATER BODIES	7100	6	BARREN LAND
5210	12	WATER BODIES	7200	6	BARREN LAND
5220	12	WATER BODIES	7400	6	BARREN LAND
5230	12	WATER BODIES	7410	6	BARREN LAND
5240	12	WATER BODIES	7420	6	BARREN LAND
5300	12	WATER BODIES	7430	6	BARREN LAND
5310	12	WATER BODIES	7440	6	BARREN LAND
5320	12	WATER BODIES	7450	6	BARREN LAND
5330	12	WATER BODIES	8100	8	OTHER URBAN
5340	12	WATER BODIES	8110	8	OTHER URBAN
5410	12	WATER BODIES	8120	8	OTHER URBAN
5600	12	WATER BODIES	8140	8	OTHER URBAN
6100	3	WETLANDS	8160	8	OTHER URBAN
6110	3	WETLANDS	8170	8	OTHER URBAN
6110	3	WETLANDS	8180	8	OTHER URBAN
6120	3	WETLANDS	8190	8	OTHER URBAN
6130	3	WETLANDS	8200	8	OTHER URBAN
6140	3	WETLANDS	8210	8	OTHER URBAN
6150	3	WETLANDS	8220	8	OTHER URBAN
6150	3	WETLANDS	8300	8	OTHER URBAN
6160	3	WETLANDS	8300	8	OTHER URBAN
6170	3	WETLANDS	8310	8	OTHER URBAN
6171	3	WETLANDS	8320	8	OTHER URBAN
6172	3	WETLANDS	8330	8	OTHER URBAN
6200	3	WETLANDS	8340	8	OTHER URBAN
			8350	8	OTHER URBAN

Appendix B

Summary List of Contacts

Citrus
1. Duda and Sons
2. Wes Williamson

Improved Pasture
1. Wes Williamson
2. Ralph Pelaez
3. Eugene Stokes
4. Daniel Candler
5. Golden Land Ranch
6. Charles Syfrett

Sod Farm.
1. Daniel's Sod Farm

Sugarcane
1. Sugarcane Growers Association
2. University of Florida

Dairy
1. McArthur Farms
2. Larson Dairy

Commercial Retailer
1. Lextron Animal Health
2. Miller Machinery and Supply CO
3. Southeast Milk, Inc.
4. Fast Track
5. Feed, medicine

Poultry
1. Okeechobee Egg

County Agents
1. Carol Cloud-Bailey, Martin County
2. Charlie Williams, Osceola County
3. Max Still, Highland County
4. Anita Neal, St. Lucie County
5. Shelley Humphrey, Glades County

Manufacturer of Phosphorus Products
1. Gator Feed
2. Okeechobee Feed
3. Syfrett Feed
4. United Feed Co
5. Walpole Feed and Supply
6. IMC Fertilizer
7. DACS-fertilizer
8. Diamond R. Fertilizer
9. Hortman Jimmie W. Spreader Service
10. Dairy Feeds, Inc
11. John Brooks
12. Mary Hartnug, FFAA

Golf Course
1. Polo Club Golf Course
2. Okeechobee Golf and Country Club

Sludge Haulers
1. Key West suppliers
2. NO OTHERS FOUND

Sludge Appliers
1. Kirton Ranch
2. NO OTHERS FOUND

Septic Companies
1. Roto Rooter
2. Mid Florida
3. Boswell Septic Tank

Appendix C

Beef Pasture Phosphorus Use Survey

General Description

Farm Layout and Design

Please provide a map of your beef operation with the fields indicated, if available.

Has your farm operation changed in the past five years? Yes ☐ No ☐
If yes, please describe ____
____

Was your farm a buyout dairy? Yes ☐ No ☐ If yes, what was the dairy herd size?
______ milking cows

What BMP's do you implement?

Soil testing for phosphorus	☐	How often? __________________
Fencing waterways	☐	Estimate length of fence _______
Wetland or other buffer strips	☐	
Other	☐	Description __________________

Do you employ other management practices that affect phosphorus use on your farm?
Yes ☐ No ☐

If yes, please describe ____

Are you considering any new phosphorus management practices?
Yes ☐ No ☐

If yes, please describe ____

What is your average stocking rate? __________ cows/acre

Please describe variations ___________________________

What type of grasses other than bahia do you grow onsite?

____

Phosphorus-Containing Inputs

Fertilizer

Please list type and quantity of purchased fertilizers.

Fertilizer Type	Quantity

How often do you apply fertilizer? ___________________________________

What type of application do you use? ________________________________

Do you follow IFAS recommendations? Yes ☐ No ☐

Can you estimate your average annual phosphorus application rate per acre?
__________ lbs/ac/yr

Do you apply different amounts of fertilizer to different fields? Yes ☐ No ☐
If yes, why ____

Do you produce forage on-site for supplementation? Yes ☐ No ☐

If yes, please list fertilizer type, quantity applied, and frequency of application.

Fertilizer type	Quantity	Frequency of application

Have your fertilization rates changed in the past five years? Yes ☐ No ☐ Please describe ____

Do you purchase your fertilizers locally? Yes ☐ No ☐

Supplements

Do you supplement your cattle with minerals, molasses, or other supplements?
Yes ☐ No ☐

If yes, please estimate type and quantity.

Supplement type	Quantity

D you purchase your supplements locally? Yes ☐ No ☐

Other Imports

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase____________________________
____

Phosphorus-Containing Products

Liveweight

Can you estimate annual liveweight sales? Yes ☐ No ☐
Please describe
____
____

Other Products

Do you sell forage or other crops? Yes ☐ No ☐
If yes, description and quantity ____________________________________

Other products? Yes ☐ No ☐
If yes, description and quantity ____________________________________

Dairy Phosphorus Use Survey

General Description

<u>Farm Layout and Design</u>

Please provide a map of your dairy operation with the barn and fields indicated, if available?

Has your farm layout changed in the past five years? If yes, please describe.

Which of the following terms best describes your current dairy management design?

> Total confinement – the milking herd is always in the barns/high intensity area with no access to pasture;
>
> Semi confinement – the milking herd has limited access to the milking herd pasture, with the majority of time spent in the barns/high intensity area;
>
> Dairy Rule design – this is the minimum requirement to meet Dairy Rule regulations. The milking herd spends more time in the designated pasture when not being fed or milked;
>
> Other – please describe.

Has your dairy design changed in the past five years? If yes, please describe.

Which of the following best describes your wastewater treatment method?

> Sprayfield only;
> Sprayfield and biological treatment (e.g hyacinth pond);
> Sprayfield and chemical treatment (e.g. lime);
> Sprayfield and "ecoreactor" (Bion technology biochemical system);
> Other – please describe.

Which of the following best describes your solids handling system?

> Solids are composted and sold for off-farm use;
> Solids are spread on designated fields – please indicate solids spreading area on the map, frequency, and amount of application;
> Other – please describe.

Do you employ other phosphorus management practices? Are you considering other phosphorus management practices? Please describe.

Herd Composition

What is the size of your milking herd? # cows

What is the composition of the rest of your herd (please show herd location on map)?

Dry cows #
Heifers #
Calves #
Bulls #
Other – please describe

Do you raise replacement heifers and calves onsite?

If yes, please indicate location on map.
If no, where do you get your replacements? Where do your calves go?

Phosphorus-Containing Inputs

Feed

Please estimate the quantity, type, and P content (if known) of feed consumed by the herds:

	Purchased Feed Quantity (lbs/cow/day)	Purchased Feed P Content (% P)	Purchased Feed Supplier (name of company)	Feed Produced Onsite (lbs/cow/day)	Produced Feed P Content (%P)	Feed Source (e.g.field)	Forage Quantity (lbs/cow/day)	Forage P Content (%P)	Forage Source (e.g supplier, field)
Milking cows									
Dry cows									
Heifers									
Calves									
Other									

Supplements

Do you supplement your herd with minerals, molasses, or other supplements? If yes, please describe type, quantity, and place of purchase.

Fertilizer

Do you purchase phosphorus-containing fertilizers? If yes, could you list the annual quantity, lbs P/yr. Please indicate on the map where the fertilizer is applied.

Cleaners

Please estimate the quantity and P content (if known) of your purchased cleaning agents:

	Quantity (ozs, lbs/time unit)	P Content (% P)	Place of Purchase
Detergent			
Line Cleaner			
Acid Rinse			
Other			

Other Imports

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase.

(C) Phosphorus-Containing Products

Milk

How many days per year are your cows milked? Days dry?

What is your average milk production rate? lbs/cow/day

Do you know the phosphorus content of your milk product? %P

Are there seasonal variations in production? Could you provide monthly records? Annual totals?

Where is the milk sold?

Do your cows receive BST? Other production enhancements?

Can you list any other factors that affect milk production?

Have you noticed changes in your milk production rates in the past five years?

Liveweight

What is your average cull rate? # cows/yr.

What is the average cull cow weight? lbs/cow.

What is your average calving rate? # calves/yr.

Number of calves sold? calves/yr. Calves kept onsite? #/yr

What is the average calf weight? lbs/calf.

Other liveweight sales? Please describe.

<u>Compost</u>

Do you sell compost?   tons/yr. Do you receive payment for compost? If yes, do you know where it goes when exported?

<u>Other Products</u>

Do you sell forage? Description and quantity.

Do you sell other crops? Description and quantity.

Other products? Please describe.

Truck Crop Phosphorus Use Survey

General Description

<u>Farm Layout and Design</u>

Please provide a map of your truck crop operation with the fields indicated, if available.

Has your farm operation changed in the past five years? If yes, please describe.

Which of the following practices have you implemented?
Soil testing for phosphorus – please indicate frequency;
Crop rotation – please indicate frequency;
Sludge application;

Do you employ other management practices that affect phosphorus use on your farm?
Are you considering any new phosphorus management practices? Please describe.

<u>Production Practices</u>

What percentage of your acreage is in production? Please indicate areas on map.

Phosphorus-Containing Inputs

<u>Fertilizer</u>

Please list type and quantity of purchased fertilizers.

Do you apply different amounts of fertilizer to different crops? If yes, why? Can you indicate fertilizer rates by crop type on your map?

Can you estimate your average annual phosphorus application rate per acre?

Have your fertilization rates changed in the past five years? ten years? Please describe.

Where do you purchase your fertilizers?

<u>Other Imports</u>

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase.

(C) Phosphorus-Containing Products

Truck Crops

Please indicate annual crop production by variety.

Are your crops packaged or processed? If yes, where?

Other Products

Other products? Please describe.

Citrus Phosphorus Use Survey

General Description

<u>Farm Layout and Design</u>

Please provide a map of your citrus operation with the fields indicated, if available.

Has your farm operation changed in the past five years? If yes, please describe.

What BMP's do you implement?
Soil testing for phosphorus,
Impoundments.

Are you considering any new phosphorus management practices? Please describe.

What types of citrus do you grow?

<u>Production Practices</u>

What percentage of your acreage is in production? What percentage is in new grove or reset? Please indicate areas on map.

What varieties of citrus do you produce? Please indicate on map.

At what age do your new trees begin production?

Phosphorus-Containing Inputs

<u>Fertilizer</u>

Please list type and quantity of purchased fertilizers.

Do you apply different amounts of fertilizer to different groves (e.g. for mature groves vs. reset)? If yes, why? Can you indicate fertilizer rates on your map?

Can you estimate your average annual phosphorus application rate per acre?

Have your fertilization rates changed in the past five years? the past ten years? Please describe.

Do you purchase your fertilizers locally?

What type of application do you use? (band, drip, other?)

Other Imports

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase.

(C) Phosphorus-Containing Products

Citrus

Please indicate annual citrus production by variety.

Other Products

Do you sell other crops? Description and quantity.

Other products? Please describe.

Sugarcane Phosphorus Use Survey

General Description

Farm Layout and Design

Please provide a map of your sugarcane operation with the fields indicated, if available.

Has your farm operation changed in the past five years? If yes, please describe.

Which of the following practices have you implemented?
- Soil testing for phosphorus – please indicate frequency;
- Crop rotation – please indicate frequency;
- Sludge application;
- Flooding.

Do you employ other management practices that affect phosphorus use on your farm? Are you considering any new phosphorus management practices? Please describe.

Production Practices

What percentage of your acreage is in production? What percentage is in new cane? What percentage is in other production (e.g. rice, sweet, corn)? What percentage is left fallow? Please indicate areas on map.

Phosphorus-Containing Inputs

Fertilizer

Please list type and quantity of purchased fertilizers.

Do you apply different amounts of fertilizer to different cane fields? If yes, why? Can you indicate fertilizer rates by crop type on your map?

Can you estimate your average annual phosphorus application rate per acre?

Have your fertilization rates changed in the past five years? the past ten years? Please describe.

Where do you purchase your fertilizers?

Other Imports

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase.

(C) Phosphorus-Containing Products

<u>Raw Cane</u>

Please indicate annual sugarcane production by variety.

Where is your sugarcane processed?

<u>Other Products</u>

Do you sell other crops? Description and quantity.

Other products? Please describe.

Sod Phosphorus Use Survey

General Description

Farm Layout and Design

Please provide a map of your sod operation with the fields indicated, if available.

Has your farm operation changed in the past five years? If yes, please describe.

Which BMP's do you implement?
- Soil testing for phosphorus,
- Field rotation,
- Sludge application.

Are you considering any new phosphorus management practices? Please describe.

Production Practices

What percentage of your acreage is in production? Please indicate areas on map.

Phosphorus-Containing Inputs

Fertilizer

Please list type and quantity of purchased fertilizers.

Do you apply different amounts of fertilizer to different fields? If yes, why? Can you indicate fertilizer rates on your map?

Can you estimate your average annual phosphorus application rate per acre?

Have your fertilization rates changed in the past five years? ten years? Please describe.

Do you purchase your fertilizers locally?

Other Imports

Please list other purchased goods that might contain phosphorus, including quantity purchased and place of purchase.

(C) Phosphorus-Containing Products

Sod

Please indicate annual sod production by area.

Other Products

Other products? Please describe.

Business Surveys

Fertilizer Dealers

Estimate total P entering plant each year.

Provide a list of formulations containing P and quantity sold each year.

Estimate P fertilizer sales by county, by land use.

Estimate changes in P fertilizer sales in past 5 years, 10 years

Estimate % of total fertilizer supplied. Estimate % sold in basin/out of basin.

Dairy Feed Suppliers

Quantity of rations sold by herd type and by dairy; % P content

Dairy name		Milk cow	Dry cow	Heifer	Calf

Estimate changes in past 5 years, 10 years

Sales of other P containing products?

Estimate % of total dairy feed supplied. Estimate % in basin/out of basin.

Beef Feed Suppliers

Estimate quanitity and P content of minerals sold.

Estimate quantity and P content of molasses sold.

Estimate amount sold locally. % of total local supply? by farm estimates?

Other P containing products?

Estimate changes in past 5 years, 10 years

Dairy Suppliers

Estimate quantity and P content of line cleaners and detergents sold by dairy.
Other P containing products?

Sludge Haulers and Sludge Appliers

Where are sludge sources? Quantity, frequency, location

Where are the disposal sites? Quantity, etc.

Where are the application sites? Quantity, etc.

Are there new septic systems in the basin since the last survey?

New package treatment plants?

Questions for Okeechobee STP

Where is effluent discharged? P content? Records of monthly discharge?

Solids disposal options? Quantity, P content, disposal location, seasonality

Data from County Agents

Sources of published and unpublished data regarding land use types, land use changes, trends in land use, production, etc.

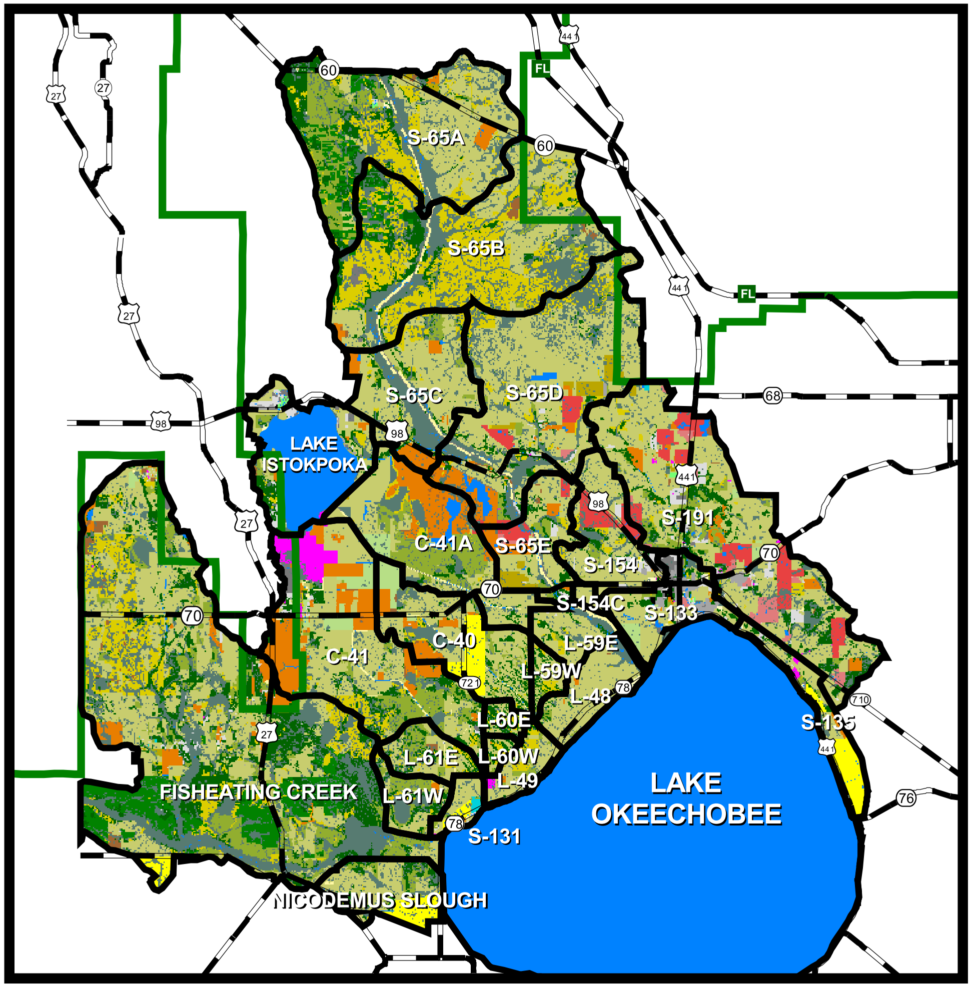
Changes in land use/land management practices?

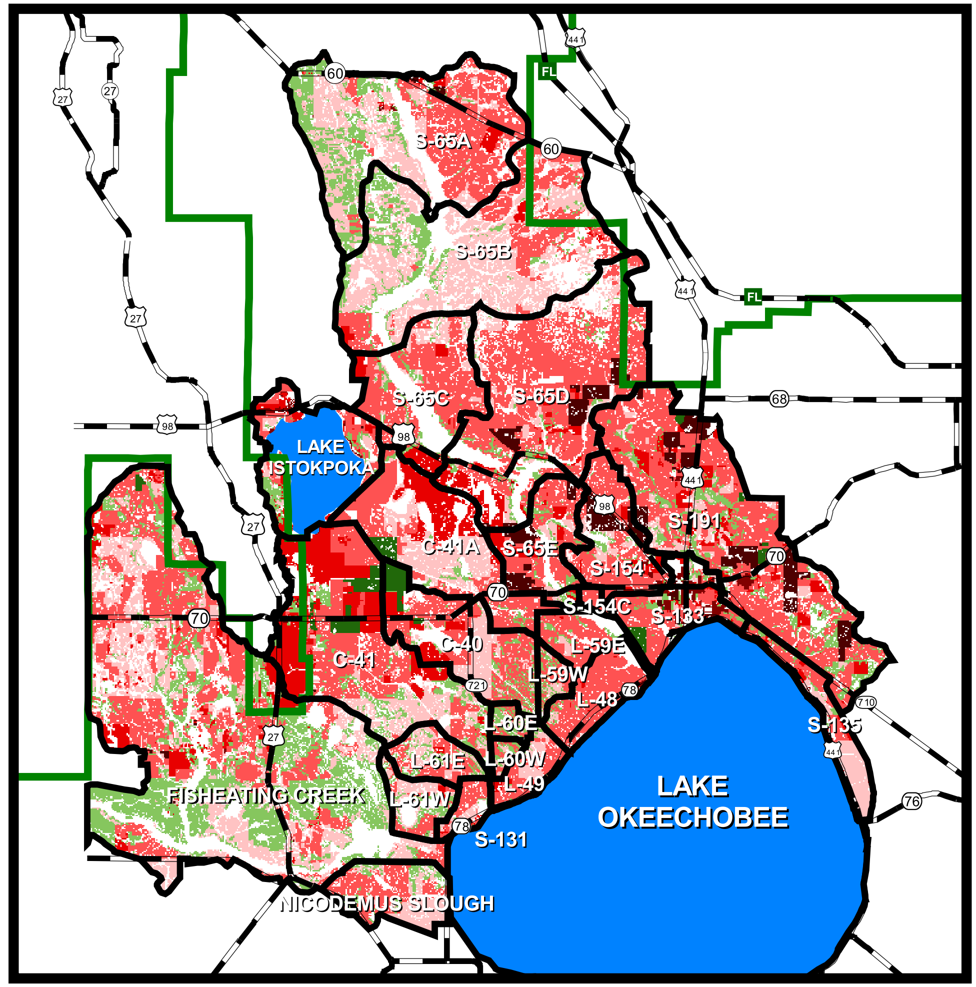
Changes in P use/significant information related to P use and management?

Appendix D

Lake Okeechobee Watershed Phosphorus Budget

N





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

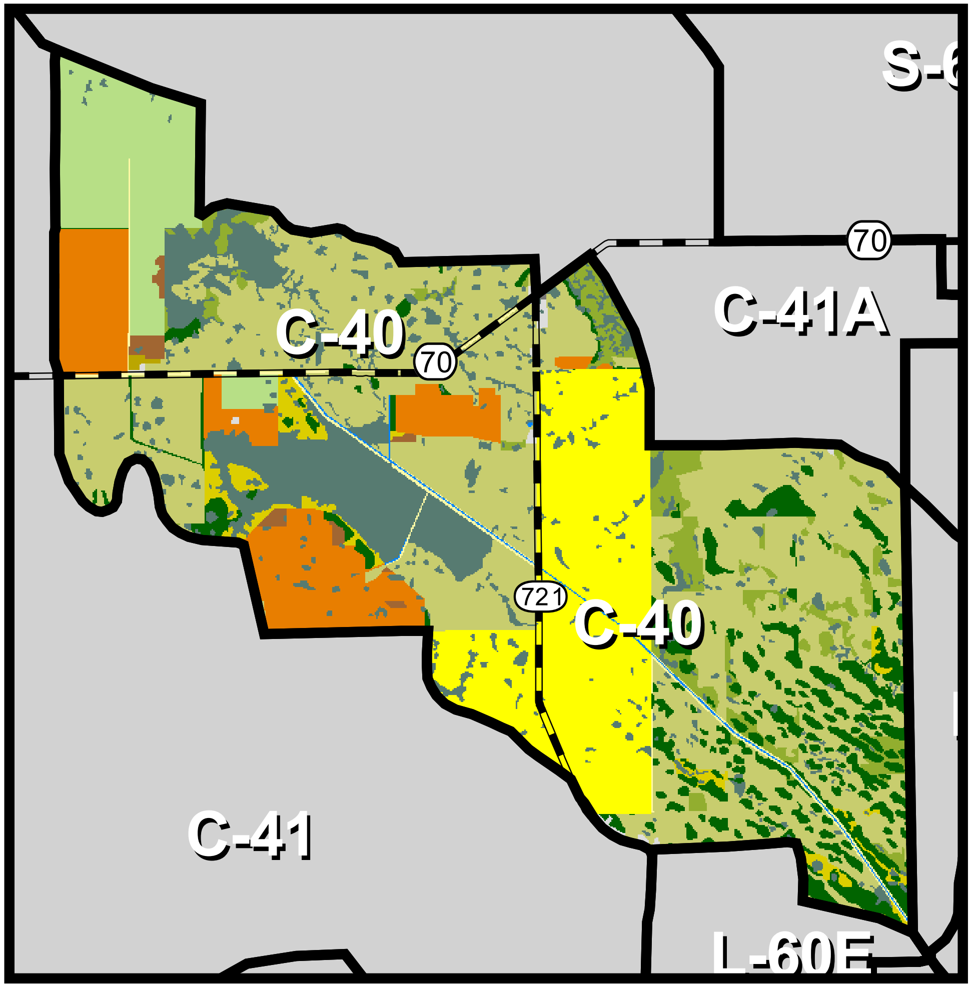
Net P Import (kg/ha-yr)

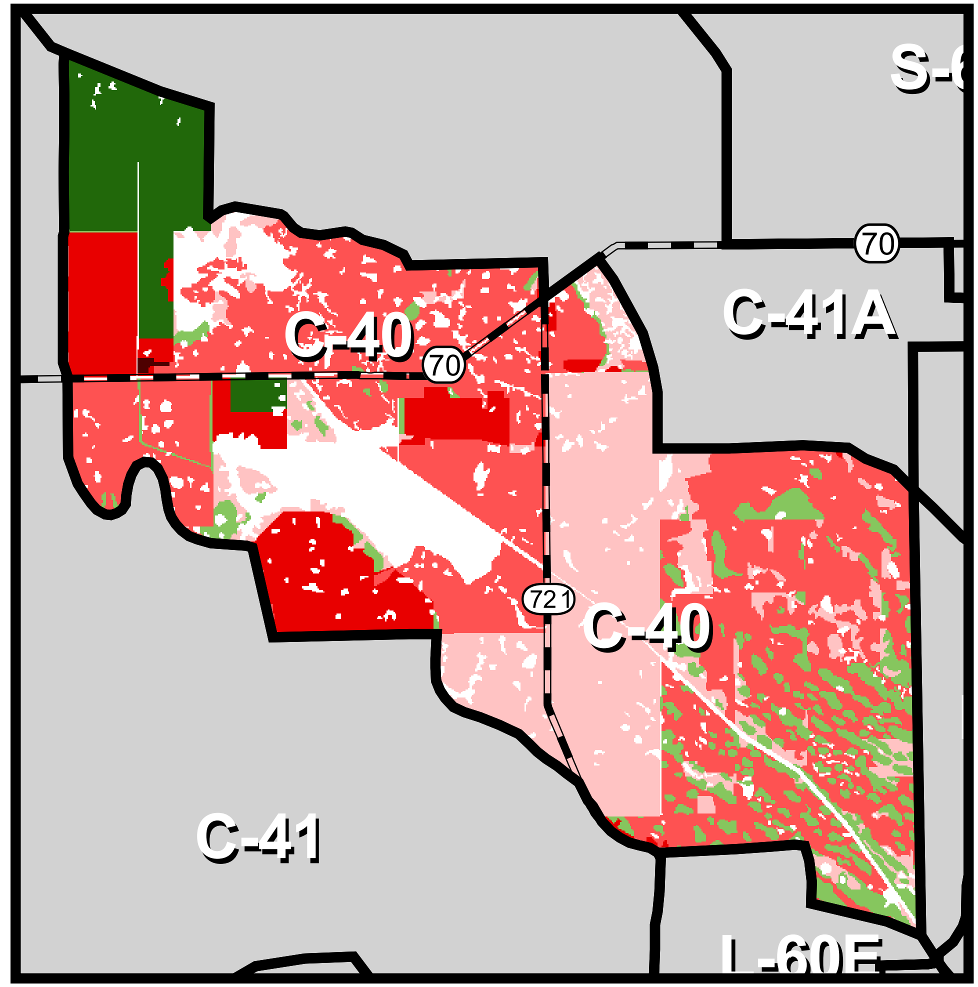
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for Lake Okeechobee Watershed Exhibit D-1

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

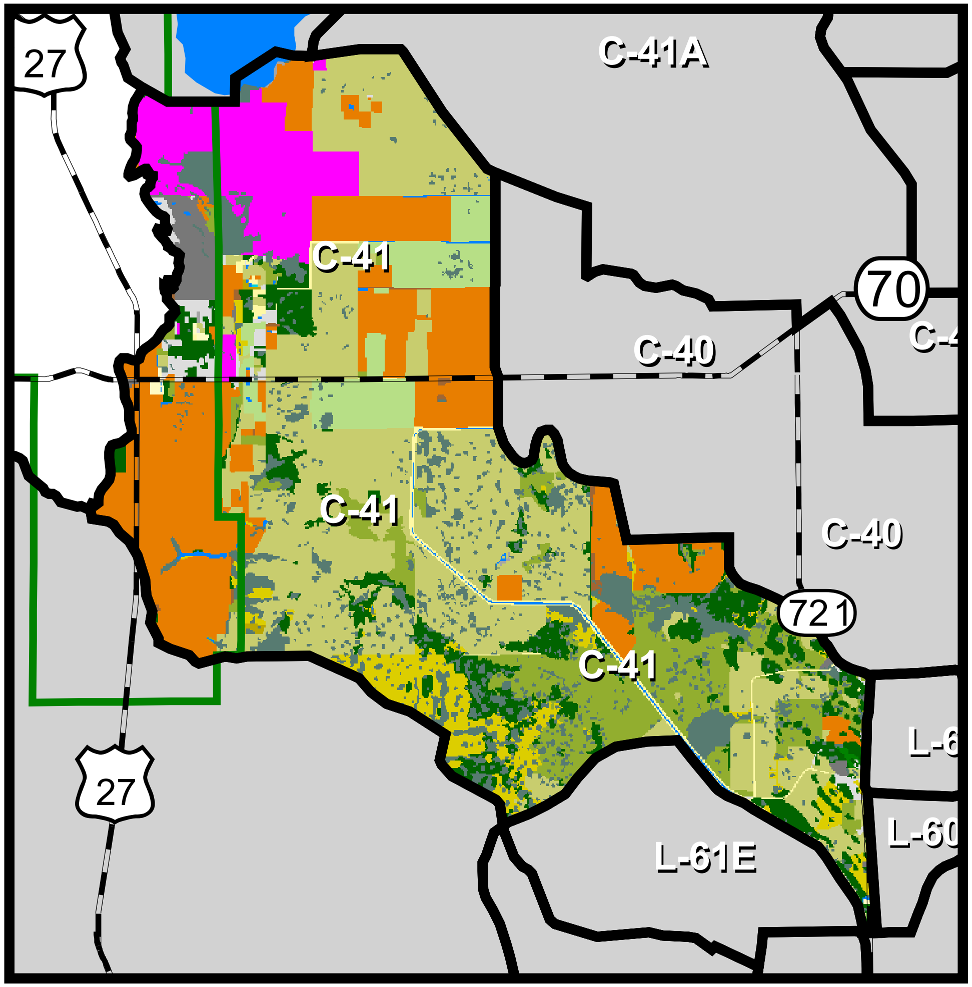
Net P Import (kg/ha-yr)

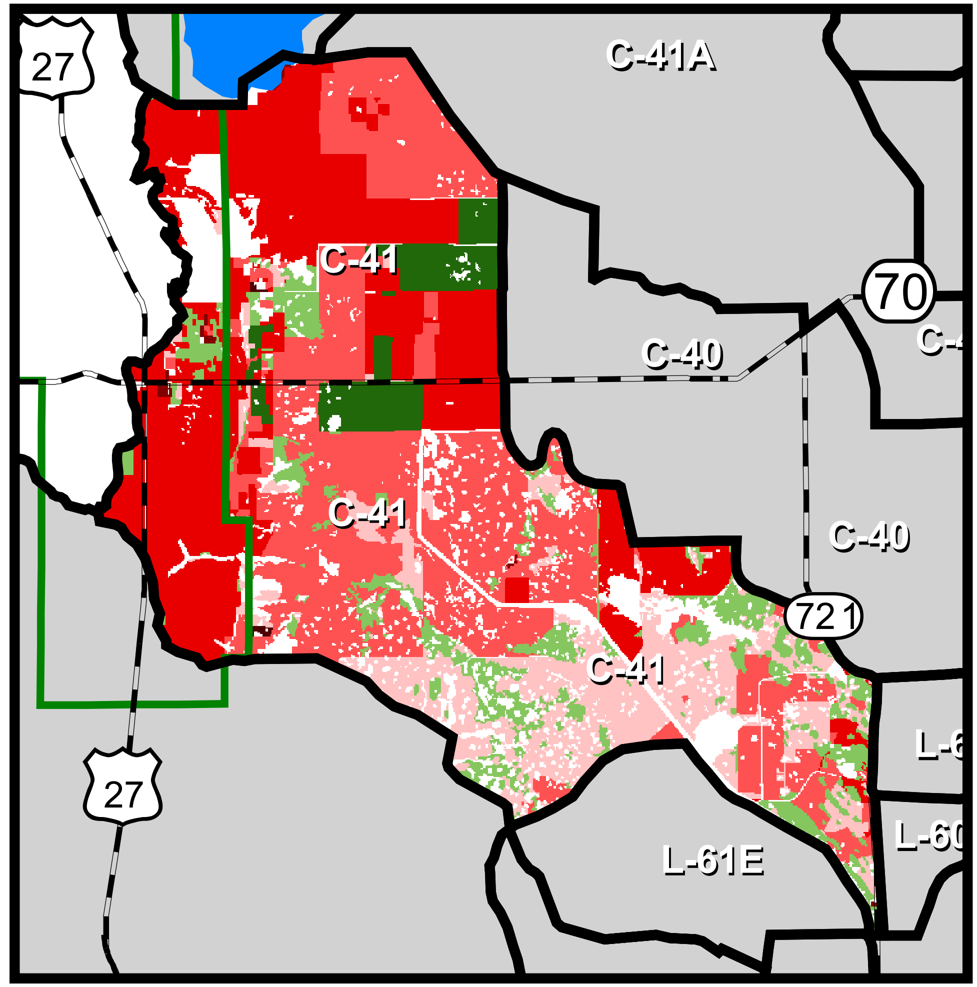
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for C-40 Basin Exhibit D-2

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

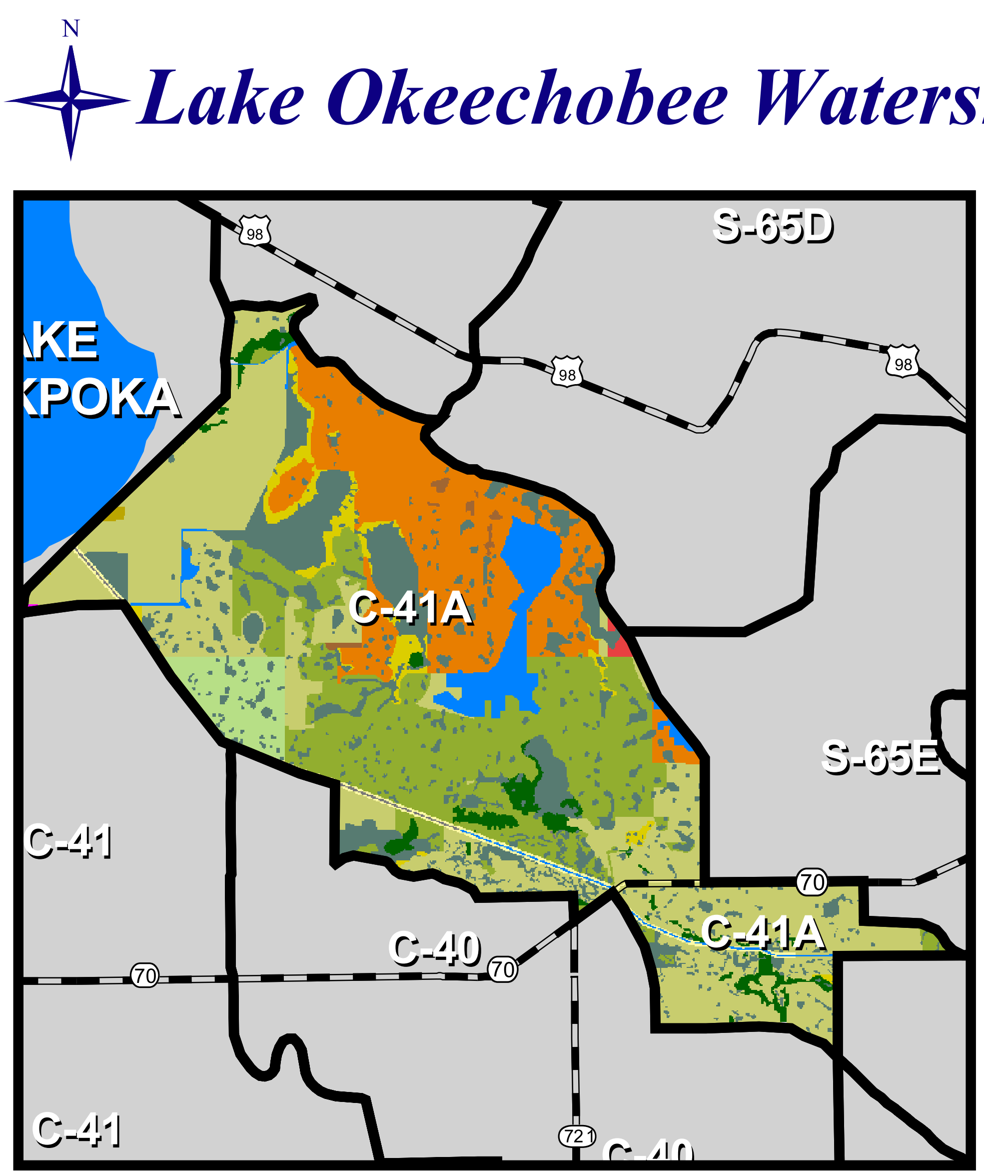
Net P Import (kg/ha-yr)

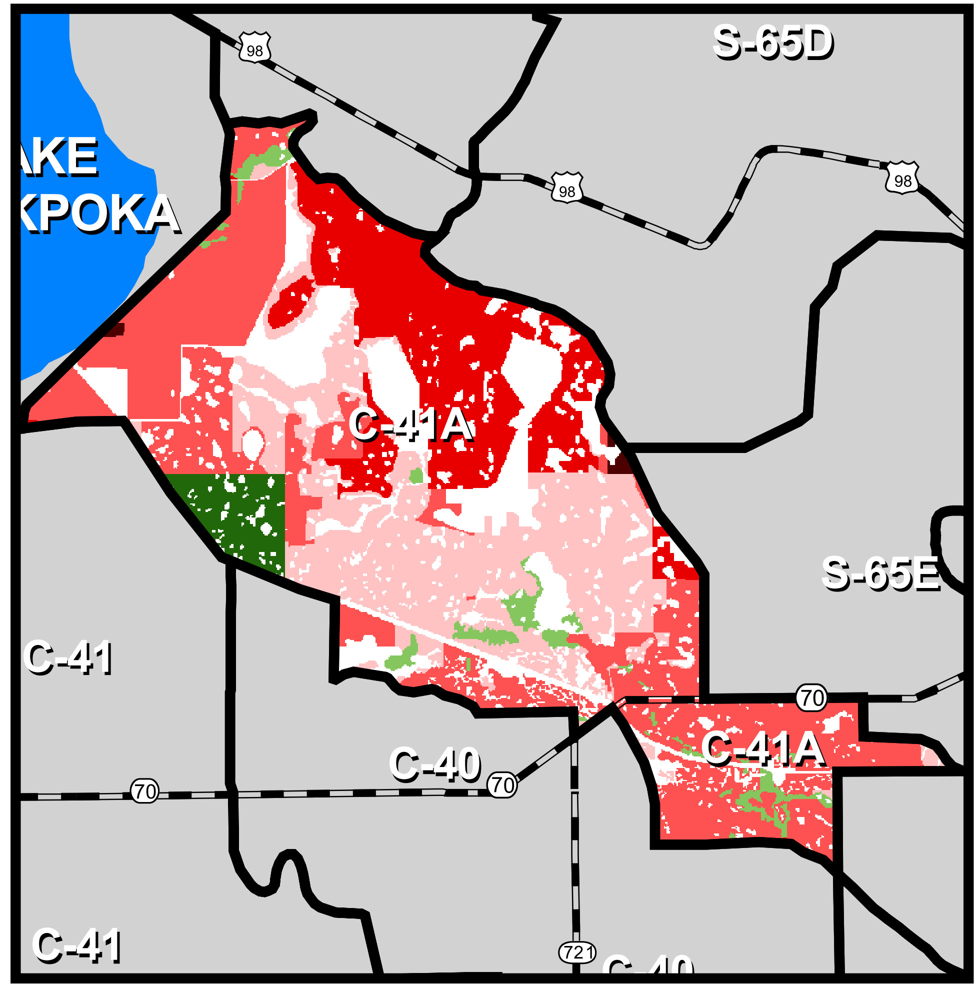
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for C-41 Basin Exhibit D-3

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

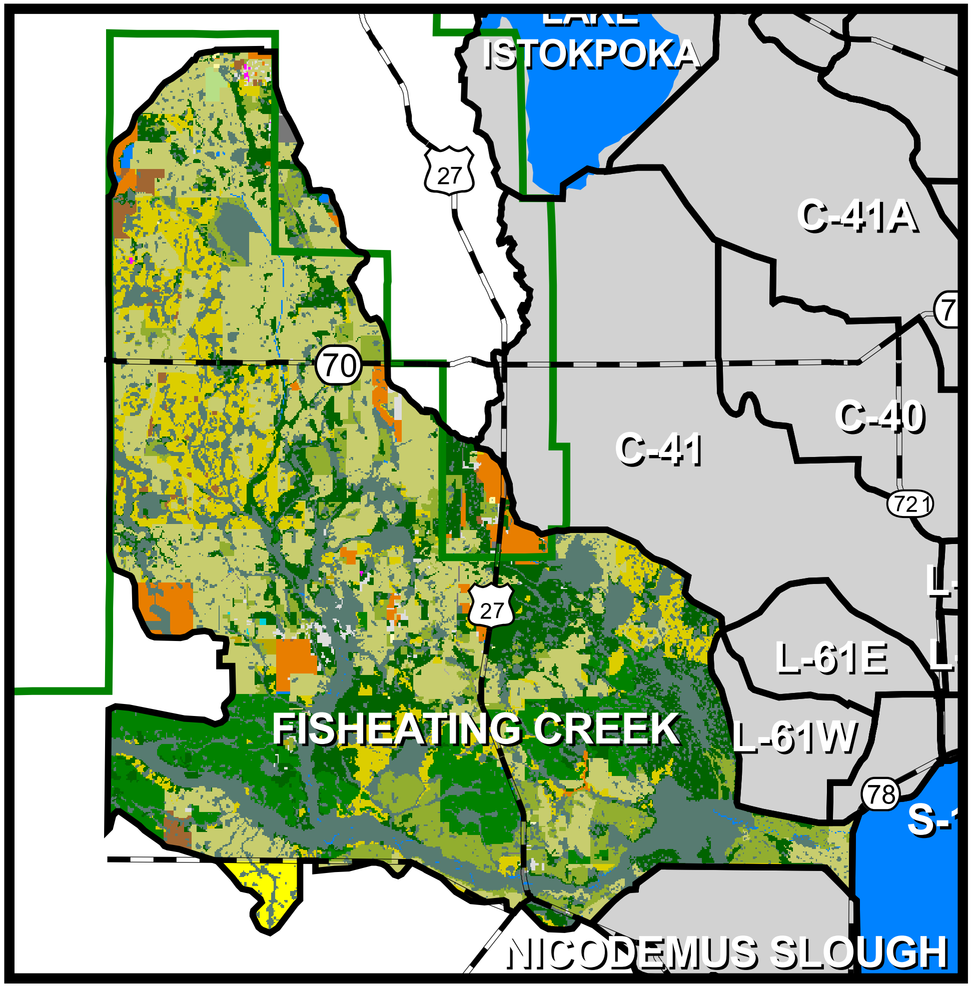
Net P Import (kg/ha-yr)

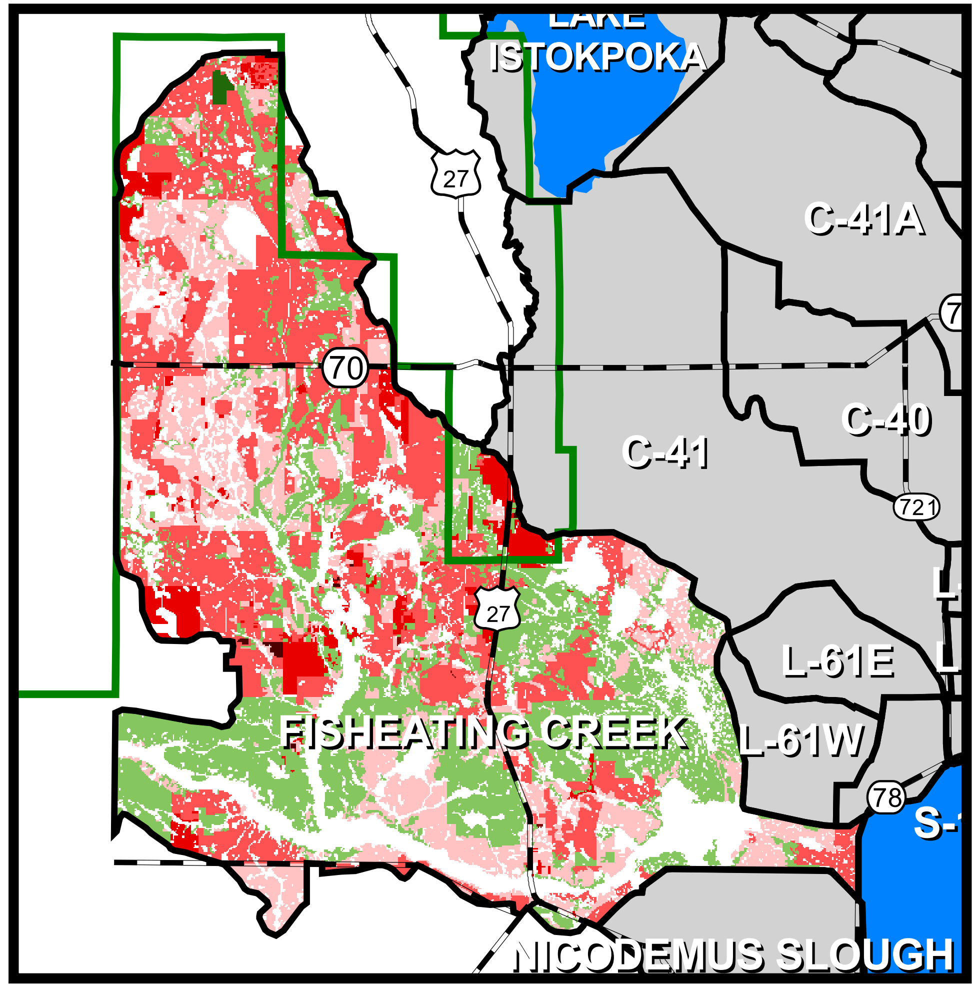
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for C-41A Basin Exhibit D-4

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

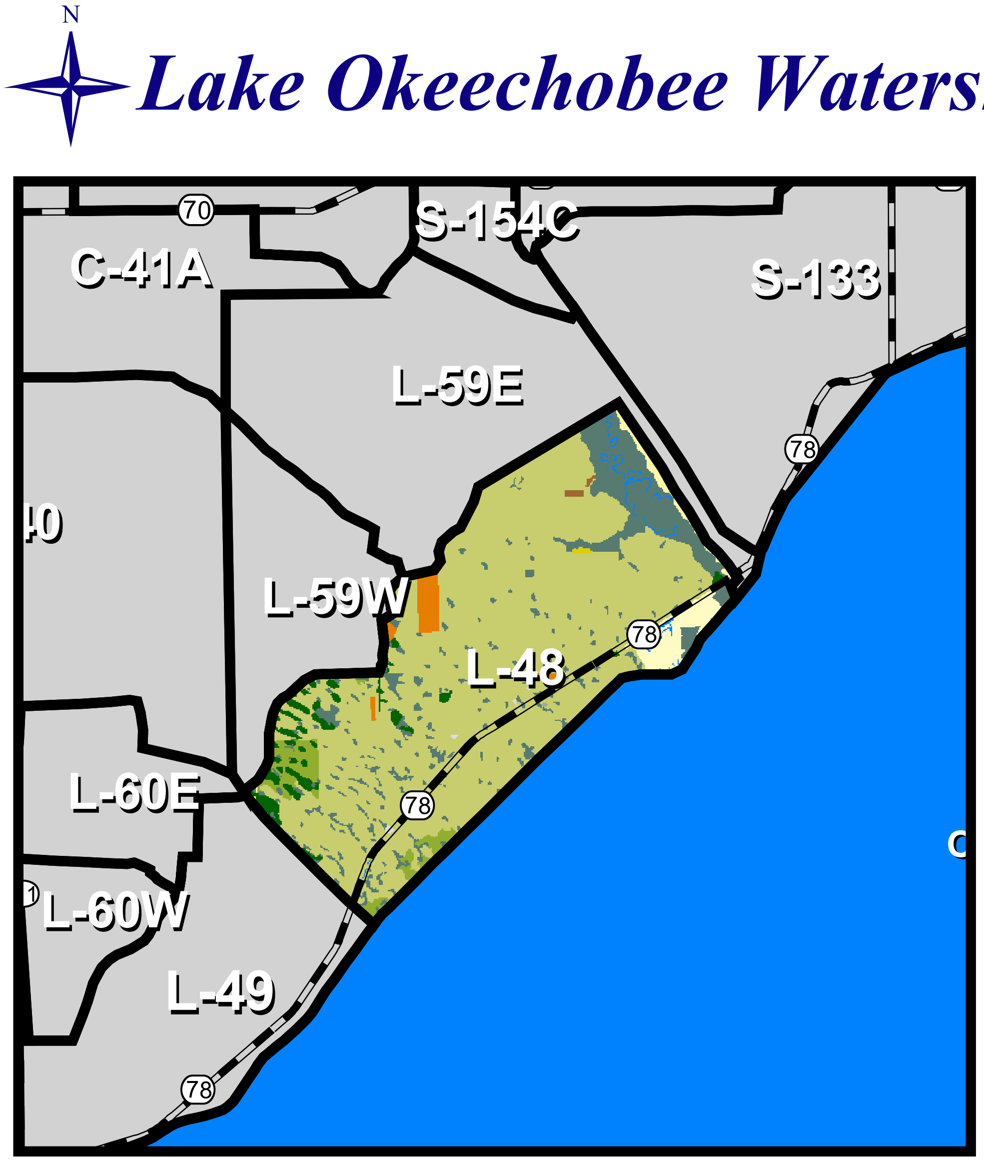
Net P Import (kg/ha-yr)

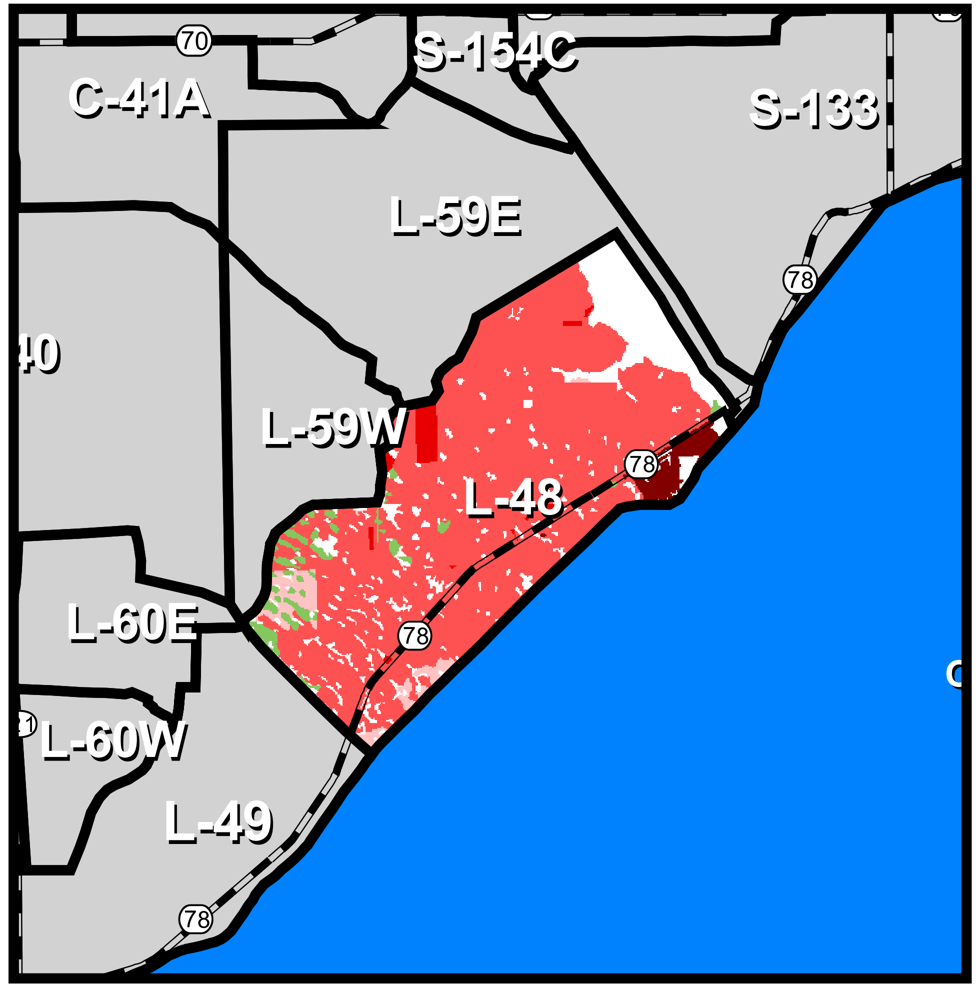
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for Fisheating Creek Basin   Exhibit D-5

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

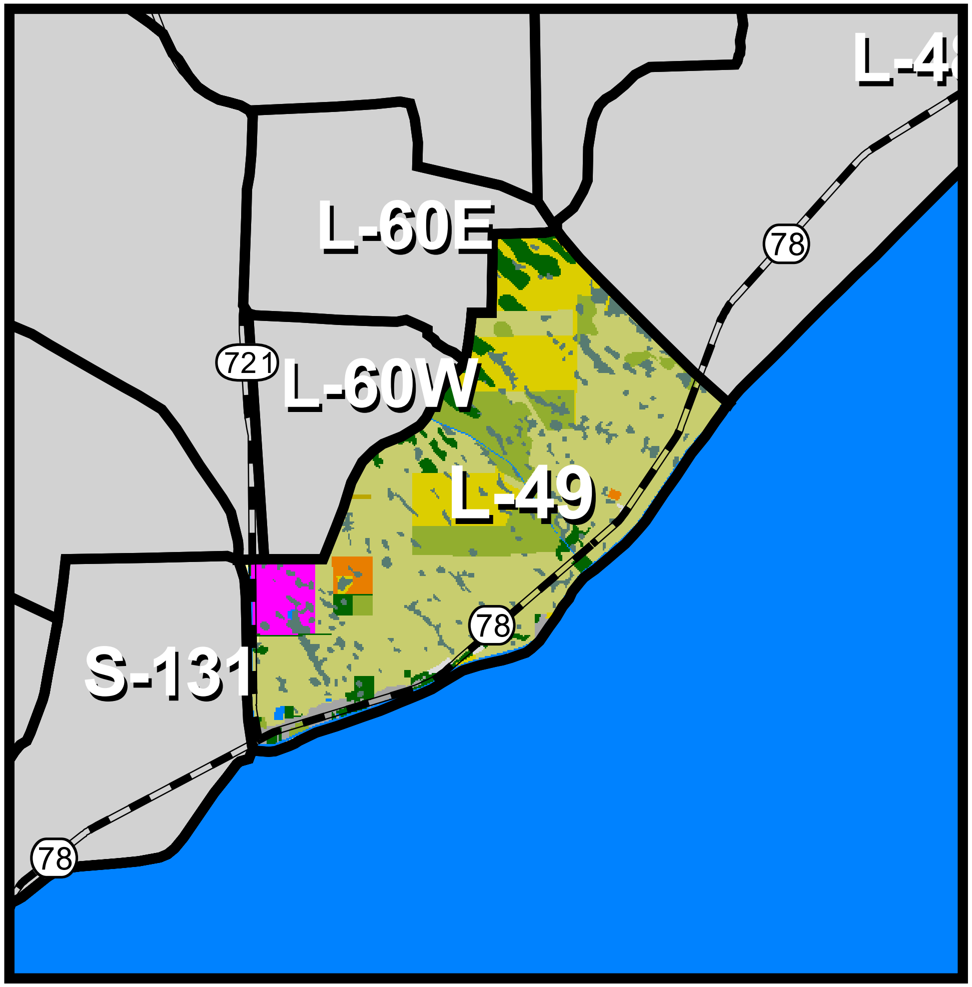
Net P Import (kg/ha-yr)

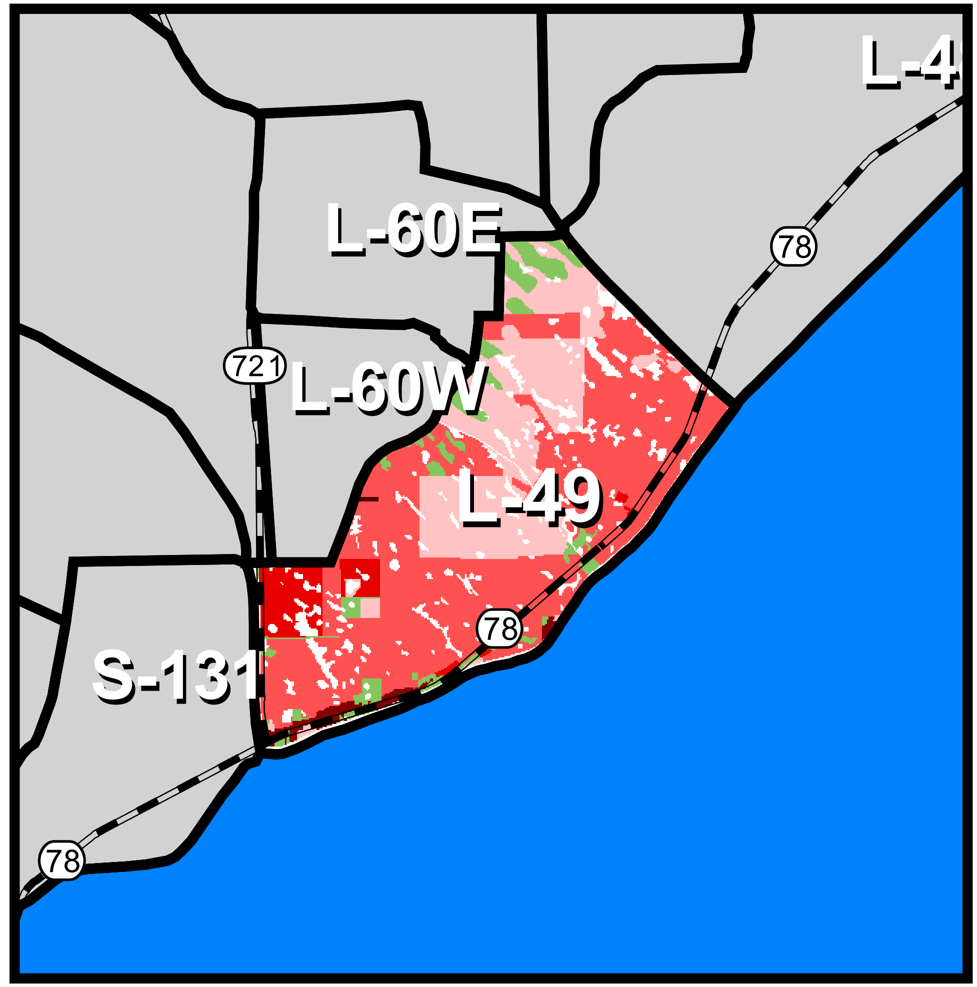
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-48 Basin Exhibit D-6

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

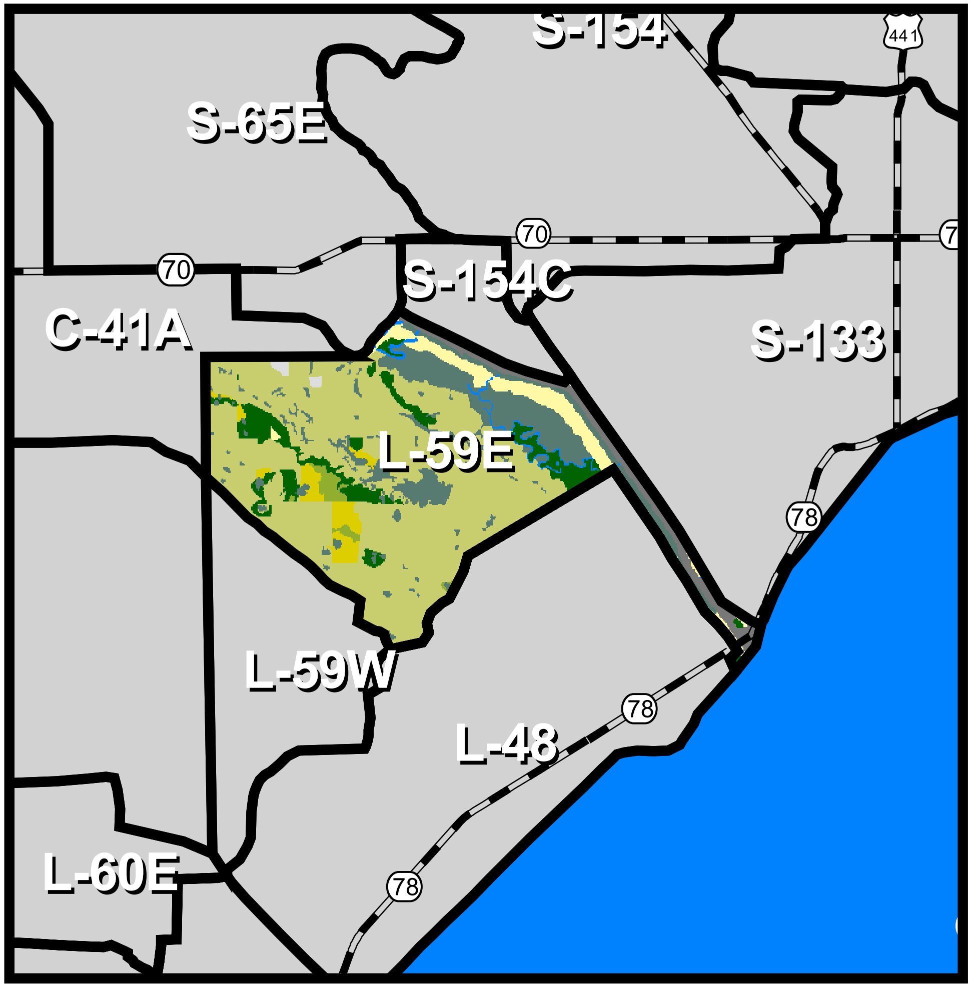
Net P Import (kg/ha-yr)

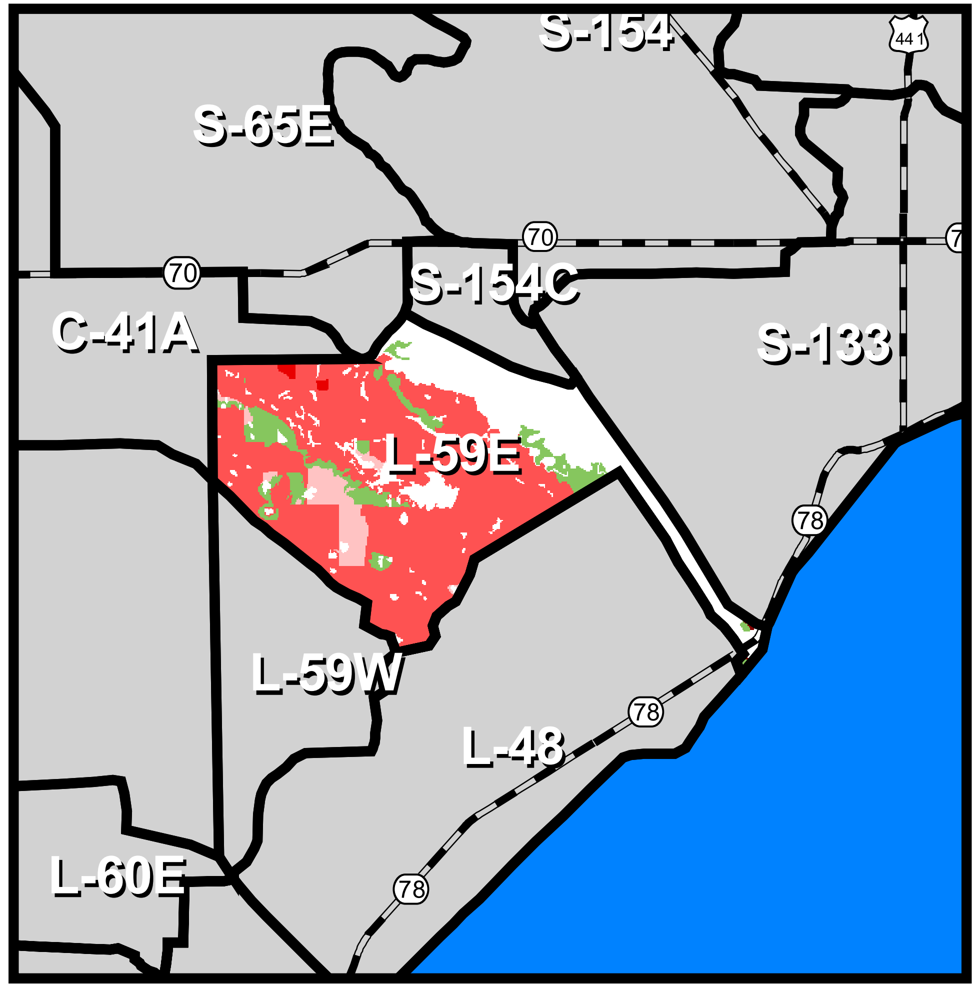
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-49 Basin Exhibit D-7

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

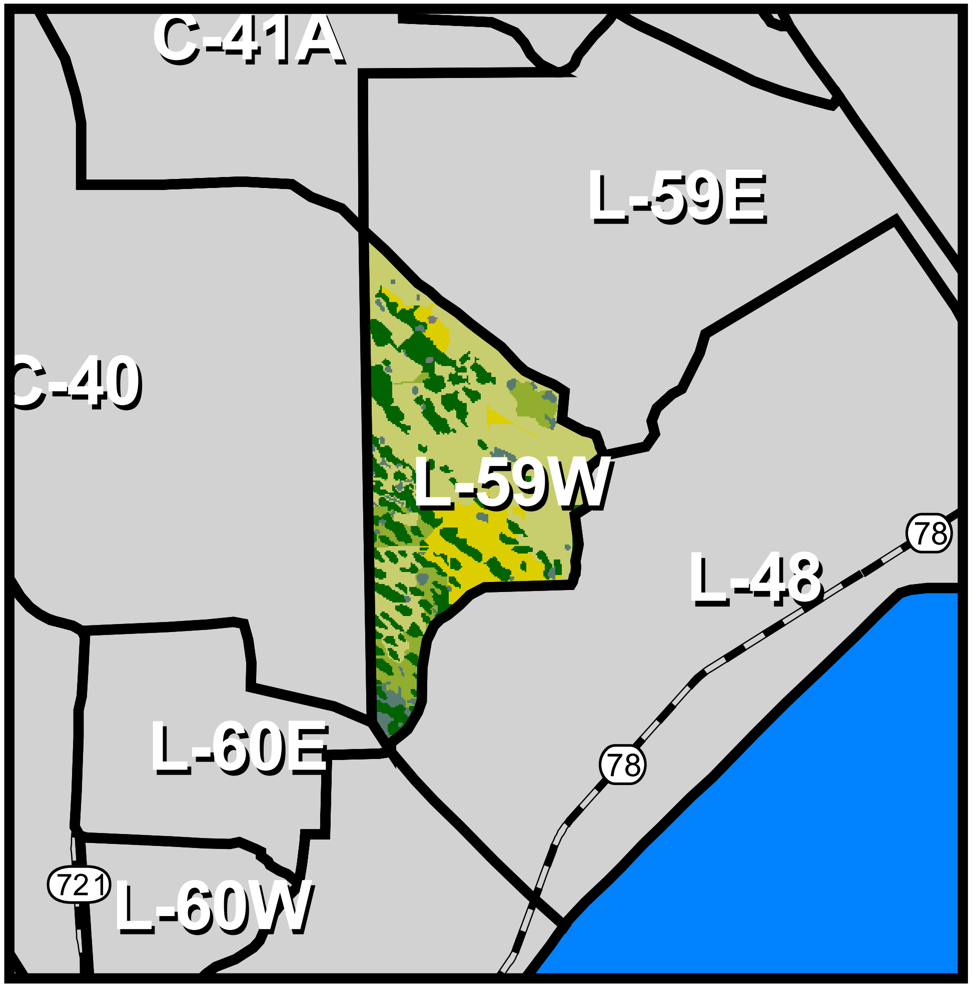
Net P Import (kg/ha-yr)

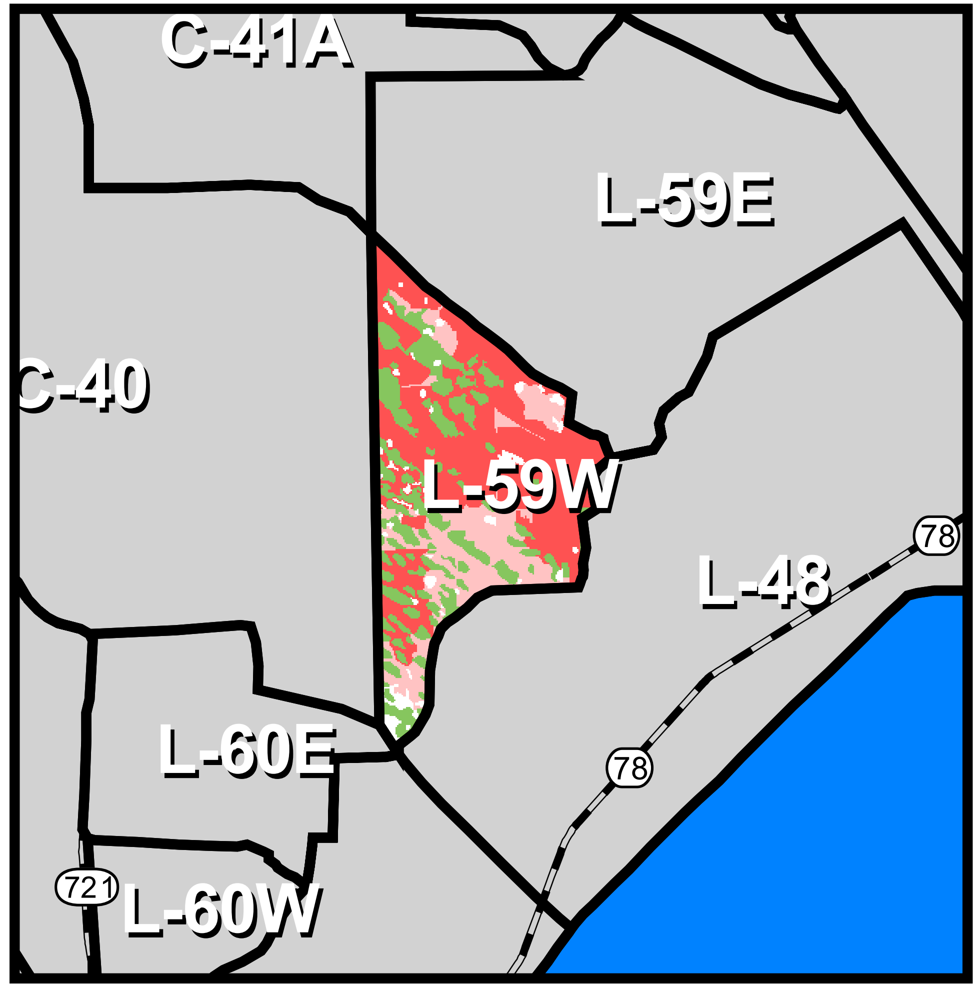
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-59E Basin Exhibit D-8

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

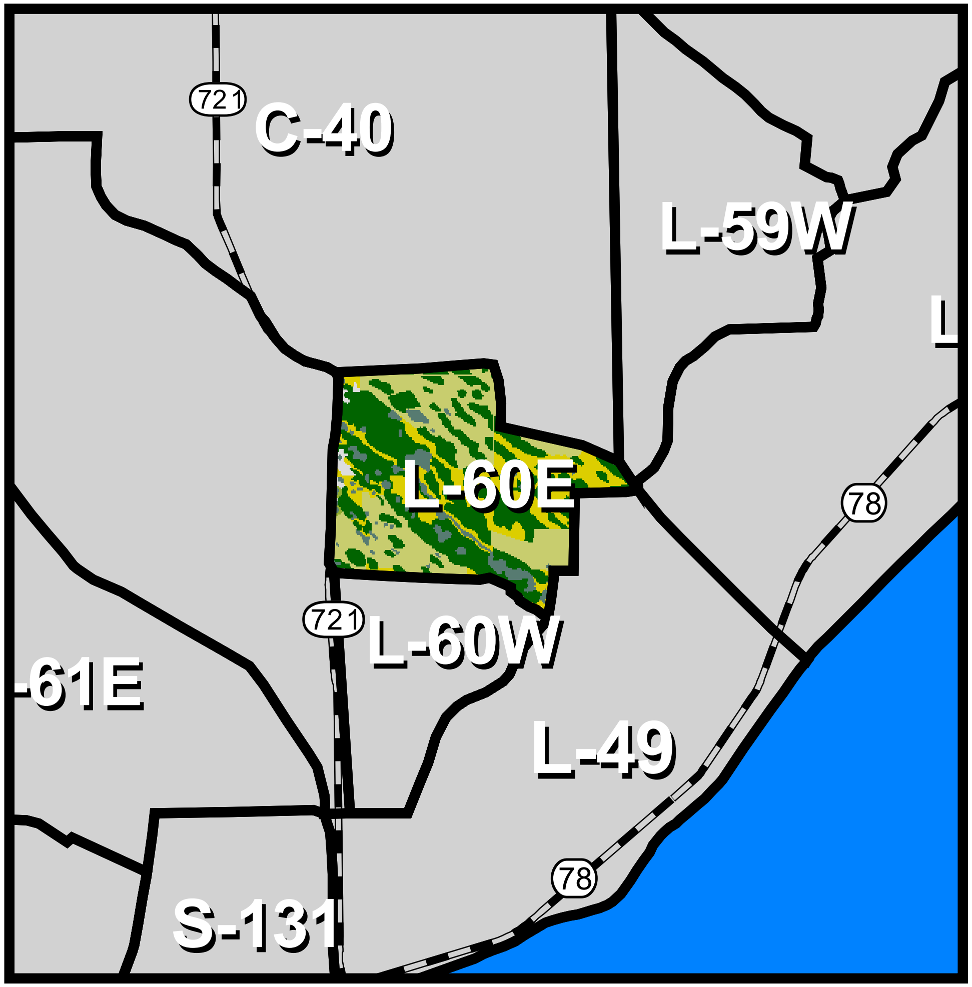
Net P Import (kg/ha-yr)

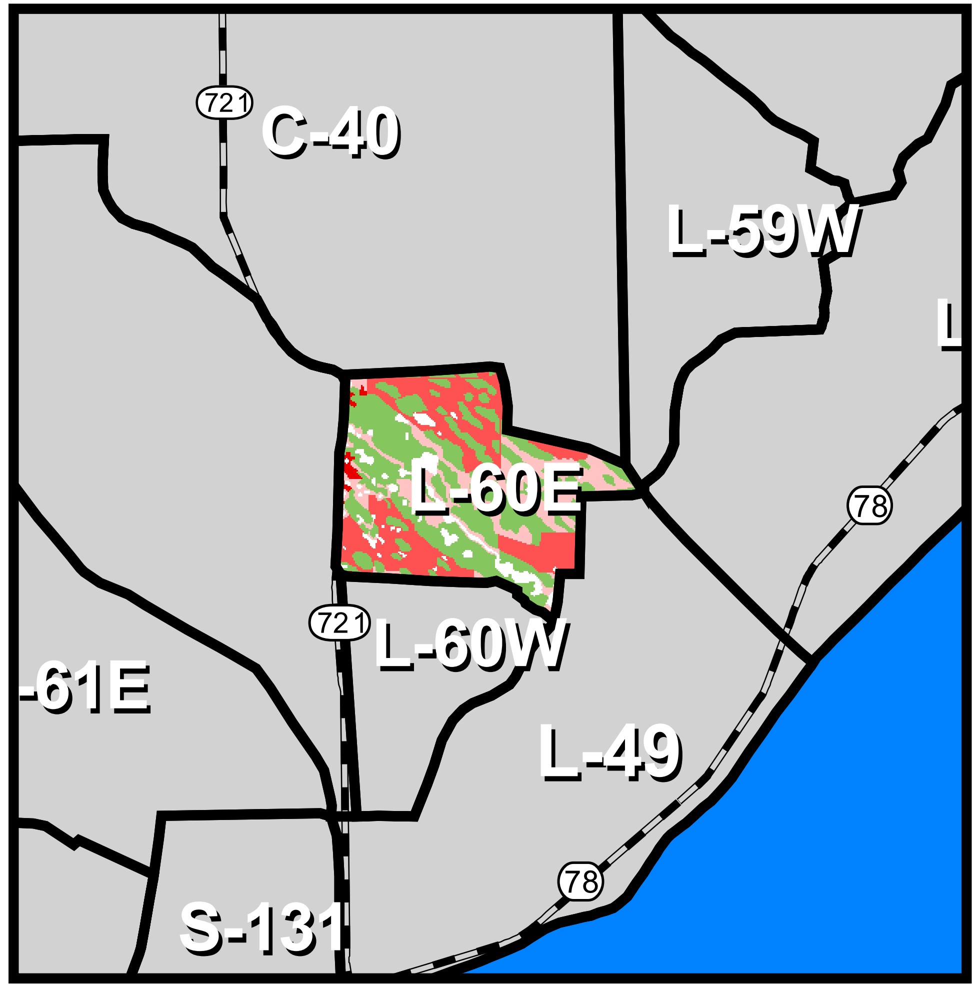
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-59W Basin Exhibit D-9

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

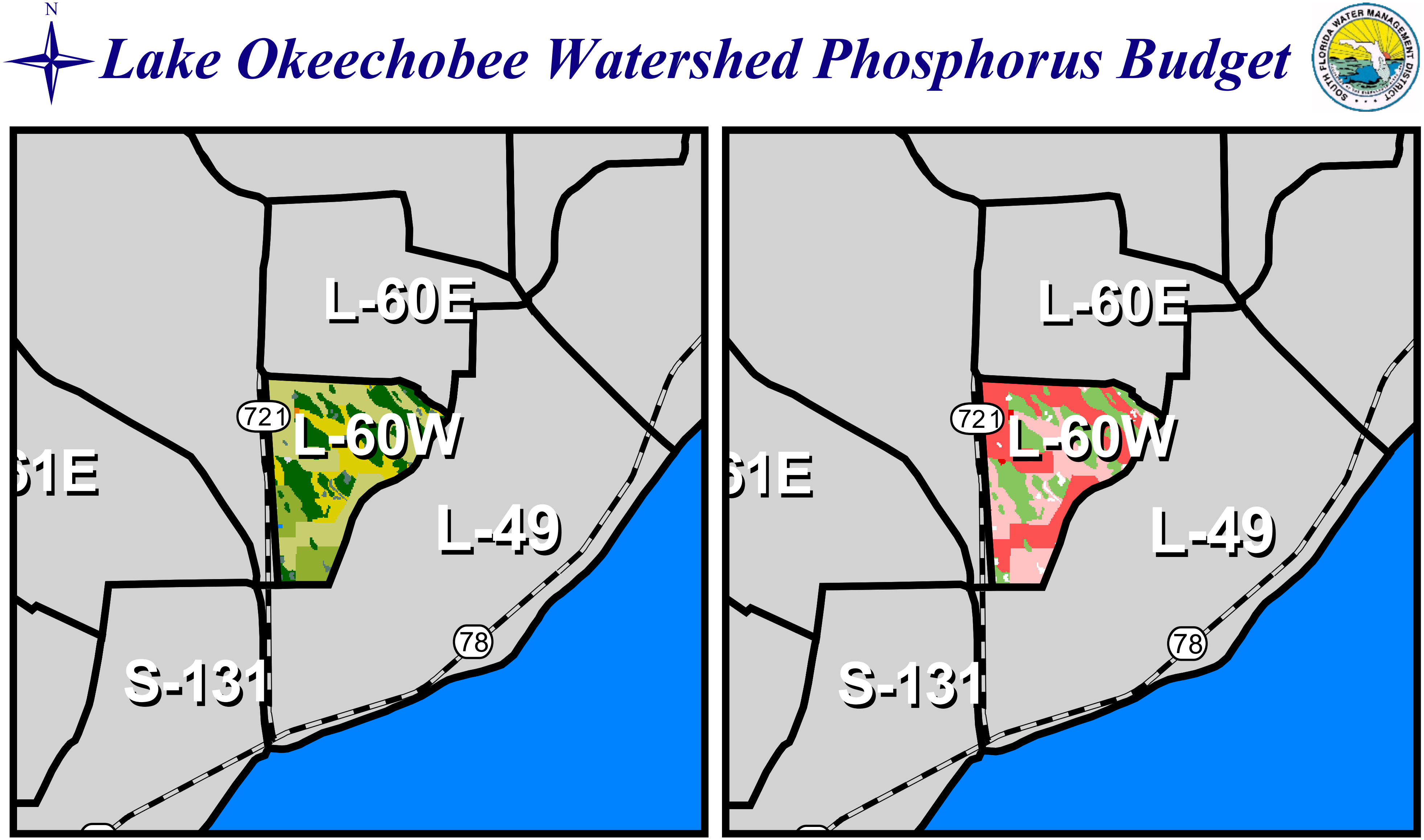
Net P Import (kg/ha-yr)

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-60E Basin Exhibit D-10

Lake Okeechobee Watershed Phosphorus Budget



Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

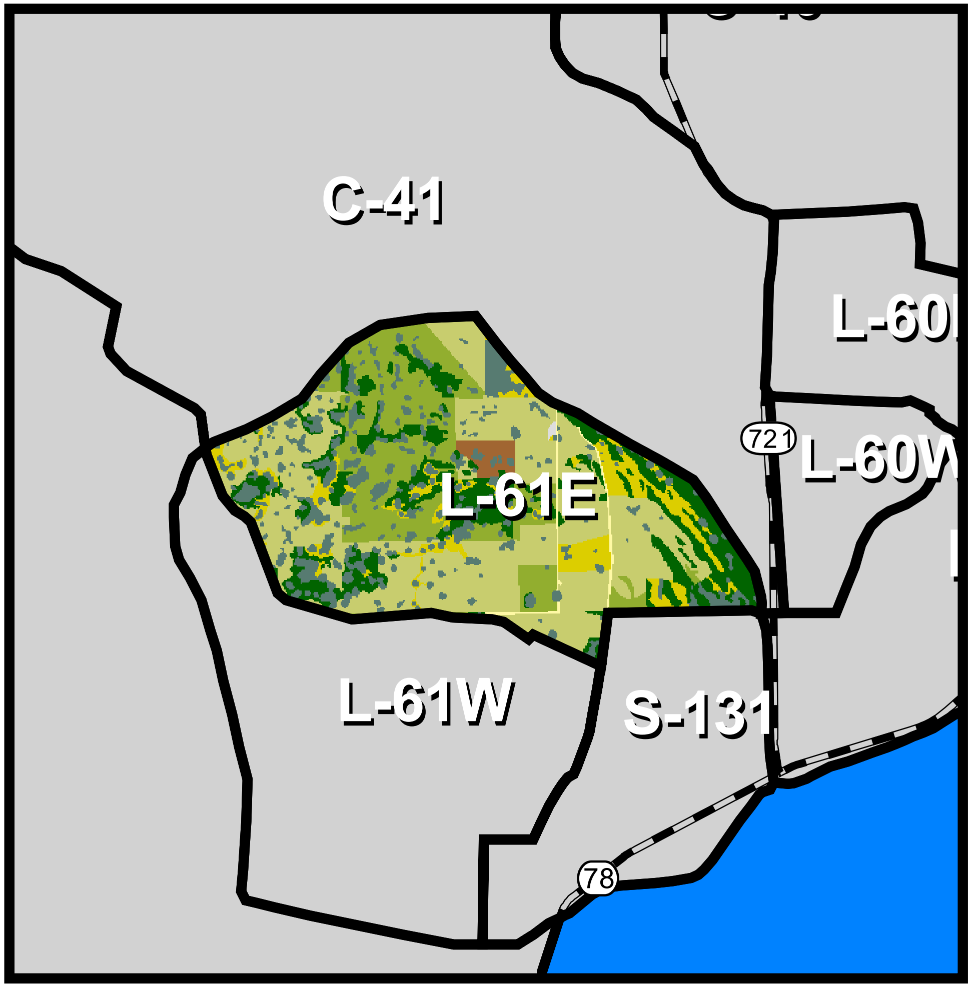
Net P Import (kg/ha-yr)

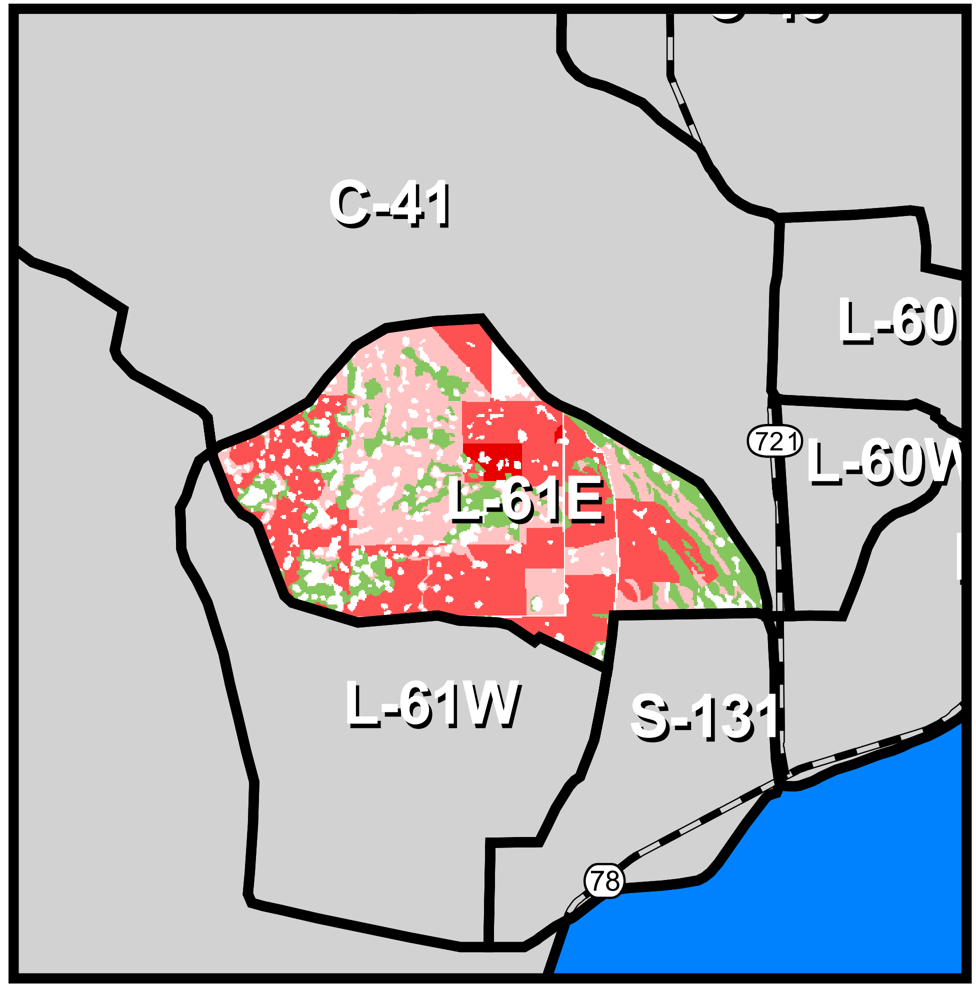
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-60W Basin Exhibit D-11

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

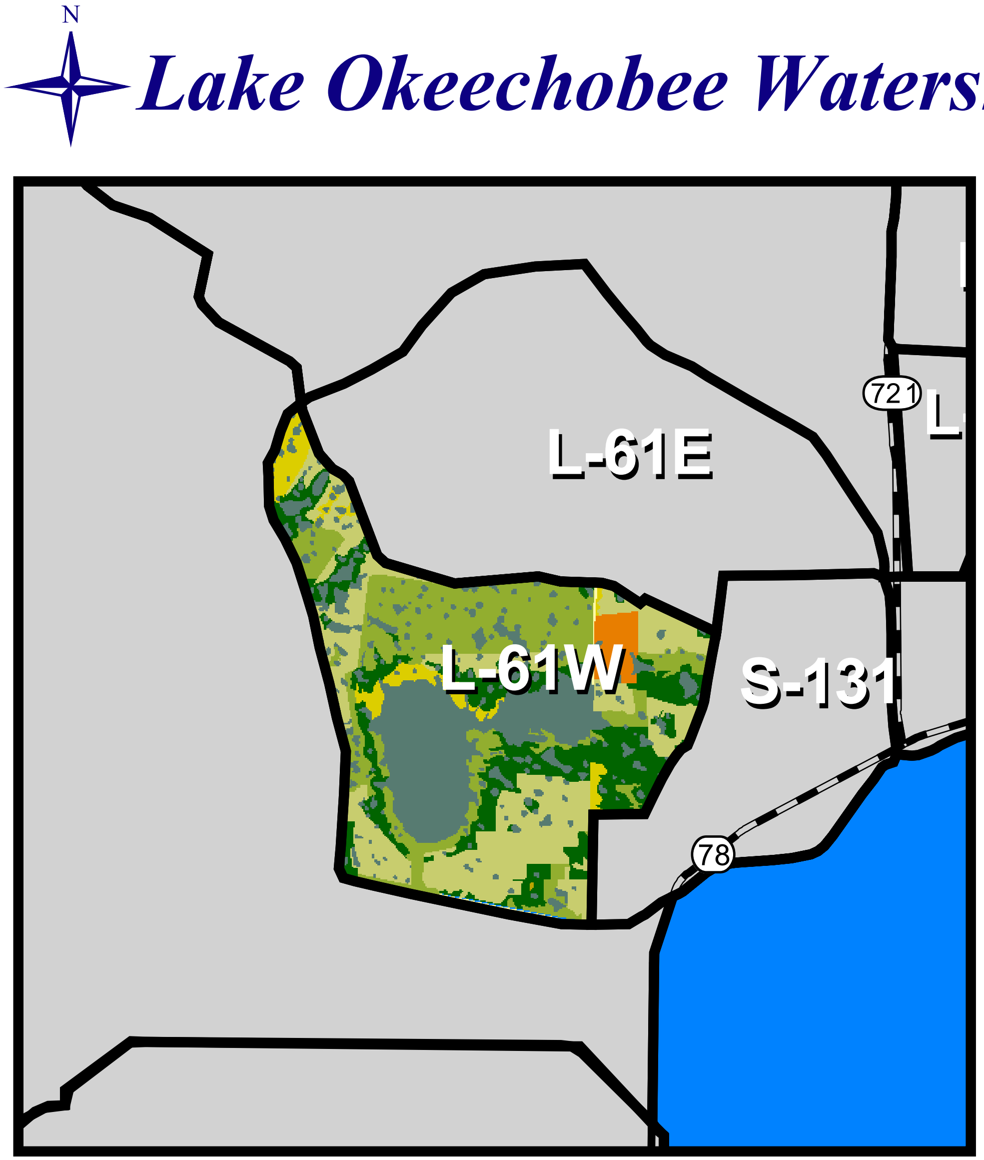
Net P Import (kg/ha-yr)

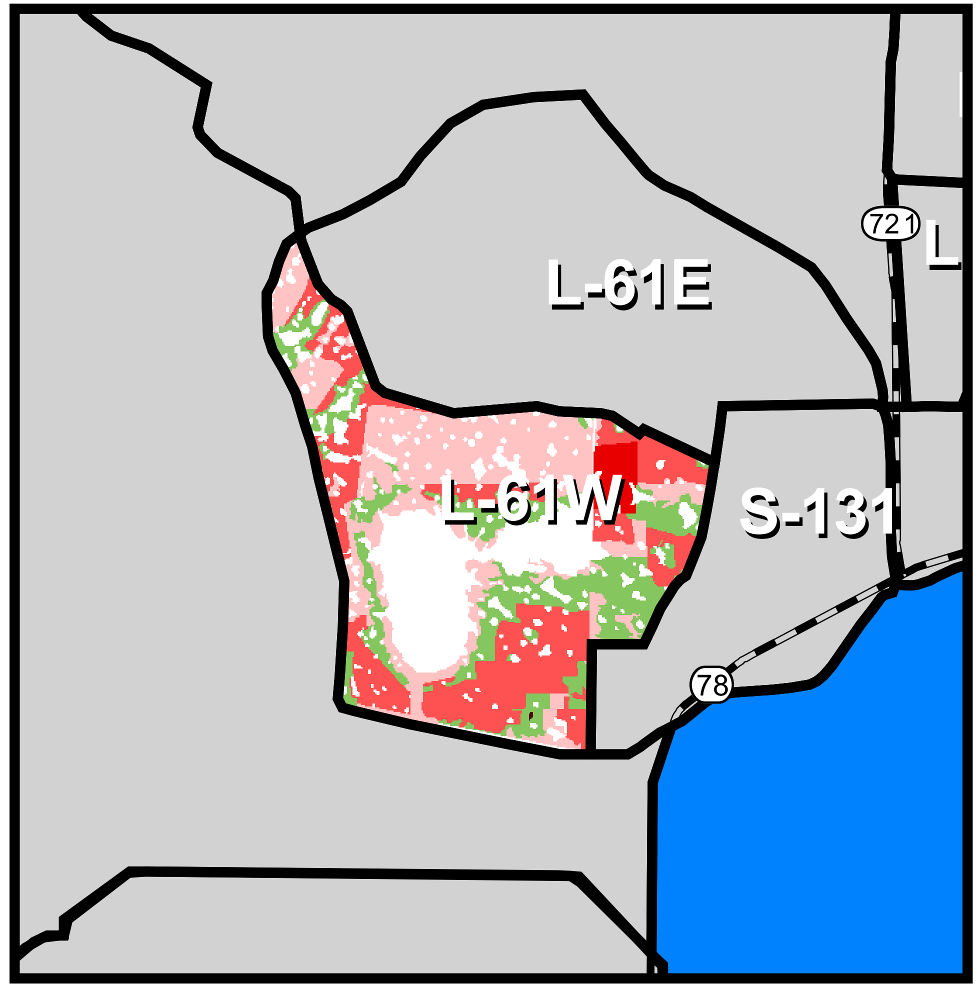
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-61E Basin   Exhibit D-12

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

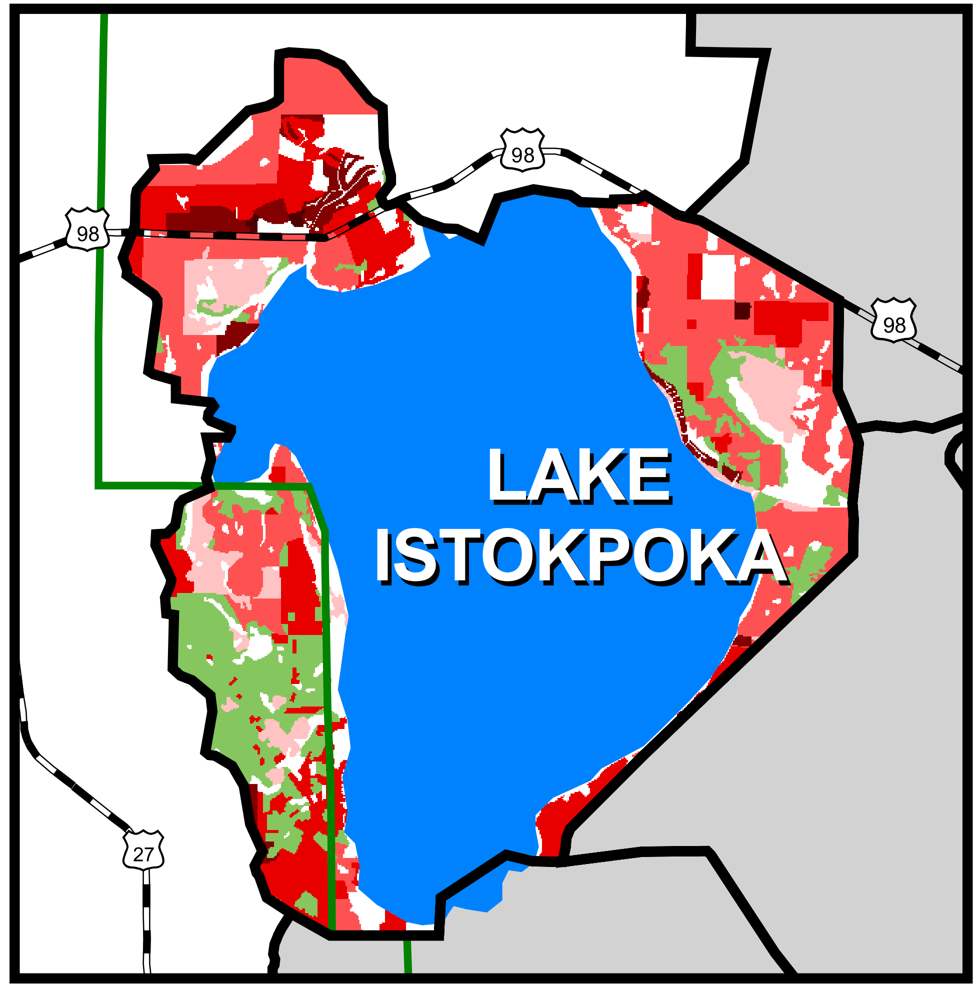
Net P Import (kg/ha-yr)

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for L-61W Basin Exhibit D-13

Lake Okeechobee Watershed Phosphorus Budget



Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

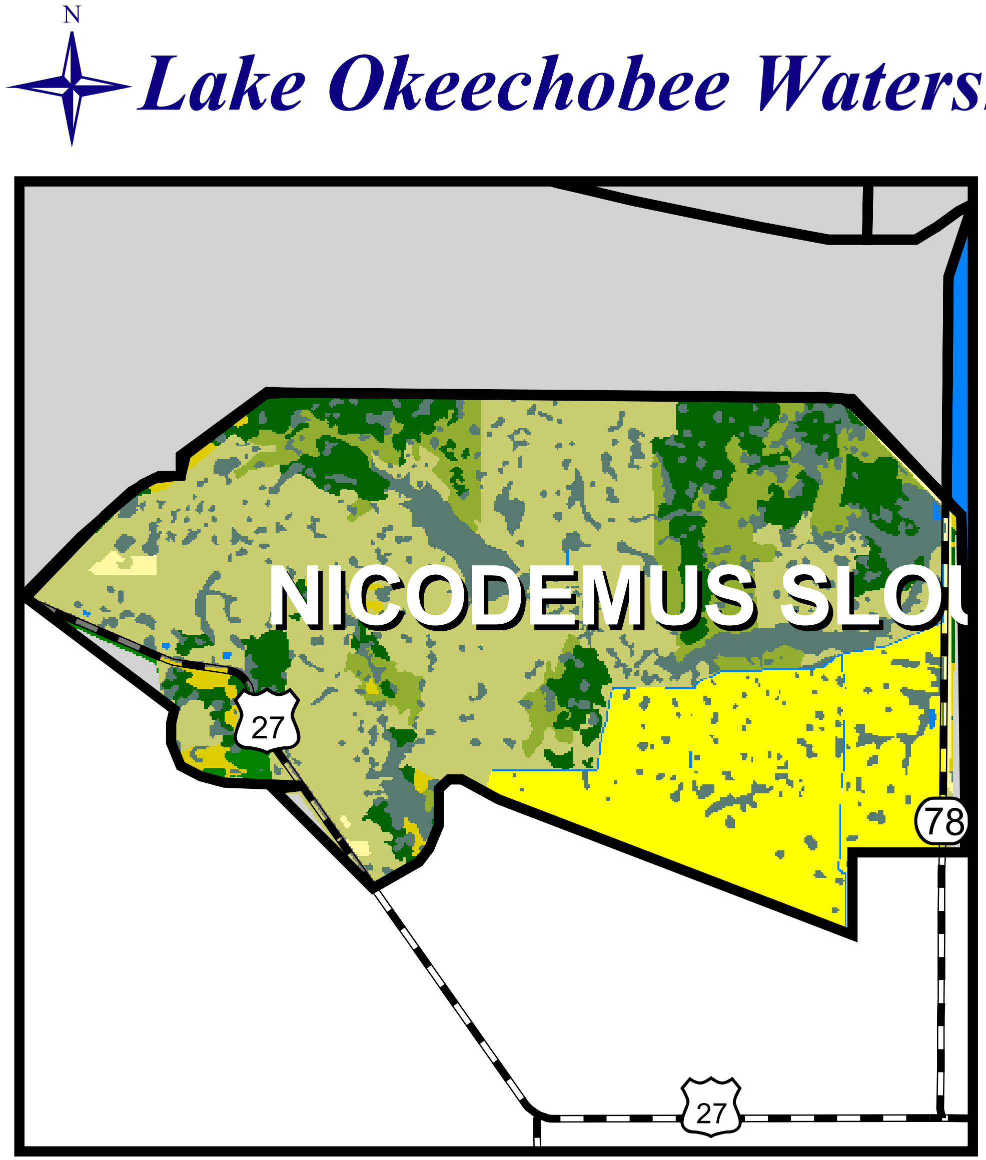
Net P Import (kg/ha-yr)

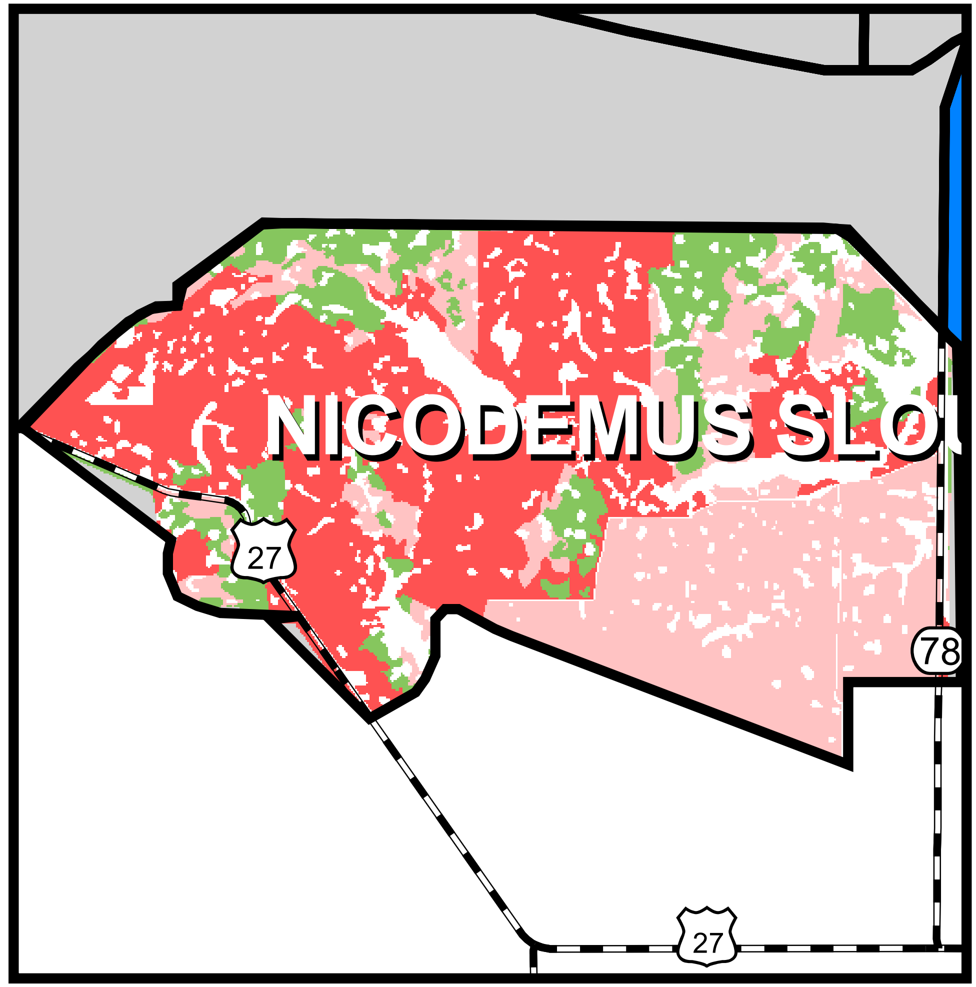
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for Lake Istokpoga Basin Exhibit D-14

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

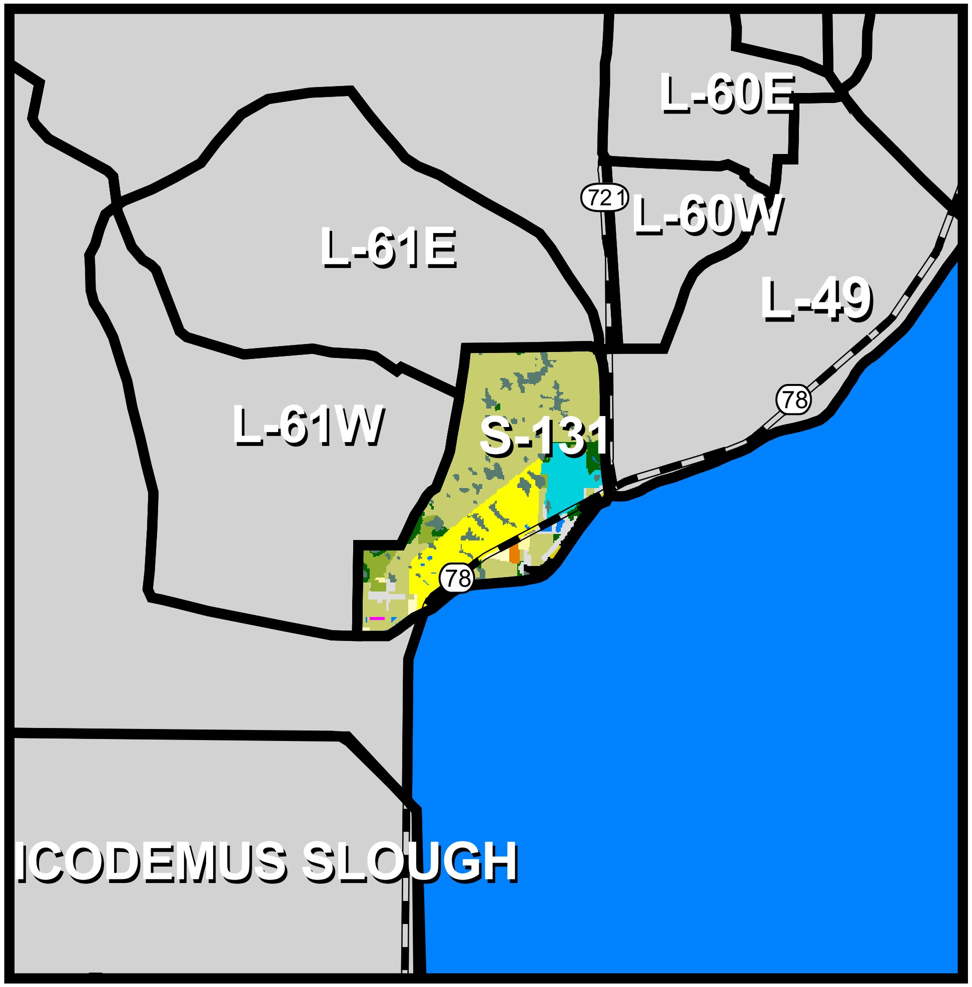
Net P Import (kg/ha-yr)

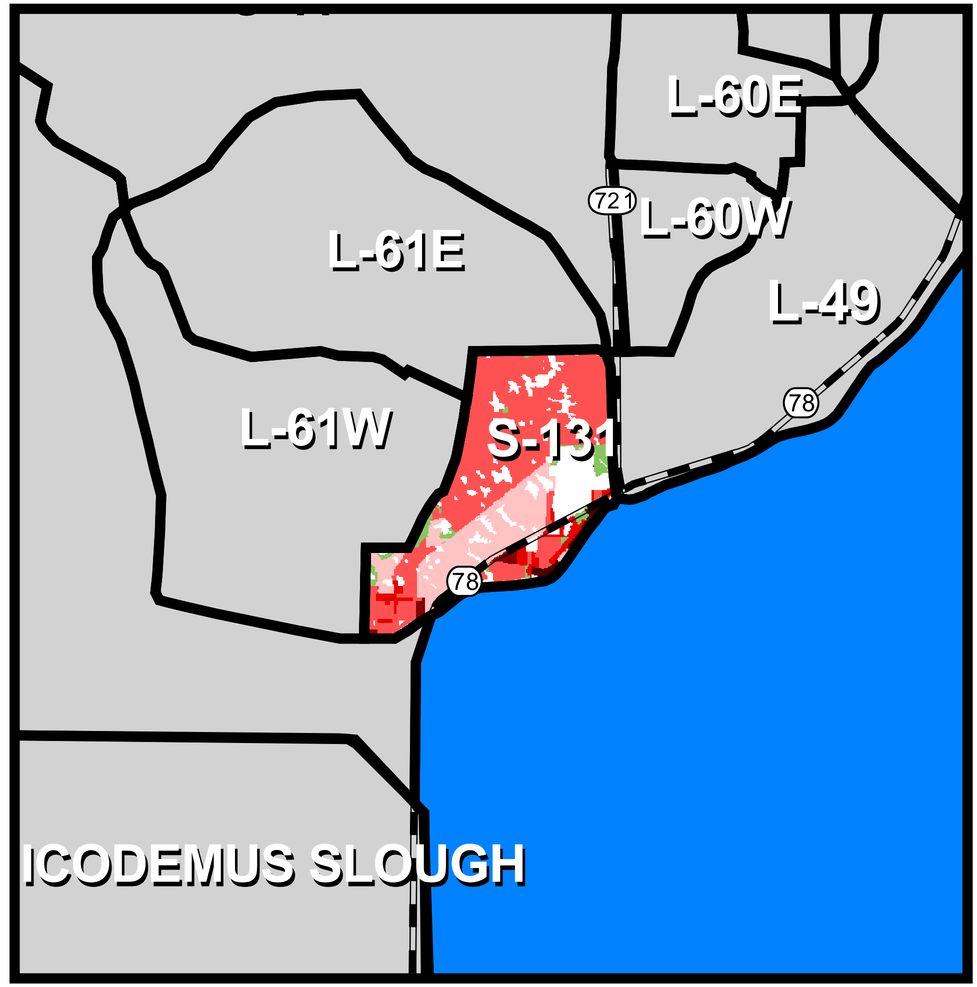
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for Nicodemus Slough Basin Exhibit D-15

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

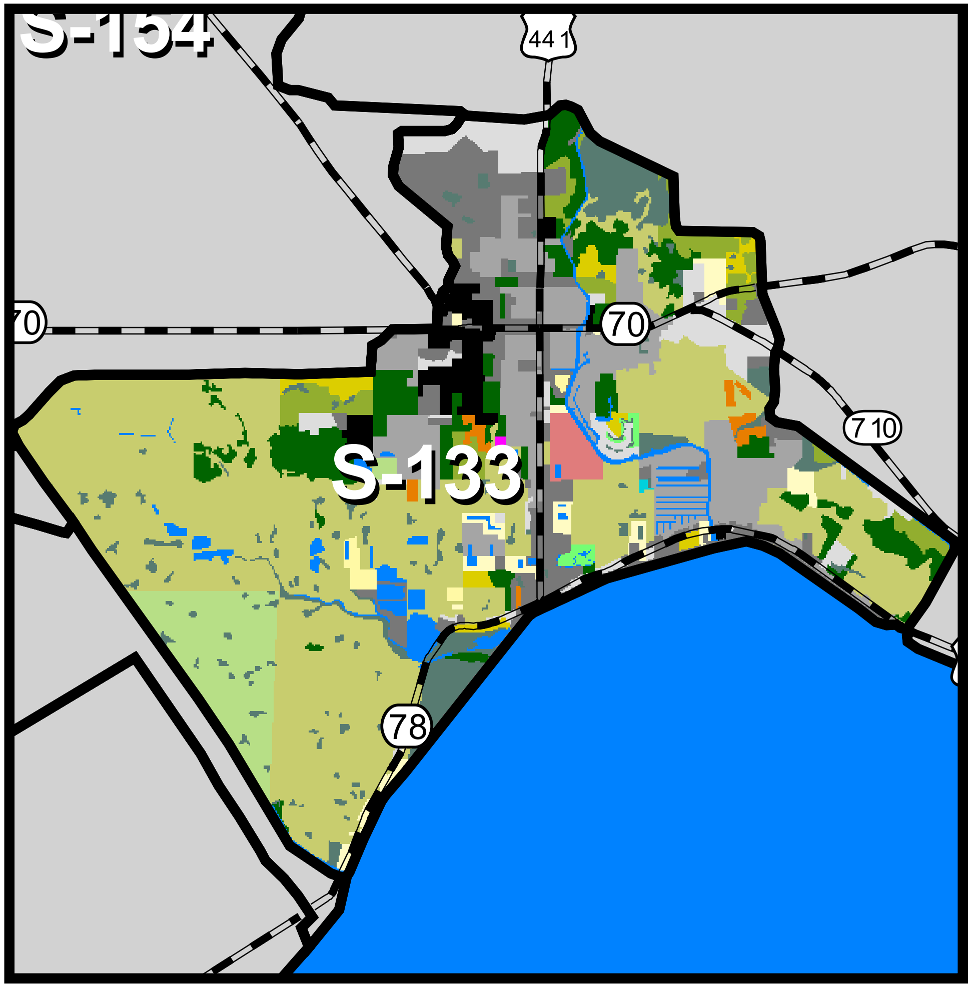
Net P Import (kg/ha-yr)

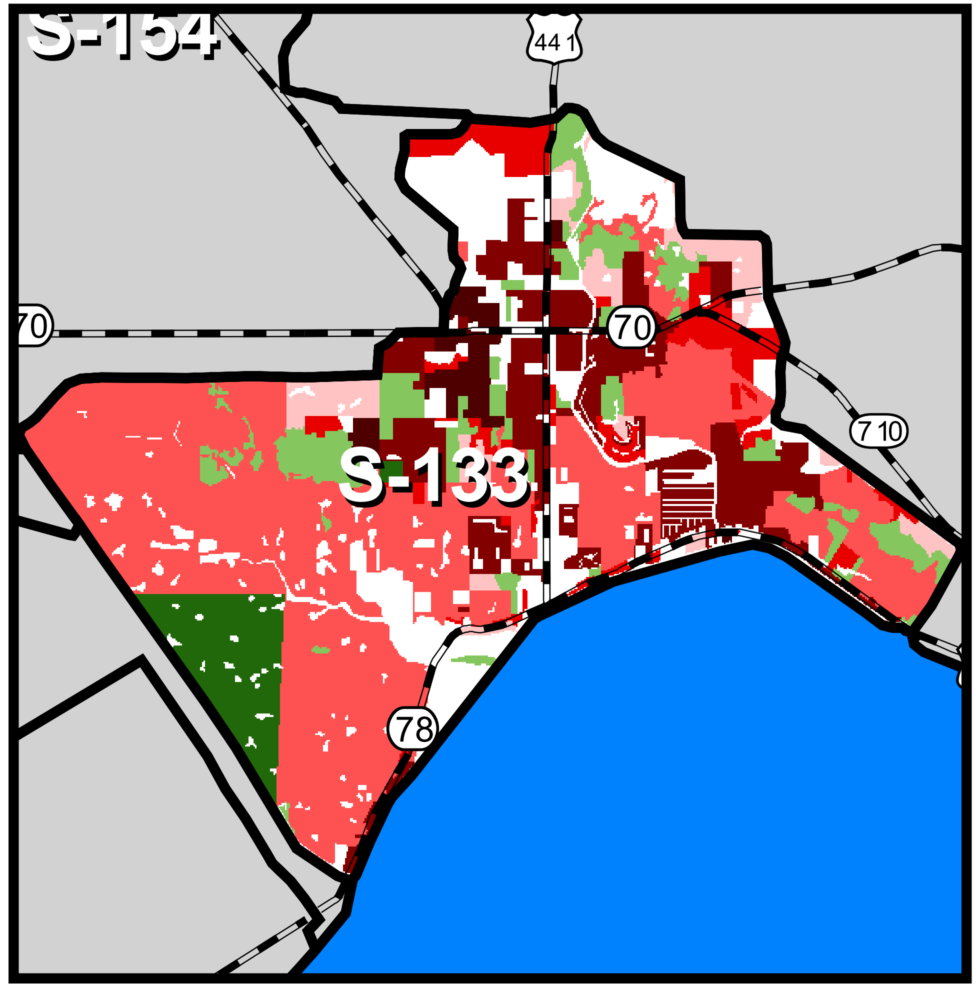
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-131 Basin Exhibit D-16

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

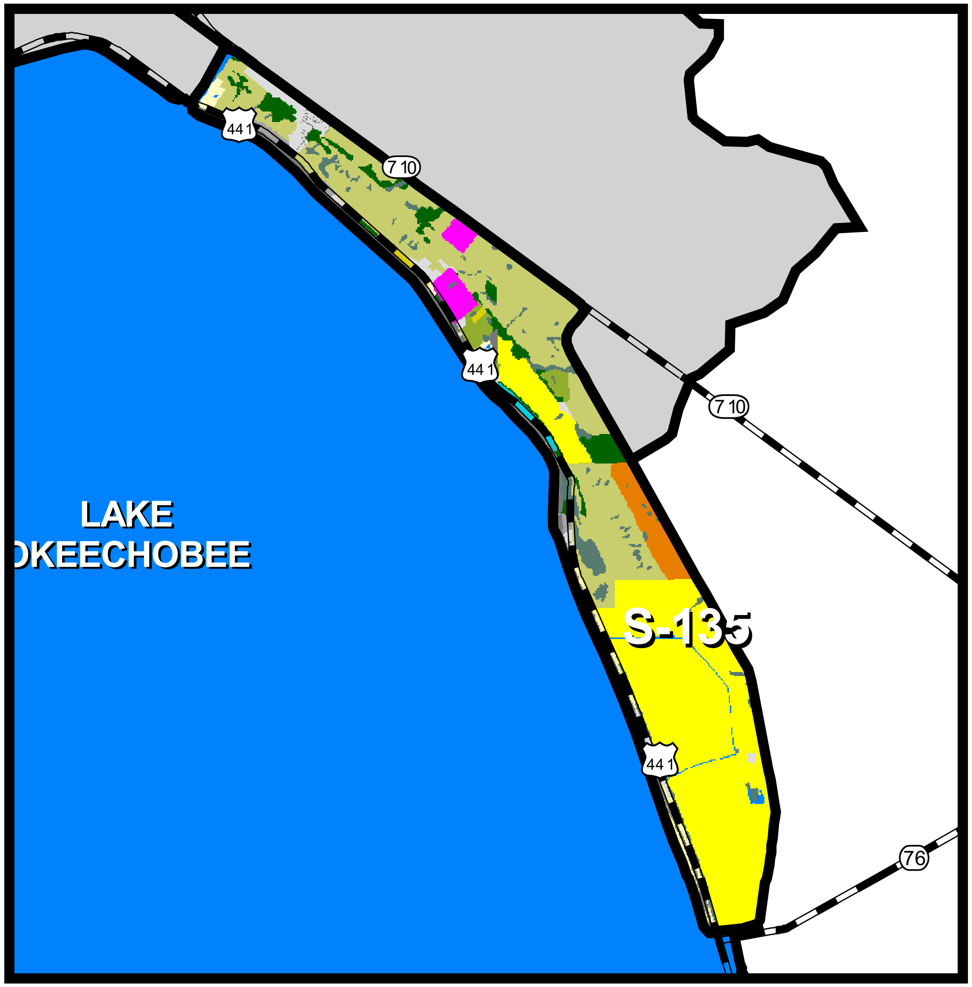
Net P Import (kg/ha-yr)

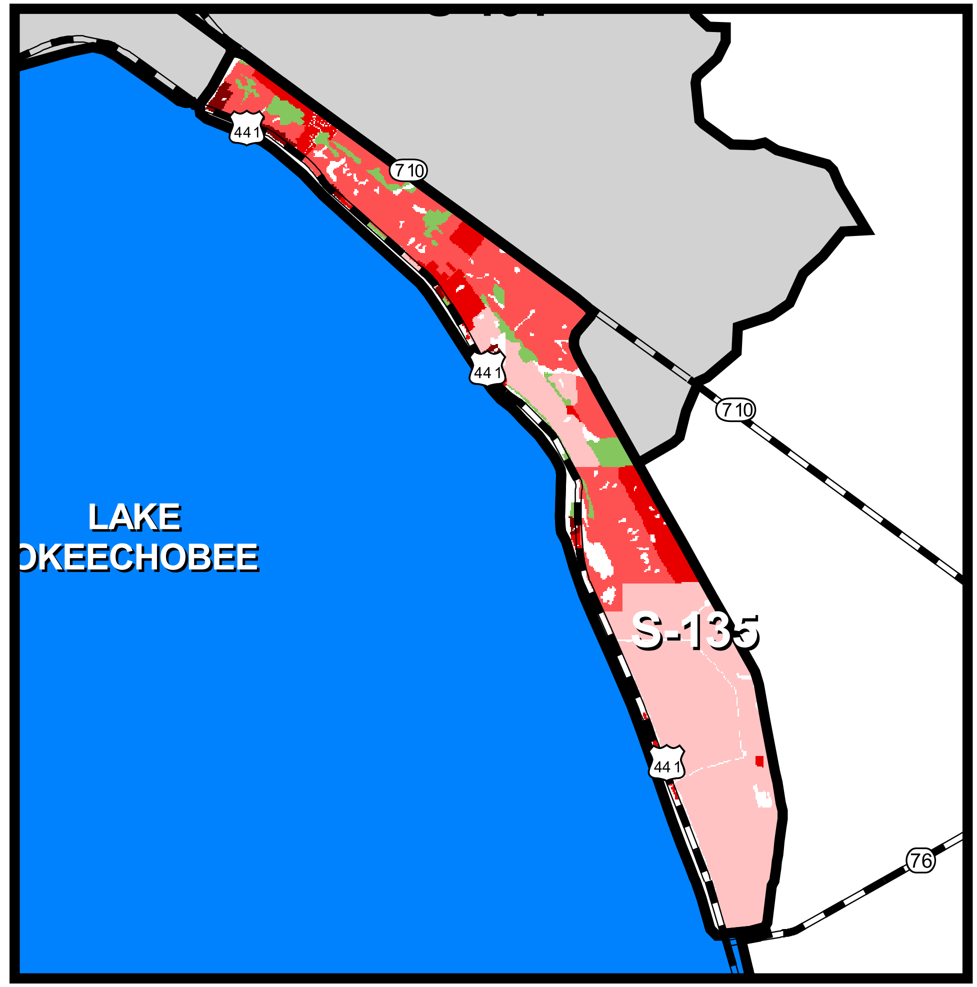
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-133 Basin Exhibit D-17

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

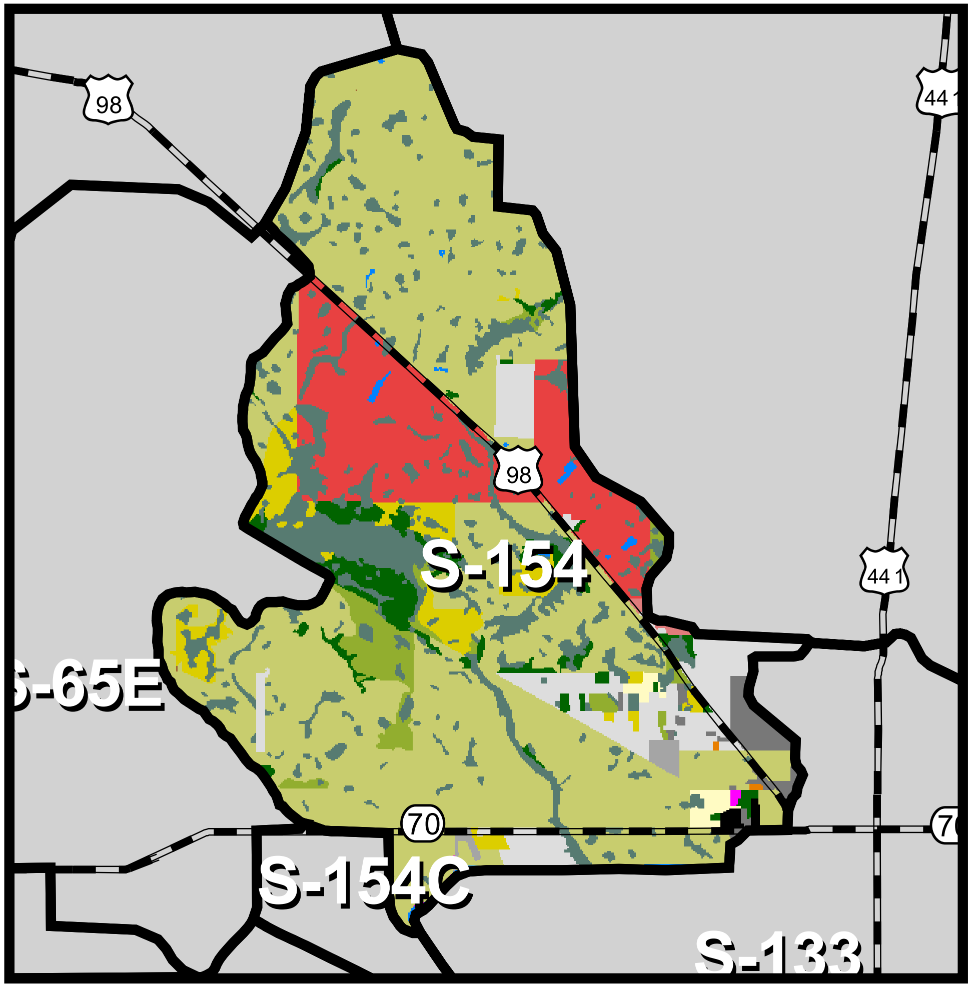
Net P Import (kg/ha-yr)

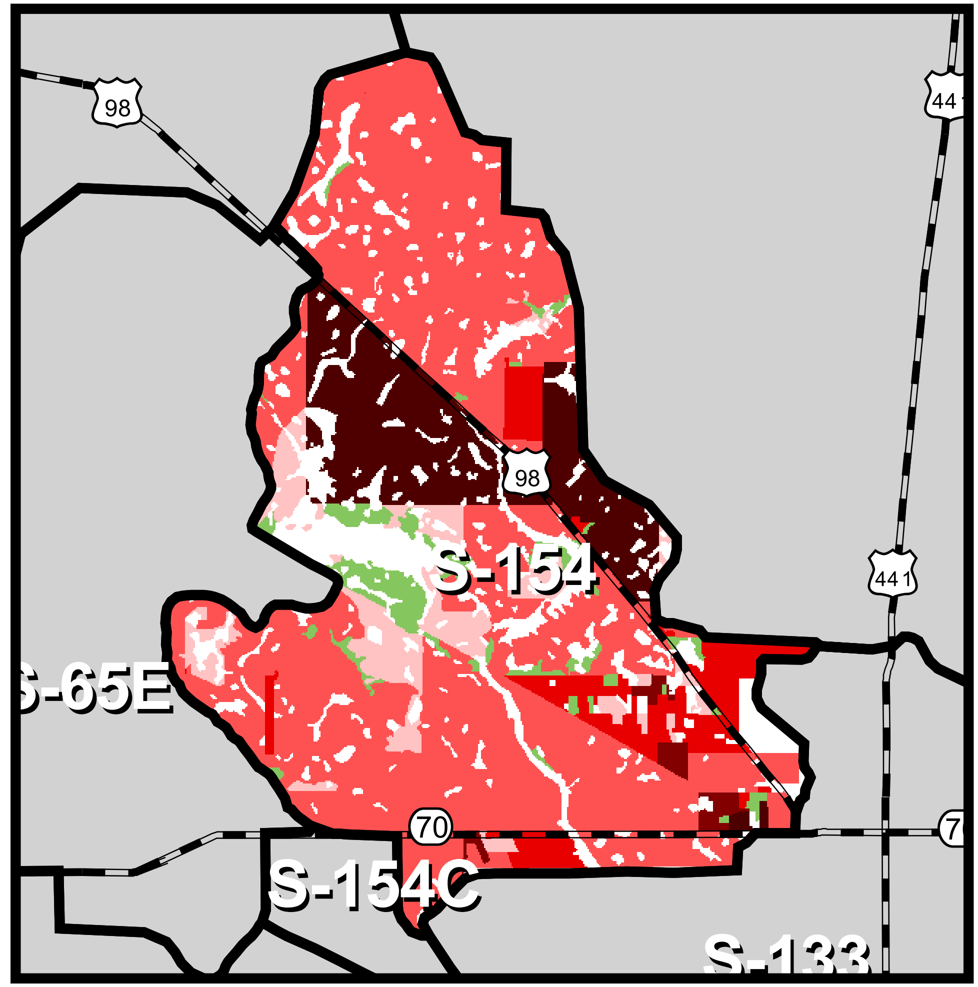
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-135 Basin Exhibit D-18

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

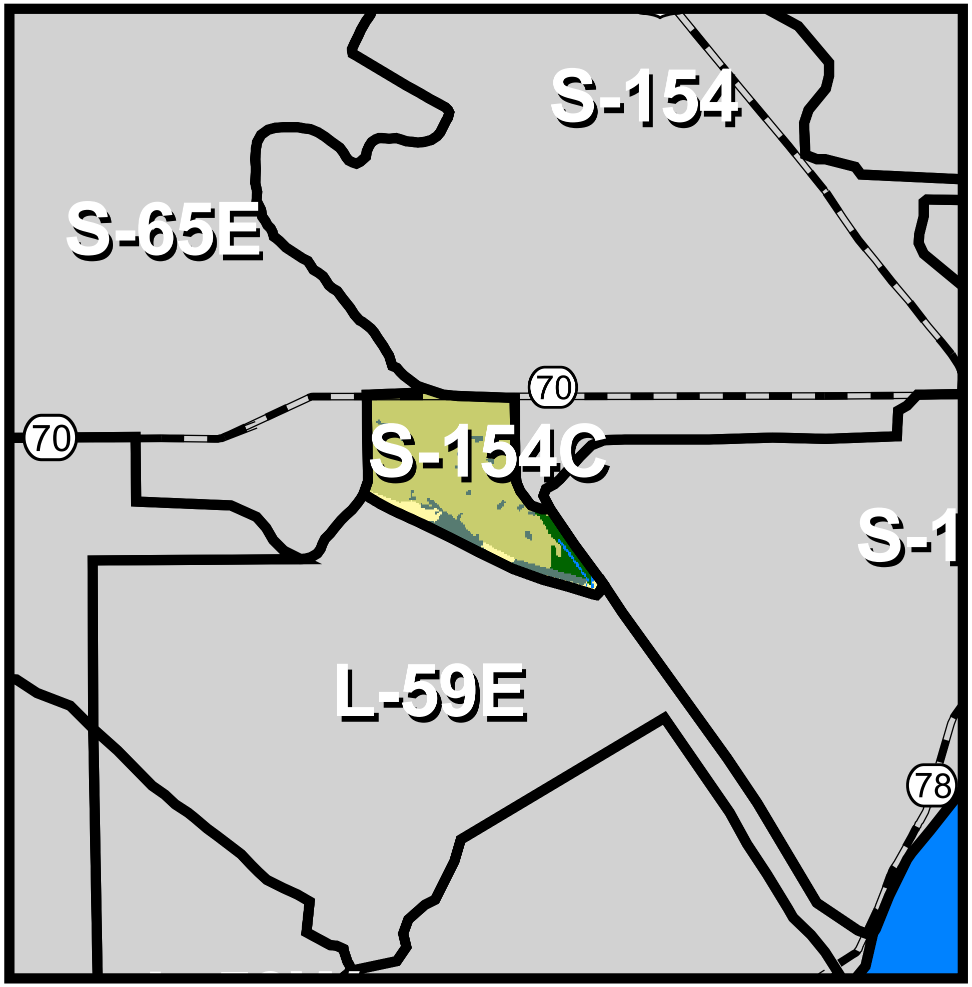
Net P Import (kg/ha-yr)

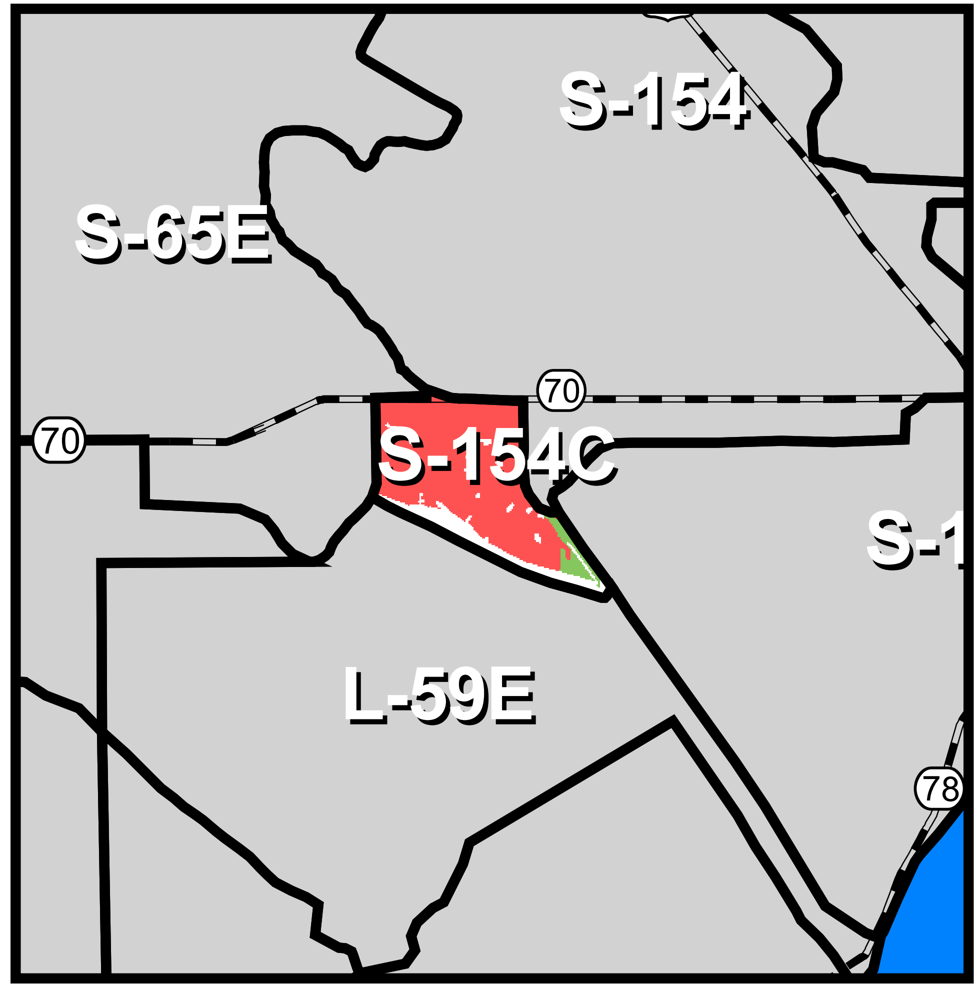
NOT TO SCALE

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

Land Use and Net P Import for S-154 Basin   Exhibit D-19

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

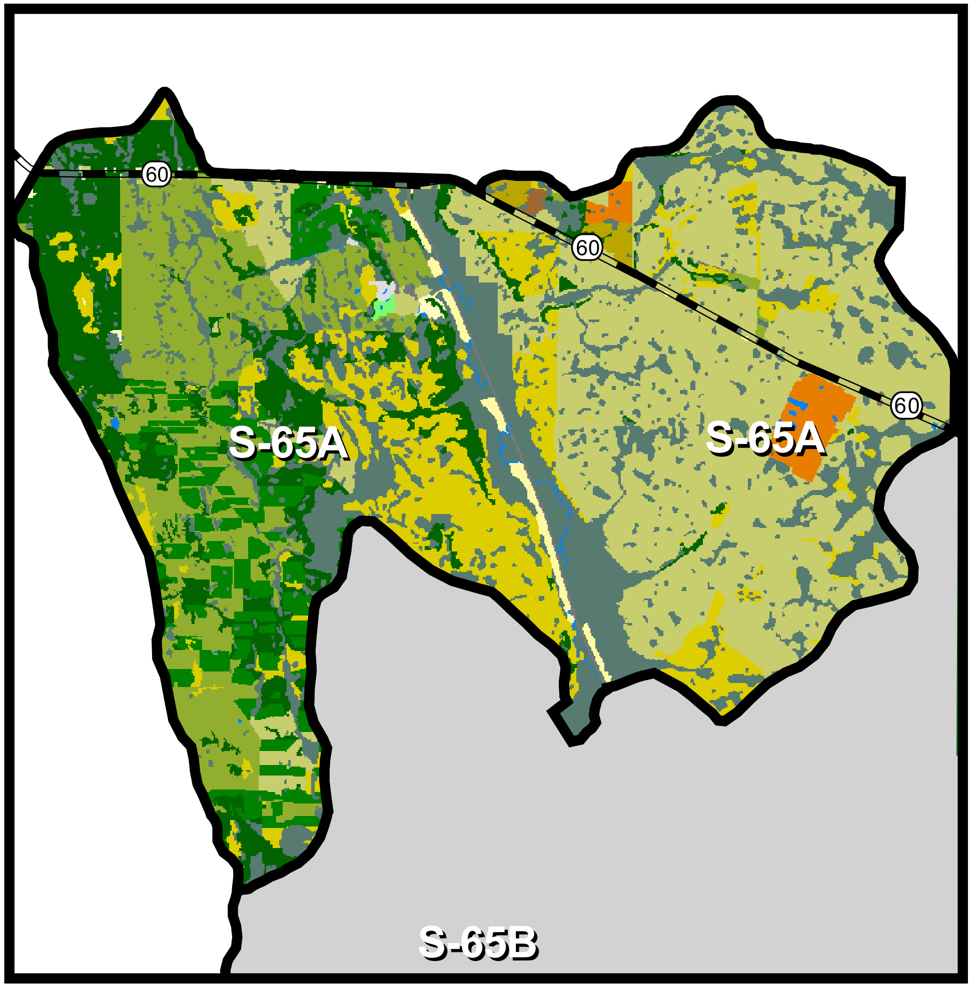
Net P Import (kg/ha-yr)

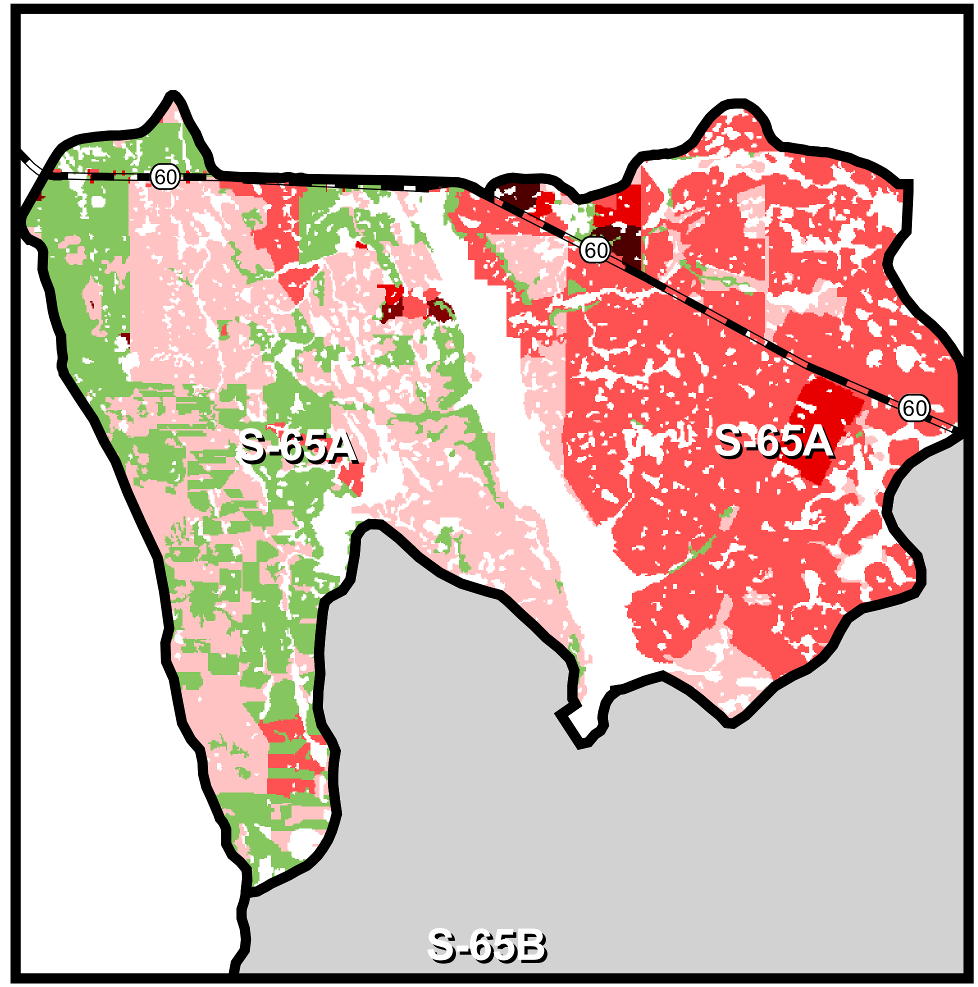
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-154C Basin Exhibit D-20

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

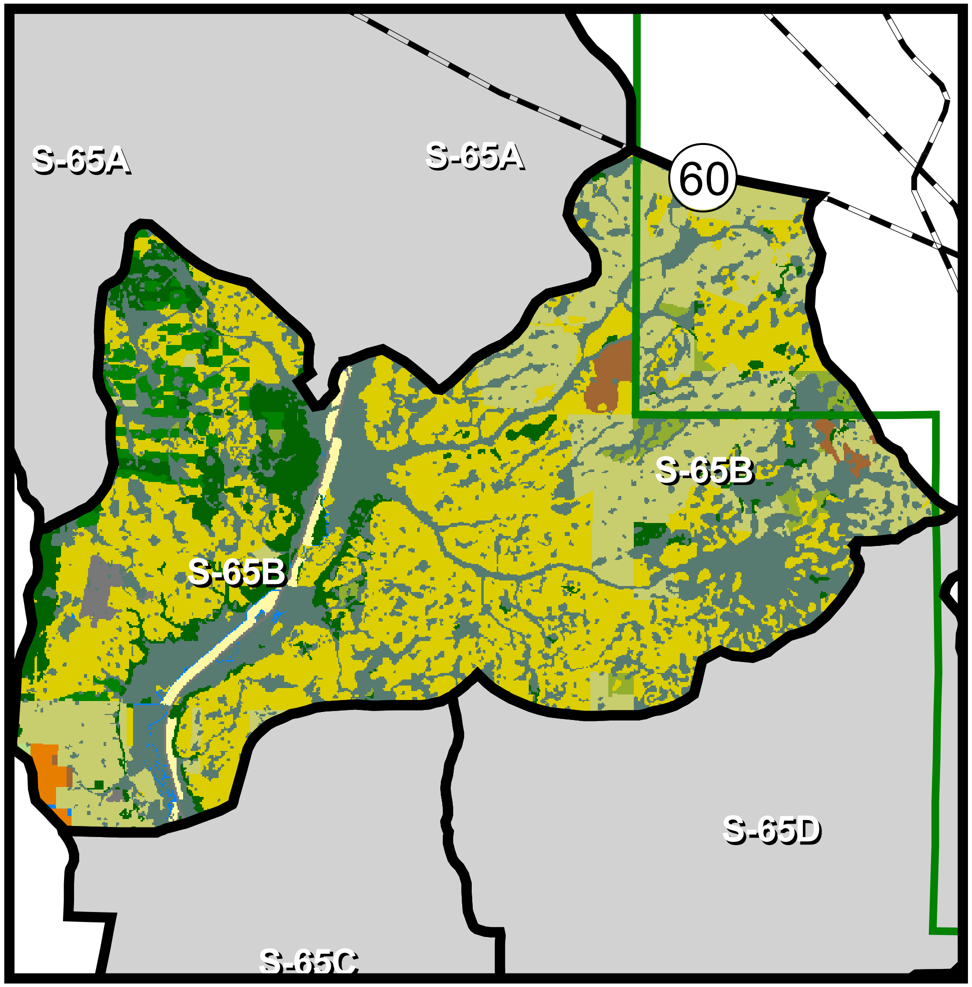
Net P Import (kg/ha-yr)

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-65A Basin Exhibit D-21

Lake Okeechobee Watershed Phosphorus Budget



Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
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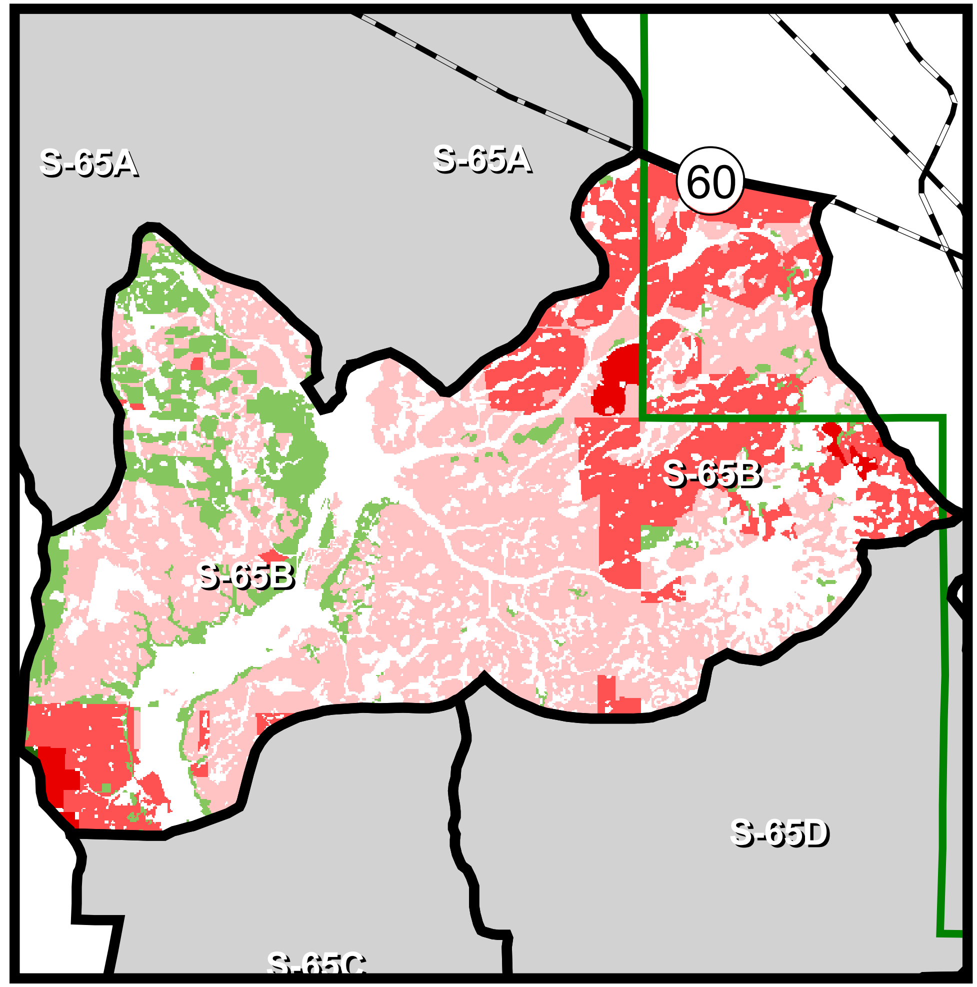
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY



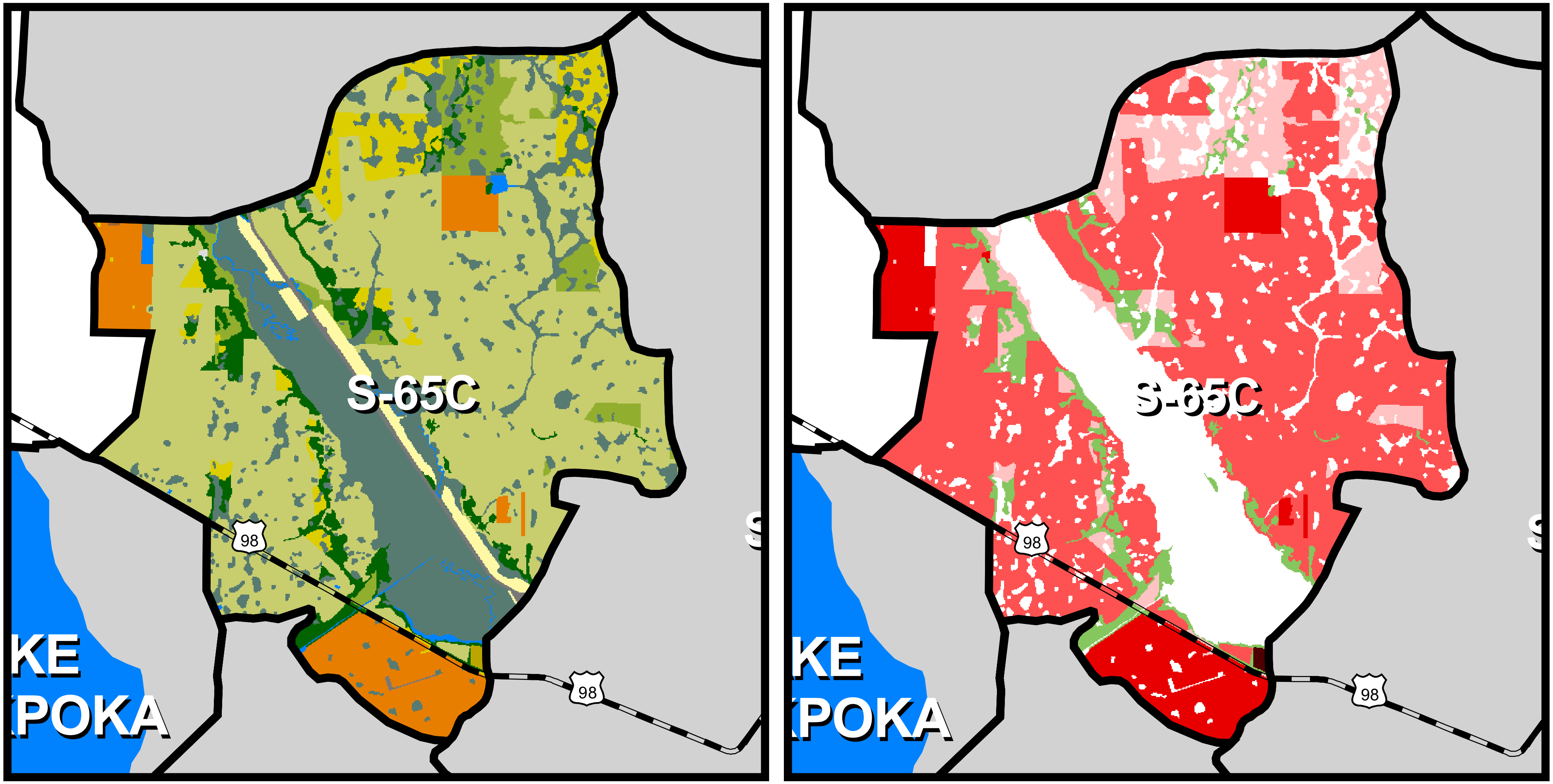
Net P Import (kg/ha-yr)

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-65B Basin Exhibit D-22

Lake Okeechobee Watershed Phosphorus Budget



Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

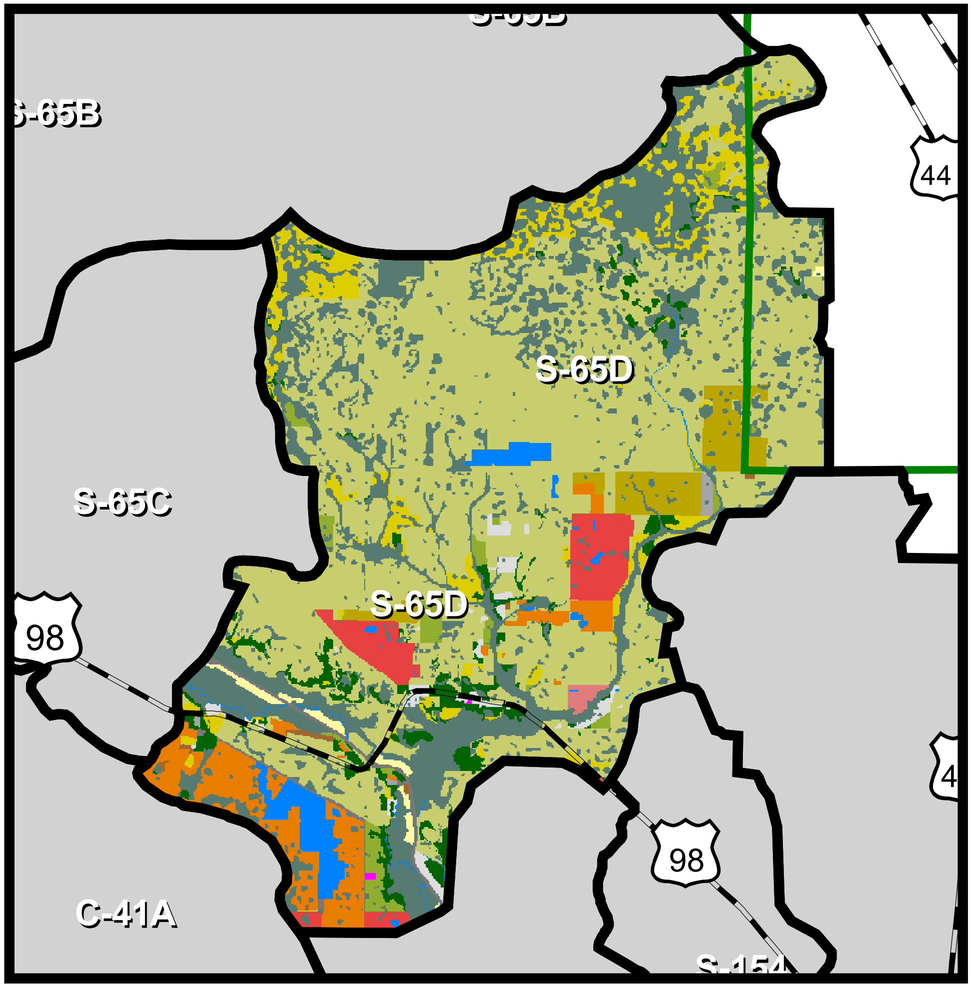
Net P Import (kg/ha-yr)

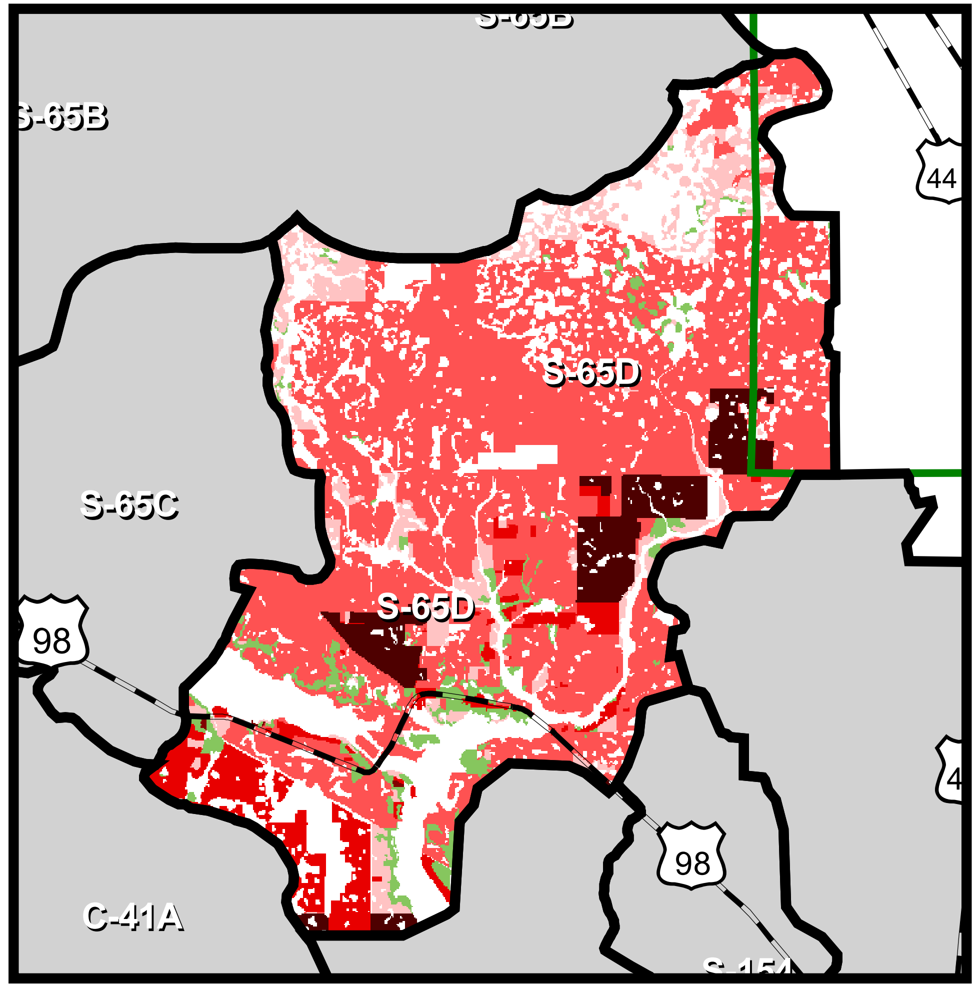
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-65C Basin Exhibit D-23

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
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- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

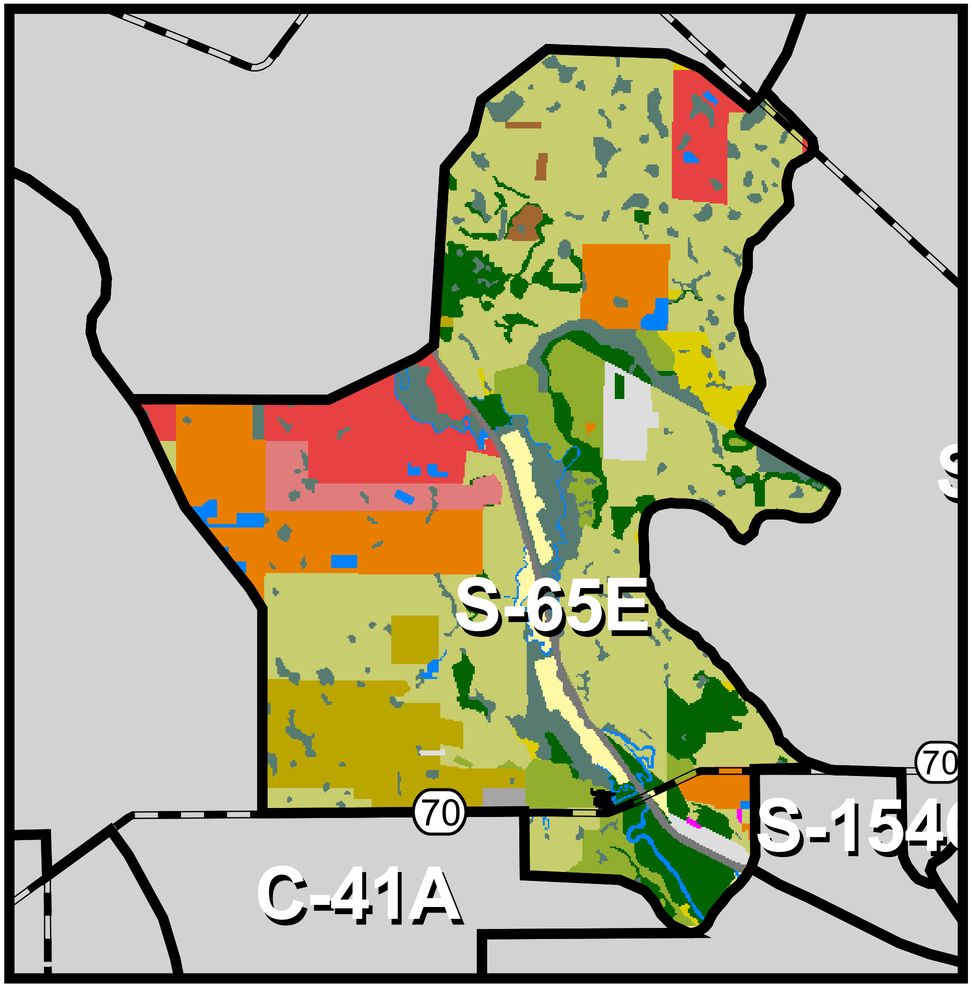
Net P Import (kg/ha-yr)

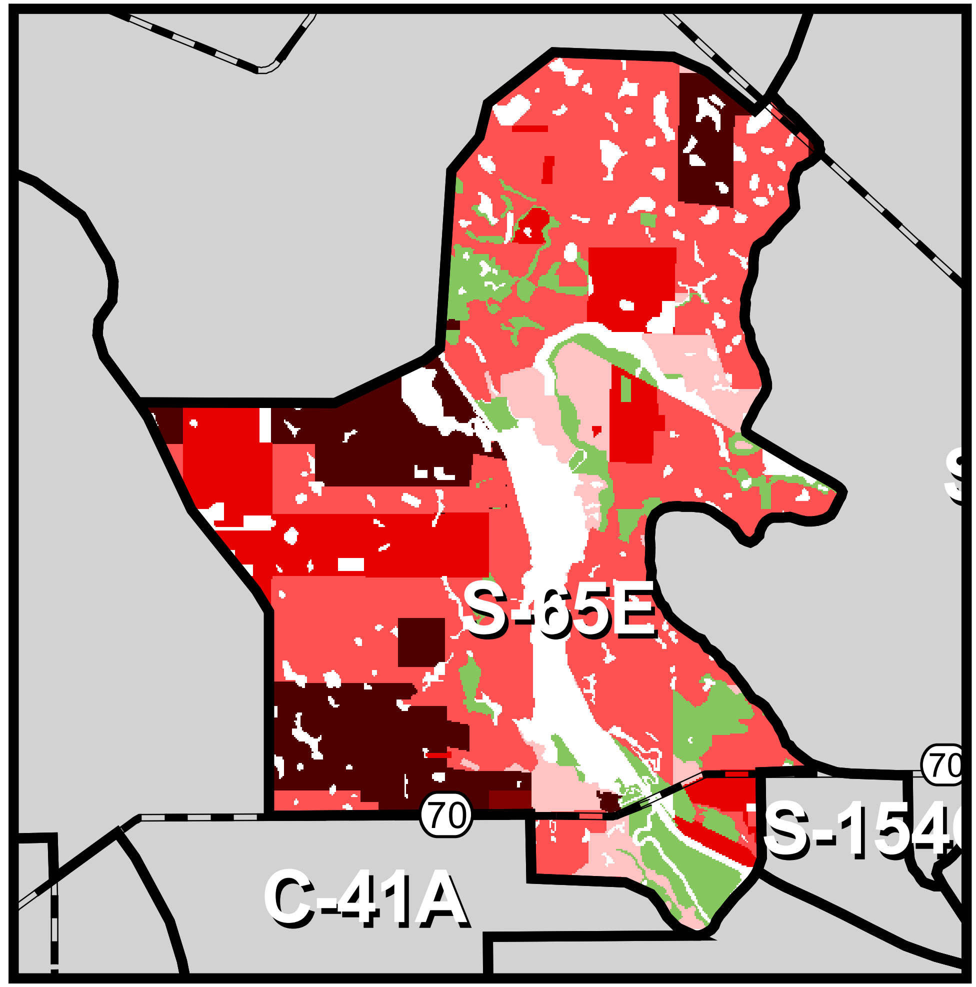
- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

NOT TO SCALE

Land Use and Net P Import for S-65D Basin   Exhibit D-24

Lake Okeechobee Watershed Phosphorus Budget





Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

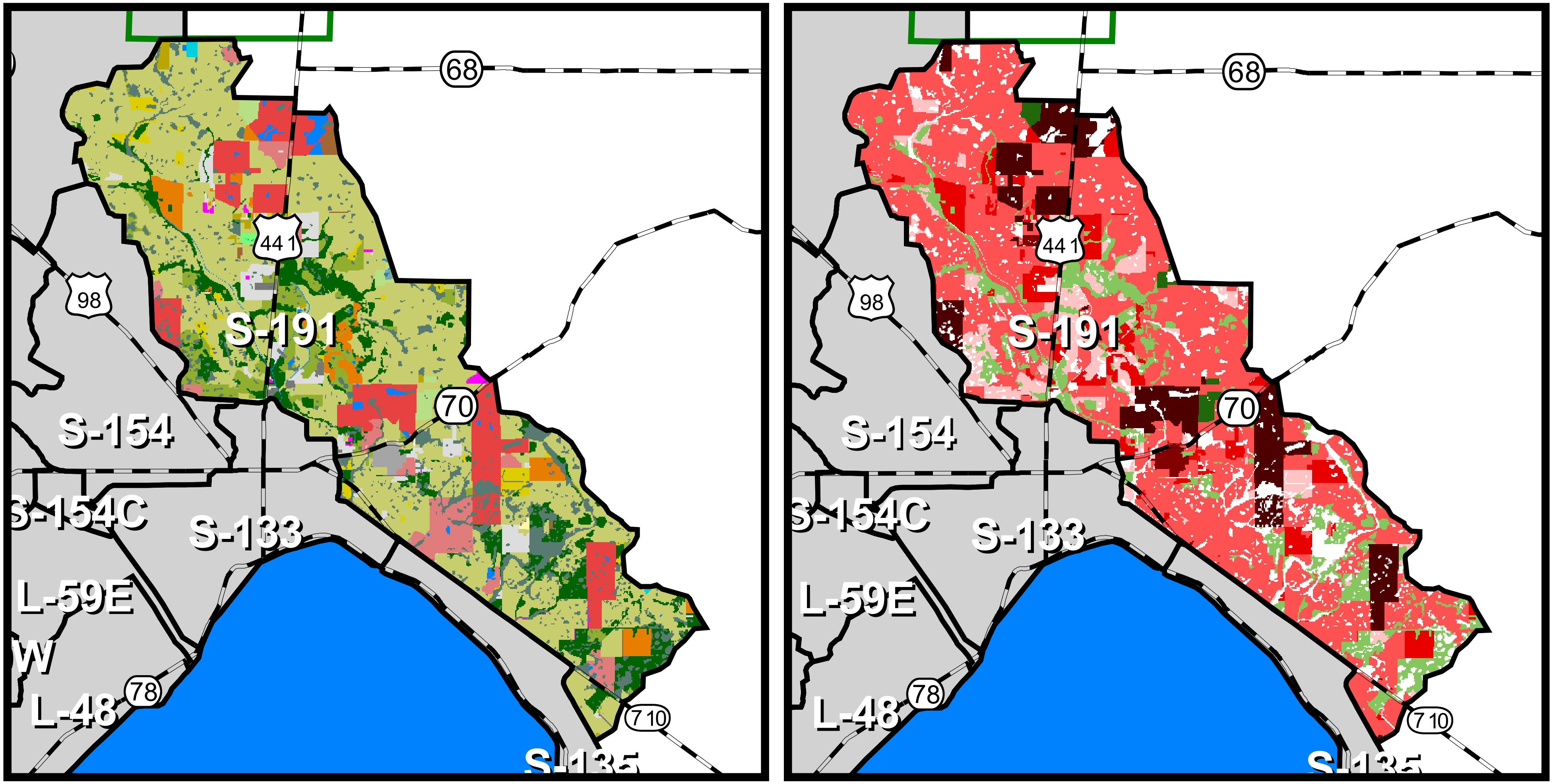
Net P Import (kg/ha-yr)

NOT TO SCALE

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

Land Use and Net P Import for S-65E Basin Exhibit D-25

Lake Okeechobee Watershed Phosphorus Budget



Land Use

- AQUACULTURE
- BARREN LAND
- CITRUS
- COMMERCIAL FORESTRY
- DAIRY
- FIELD CROPS
- FORESTED UPLANDS
- GOLF COURSE
- IMPROVED PASTURE
- ORNAMENTALS
- OTHER URBAN
- POULTRY
- RANGELAND
- RESIDENTIAL - HIGH DENSITY
- RESIDENTIAL - LOW DENSITY
- RESIDENTIAL - MEDIUM DENSITY
- RESIDENTIAL - MOBILE HOME UNITS
- SOD FARM
- SUGARCANE
- TRUCK CROPS
- UNIMPROVED PASTURE
- WASTE TREATMENT / DISPOSAL
- WATER BODIES
- WETLANDS
- ABANDONED DAIRY

Net P Import (kg/ha-yr)

NOT TO SCALE

- -100 - -10
- -10 - -1
- -1 - 0
- 0
- 0 - 1
- 1 - 3
- 3 - 5
- 5 - 10
- 10 - 50
- 50 - 500

Land Use and Net P Import for S-191 Basin Exhibit D-26

Table D-1: Phosphorus Budget by Basin in the Lake Okeechobee Watershed

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
C-40	17795	120320	7508	0	127828	53484	10033	549	87245	0	2	151313	-23485
C-41	38409	236428	18288	0	254716	73729	17143	910	118063	0	23	209868	44848
C-41A	23671	91745	12849	7	104601	15858	11589	597	47955	1299	0	77298	27303
Fisheating Creek	114229	242856	40643	0	283499	66328	47356	2459	16977	0	29	133149	150350
L-48	8406	24490	15528	0	40018	811	8671	481	967	0	0	10930	29088
L-49	4895	15009	4639	0	19648	3016	3668	195	392	0	11	7282	12366
L-59E	5828	12579	3827	0	16406	70	4810	266	535	0	1	5682	10724
L-59W	2605	4961	1409	0	6370	99	1963	105	211	0	0	2378	3992
L-60E	2039	2124	885	0	3009	136	859	44	89	0	1	1129	1880
L-60W	1324	2028	623	0	2651	83	797	41	83	0	0	1004	1647
L-61E	5782	11293	2505	0	13798	2647	3378	175	352	0	0	6552	7246
L-61W	5487	6561	1582	0	8143	581	2128	106	213	0	0	3028	5115
Lake Istokpoka	19559	26446	17838	0	44284	4929	4201	227	458	0	71	9886	34398
Nicodemus Slough	9857	48212	3968	0	52180	32289	5558	301	606	0	0	38754	13426
S-131	2899	13704	5402	0	19106	7722	2026	112	225	0	9	10094	9012
S-133	10386	28593	60933	0	89526	400	5945	327	35705	0	228	42605	46921
S-135	7320	63257	7413	0	70670	49525	2876	159	320	0	17	52897	17773
S-154	12795	35673	129005	179	164857	244	10778	535	1079	32983	42	45661	119196
S-154C	882	2550	677	0	3227	12	962	54	108	0	0	1136	2091
S-65A	41825	106360	16938	0	123298	9003	19861	1015	2043	0	2	31924	91374
S-65B	51931	59759	13159	0	72918	17359	17107	782	3488	0	0	38736	34182
S-65C	20409	61975	10511	0	72486	6465	14688	800	1611	0	0	23564	48922
S-65D	47187	397875	124679	157	522711	34871	35047	1871	3765	28981	17	104552	418159
S-65E	11799	212944	65702	94	278740	21347	7857	401	808	17228	13	47654	231086
Taylor Creek	48668	204215	362512	518	567245	18597	39475	2005	32308	95308	94	187787	379458
Total	515987	2031957	929023	955	2961935	419605	278776	14517	355606	175799	560	1244863	1717072

Table D-2: Phosphorus Budget by Land Use in the Lake Okeechobee Watershed

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Abandoned Dairy	2344	8646	2311	0	10957	0	3284	183	368	0	0	3835	7122
Aquaculture	336	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	4611	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	25392	262962	0	0	262962	79401	0	0	0	0	0	79401	183561
Commercial Forestry	13299	0	0	0	0	2088	0	0	0	0	0	2088	-2088
Dairy	8524	49680	588552	955	639187	0	5447	0	0	175799	0	181246	457941
Field Crops	2276	89793	0	0	89793	74080	0	0	0	0	0	74080	15713
Forested Uplands	49887	0	0	0	0	7832	0	0	0	0	0	7832	-7832
Golf Course	377	3877	0	0	3877	0	0	0	0	0	0	0	3877
Improved Pasture	183776	677765	181203	0	858968	0	257470	14335	28853	0	0	300658	558310
Ornamentals	3212	85535	0	0	85535	55080	0	0	0	0	0	55080	30455
Other Urban	5274	0	0	0	0	0	0	0	0	0	0	0	0
Poultry	20	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	46640	0	7836	0	7836	0	7322	0	0	0	0	7322	514
Residential - High Density	352	422	19859	0	20281	0	0	0	0	0	55	55	20226
Residential - Low Density	6671	4937	41577	0	46514	0	0	0	0	0	227	227	46287
Residential - Medium Density	1923	2628	49245	0	51873	0	0	0	0	0	281	281	51592
Residential - Mobile Home Units	794	0	32825	0	32825	0	0	0	0	0	0	0	32825
Sod Farm	4816	90840	0	0	90840	0	0	0	326383	0	0	326383	-235543
Sugarcane	8755	155441	0	0	155441	146809	0	0	0	0	0	146809	8632
Truck Crops	2868	599437	0	0	599437	54319	0	0	0	0	0	54319	545118
Unimproved Pasture	33453	0	5620	0	5620	0	5252	0	0	0	0	5252	368
Waste Treatment / Disposal	64	0	0	0	0	0	0	0	0	0	0	0	0
Water Bodies	14909	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	95422	0	0	0	0	0	0	0	0	0	0	0	0
Total	515995	2031963	929028	955	2961946	419609	278775	14518	355604	175799	563	1244868	1717078

Table D-3: Phosphorus Budget by Land Use in the C-40 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	239	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	1545	16002	0	0	16002	4832	0	0	0	0	0	4832	11170
Field Crops	98	3863	0	0	3863	3187	0	0	0	0	0	3187	676
Forested Uplands	1451	0	0	0	0	228	0	0	0	0	0	228	-228
Improved Pasture	7043	25975	6945	0	32920	0	9867	549	1106	0	0	11522	21398
Other Urban	12	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	290	0	49	0	49	0	45	0	0	0	0	45	4
Residential - Low Density	59	44	368	0	412	0	0	0	0	0	2	2	410
Residential - Medium Density	1	1	17	0	18	0	0	0	0	0	0	0	18
Sod Farm	1271	23975	0	0	23975	0	0	0	86139	0	0	86139	-62164
Sugarcane	2682	47625	0	0	47625	44980	0	0	0	0	0	44980	2645
Truck Crops	14	2835	0	0	2835	257	0	0	0	0	0	257	2578
Unimproved Pasture	768	0	129	0	129	0	121	0	0	0	0	121	8
Water Bodies	86	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	2236	0	0	0	0	0	0	0	0	0	0	0	0
Total	17795	120320	7508	0	127828	53484	10033	549	87245	0	2	151313	-23485

Table D-4: Phosphorus Budget by Land Use in the C-41 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Aquaculture	2	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	533	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	7815	80930	0	0	80930	24437	0	0	0	0	0	24437	56493
Commercial Forestry	24	0	0	0	0	4	0	0	0	0	0	4	-4
Field Crops	116	4567	0	0	4567	3768	0	0	0	0	0	3768	799
Forested Uplands	3319	0	0	0	0	521	0	0	0	0	0	521	-521
Improved Pasture	11668	43030	11504	0	54534	0	16346	910	1832	0	0	19088	35446
Ornamentals	2590	68968	0	0	68968	44412	0	0	0	0	0	44412	24556
Other Urban	611	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	1537	0	258	0	258	0	241	0	0	0	0	241	17
Residential - Low Density	521	386	3250	0	3636	0	0	0	0	0	18	18	3618
Residential - Medium Density	33	45	840	0	885	0	0	0	0	0	5	5	880
Residential - Mobile Home Units	45	0	1841	0	1841	0	0	0	0	0	0	0	1841
Sod Farm	1715	32350	0	0	32350	0	0	0	116231	0	0	116231	-83881
Sugarcane	2	35	0	0	35	33	0	0	0	0	0	33	2
Truck Crops	29	6117	0	0	6117	554	0	0	0	0	0	554	5563
Unimproved Pasture	3541	0	595	0	595	0	556	0	0	0	0	556	39
Water Bodies	330	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	3978	0	0	0	0	0	0	0	0	0	0	0	0
Total	38409	236428	18288	0	254716	73729	17143	910	118063	0	23	209868	44848

Table D-5: Phosphorus Budget by Land Use in the C-41A Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Barren Land	308	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	3967	41079	0	0	41079	12404	0	0	0	0	0	12404	28675
Dairy	63	367	4349	7	4723	0	40	0	0	1299	0	1339	3384
Field Crops	81	3196	0	0	3196	2637	0	0	0	0	0	2637	559
Forested Uplands	644	0	0	0	0	101	0	0	0	0	0	101	-101
Improved Pasture	7655	28232	7548	0	35780	0	10725	597	1202	0	0	12524	23256
Ornamentals	10	280	0	0	280	180	0	0	0	0	0	180	100
Other Urban	82	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	550	0	92	0	92	0	86	0	0	0	0	86	6
Residential - Low Density	11	8	70	0	78	0	0	0	0	0	0	0	78
Sod Farm	690	13012	0	0	13012	0	0	0	46753	0	0	46753	-33741
Sugarcane	2	36	0	0	36	34	0	0	0	0	0	34	2
Truck Crops	26	5535	0	0	5535	502	0	0	0	0	0	502	5033
Unimproved Pasture	4703	0	790	0	790	0	738	0	0	0	0	738	52
Water Bodies	1027	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	3852	0	0	0	0	0	0	0	0	0	0	0	0
Total	23671	91745	12849	7	104601	15858	11589	597	47955	1299	0	77298	27303

Table D-6: Phosphorus Budget by Land Use in the Fisheating Creek Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Aquaculture	24	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	74	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	3631	37600	0	0	37600	11353	0	0	0	0	0	11353	26247
Commercial Forestry	9458	0	0	0	0	1485	0	0	0	0	0	1485	-1485
Field Crops	970	38258	0	0	38258	31564	0	0	0	0	0	31564	6694
Forested Uplands	17252	0	0	0	0	2709	0	0	0	0	0	2709	-2709
Improved Pasture	31529	116279	31088	0	147367	0	44172	2459	4950	0	0	51581	95786
Ornamentals	30	794	0	0	794	511	0	0	0	0	0	511	283
Other Urban	644	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	11657	0	1958	0	1958	0	1830	0	0	0	0	1830	128
Residential - Low Density	846	626	5270	0	5896	0	0	0	0	0	29	29	5867
Residential - Medium Density	3	4	67	0	71	0	0	0	0	0	0	0	71
Residential - Mobile Home Units	20	0	811	0	811	0	0	0	0	0	0	0	811
Sod Farm	177	3347	0	0	3347	0	0	0	12027	0	0	12027	-8680
Sugarcane	959	17032	0	0	17032	16086	0	0	0	0	0	16086	946
Truck Crops	138	28916	0	0	28916	2620	0	0	0	0	0	2620	26296
Unimproved Pasture	8623	0	1449	0	1449	0	1354	0	0	0	0	1354	95
Water Bodies	413	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	27781	0	0	0	0	0	0	0	0	0	0	0	0
Total	114229	242856	40643	0	283499	66328	47356	2459	16977	0	29	133149	150350

Table D-7: Phosphorus Budget by Land Use in the L-48 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	194	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	125	1291	0	0	1291	390	0	0	0	0	0	390	901
Field Crops	12	465	0	0	465	384	0	0	0	0	0	384	81
Forested Uplands	233	0	0	0	0	37	0	0	0	0	0	37	-37
Improved Pasture	6162	22726	6076	0	28802	0	8633	481	967	0	0	10081	18721
Other Urban	30	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	6	0	1	0	1	0	1	0	0	0	0	1	0
Residential - Low Density	8	6	51	0	57	0	0	0	0	0	0	0	57
Residential - Medium Density	1	2	31	0	33	0	0	0	0	0	0	0	33
Residential - Mobile Home Units	226	0	9329	0	9329	0	0	0	0	0	0	0	9329
Unimproved Pasture	236	0	40	0	40	0	37	0	0	0	0	37	3
Water Bodies	141	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	1032	0	0	0	0	0	0	0	0	0	0	0	0
Total	8406	24490	15528	0	40018	811	8671	481	967	0	0	10930	29088

Table D-8: Phosphorus Budget by Land Use in the L-49 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	145	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	53	551	0	0	551	166	0	0	0	0	0	166	385
Forested Uplands	318	0	0	0	0	50	0	0	0	0	0	50	-50
Improved Pasture	2494	9197	2459	0	11656	0	3494	195	392	0	0	4081	7575
Ornamentals	158	4218	0	0	4218	2716	0	0	0	0	0	2716	1502
Rangeland	593	0	100	0	100	0	93	0	0	0	0	93	7
Residential - Low Density	13	9	78	0	87	0	0	0	0	0	0	0	87
Residential - Medium Density	75	102	1915	0	2017	0	0	0	0	0	11	11	2006
Truck Crops	4	932	0	0	932	84	0	0	0	0	0	84	848
Unimproved Pasture	516	0	87	0	87	0	81	0	0	0	0	81	6
Water Bodies	113	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	413	0	0	0	0	0	0	0	0	0	0	0	0
Total	4895	15009	4639	0	19648	3016	3668	195	392	0	11	7282	12366

Table D-9: Phosphorus Budget by Land Use in the L-59E Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	427	0	0	0	0	0	0	0	0	0	0	0	0
Forested Uplands	446	0	0	0	0	70	0	0	0	0	0	70	-70
Improved Pasture	3406	12561	3358	0	15919	0	4772	266	535	0	0	5573	10346
Other Urban	293	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	169	0	28	0	28	0	27	0	0	0	0	27	1
Residential - Low Density	24	18	149	0	167	0	0	0	0	0	1	1	166
Residential - Mobile Home Units	7	0	280	0	280	0	0	0	0	0	0	0	280
Unimproved Pasture	70	0	12	0	12	0	11	0	0	0	0	11	1
Water Bodies	109	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	877	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	5828	12579	3827	0	16406	70	4810	266	535	0	1	5682	10724

Table D-10: Phosphorus Budget by Land Use in the L-59W Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Barren Land	19	0	0	0	0	0	0	0	0	0	0	0	0
Forested Uplands	628	0	0	0	0	99	0	0	0	0	0	99	-99
Improved Pasture	1345	4961	1326	0	6287	0	1885	105	211	0	0	2201	4086
Other Urban	4	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	303	0	51	0	51	0	48	0	0	0	0	48	3
Unimproved Pasture	190	0	32	0	32	0	30	0	0	0	0	30	2
Water Bodies	8	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	108	0	0	0	0	0	0	0	0	0	0	0	0
Total	2605	4961	1409	0	6370	99	1963	105	211	0	0	2378	3992

Table D-11: Phosphorus Budget by Land Use in the L-60E Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Barren Land	10	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	1	6	0	0	6	2	0	0	0	0	0	2	4
Forested Uplands	851	0	0	0	0	134	0	0	0	0	0	134	-134
Improved Pasture	566	2087	558	0	2645	0	793	44	89	0	0	926	1719
Other Urban	3	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	413	0	69	0	69	0	65	0	0	0	0	65	4
Residential - Low Density	41	31	257	0	288	0	0	0	0	0	1	1	287
Unimproved Pasture	8	0	1	0	1	0	1	0	0	0	0	1	0
Wetlands	146	0	0	0	0	0	0	0	0	0	0	0	0
Total	2039	2124	885	0	3009	136	859	44	89	0	1	1129	1880

Table D-12: Phosphorus Budget by Land Use in the L-60W Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	15	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	6	63	0	0	63	19	0	0	0	0	0	19	44
Forested Uplands	368	0	0	0	0	58	0	0	0	0	0	58	-58
Improved Pasture	529	1950	521	0	2471	0	741	41	83	0	0	865	1606
Ornamentals	0	10	0	0	10	6	0	0	0	0	0	6	4
Rangeland	217	0	36	0	36	0	34	0	0	0	0	34	2
Residential - Low Density	7	5	42	0	47	0	0	0	0	0	0	0	47
Unimproved Pasture	140	0	24	0	24	0	22	0	0	0	0	22	2
Water Bodies	2	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	40	0	0	0	0	0	0	0	0	0	0	0	0
Total	1324	2028	623	0	2651	83	797	41	83	0	0	1004	1647

Table D-13: Phosphorus Budget by Land Use in the L-61E Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Barren Land	56	0	0	0	0	0	0	0	0	0	0	0	0
Field Crops	76	3017	0	0	3017	2489	0	0	0	0	0	2489	528
Forested Uplands	1007	0	0	0	0	158	0	0	0	0	0	158	-158
Improved Pasture	2243	8271	2211	0	10482	0	3142	175	352	0	0	3669	6813
Rangeland	459	0	77	0	77	0	72	0	0	0	0	72	5
Residential - Low Density	7	5	41	0	46	0	0	0	0	0	0	0	46
Unimproved Pasture	1047	0	176	0	176	0	164	0	0	0	0	164	12
Water Bodies	15	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	872	0	0	0	0	0	0	0	0	0	0	0	0
Total	5782	11293	2505	0	13798	2647	3378	175	352	0	0	6552	7246

Table D-14: Phosphorus Budget by Land Use in the L-61W Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	31	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	125	1296	0	0	1296	391	0	0	0	0	0	391	905
Forested Uplands	1052	0	0	0	0	165	0	0	0	0	0	165	-165
Improved Pasture	1354	4993	1335	0	6328	0	1897	106	213	0	0	2216	4112
Rangeland	234	0	39	0	39	0	37	0	0	0	0	37	2
Truck Crops	1	272	0	0	272	25	0	0	0	0	0	25	247
Unimproved Pasture	1236	0	208	0	208	0	194	0	0	0	0	194	14
Water Bodies	8	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	1446	0	0	0	0	0	0	0	0	0	0	0	0
Total	5487	6561	1582	0	8143	581	2128	106	213	0	0	3028	5115

Table D-15: Phosphorus Budget by Land Use in the Lake Istokpoga Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	11	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	410	4245	0	0	4245	1282	0	0	0	0	0	1282	2963
Field Crops	52	2064	0	0	2064	1702	0	0	0	0	0	1702	362
Forested Uplands	1419	0	0	0	0	223	0	0	0	0	0	223	-223
Golf Course	120	1236	0	0	1236	0	0	0	0	0	0	0	1236
Improved Pasture	2915	10752	2875	0	13627	0	4085	227	458	0	0	4770	8857
Ornamentals	74	1962	0	0	1962	1263	0	0	0	0	0	1263	699
Other Urban	475	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	380	0	64	0	64	0	60	0	0	0	0	60	4
Residential - High Density	17	20	960	0	980	0	0	0	0	0	3	3	977
Residential - Low Density	1095	810	6821	0	7631	0	0	0	0	0	37	37	7594
Residential - Medium Density	210	288	5387	0	5675	0	0	0	0	0	31	31	5644
Residential - Mobile Home Units	40	0	1671	0	1671	0	0	0	0	0	0	0	1671
Truck Crops	24	5069	0	0	5069	459	0	0	0	0	0	459	4610
Unimproved Pasture	357	0	60	0	60	0	56	0	0	0	0	56	4
Water Bodies	9584	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	2376	0	0	0	0	0	0	0	0	0	0	0	0
Total	19559	26446	17838	0	44284	4929	4201	227	458	0	71	9886	34398

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Table D-16: Phosphorus Budget by Land Use in the Nicodemus Slough Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	118	0	0	0	0	0	0	0	0	0	0	0	0
Commercial Forestry	56	0	0	0	0	9	0	0	0	0	0	9	-9
Forested Uplands	1181	0	0	0	0	185	0	0	0	0	0	185	-185
Improved Pasture	3858	14229	3804	0	18033	0	5405	301	606	0	0	6312	11721
Other Urban	72	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	168	0	28	0	28	0	26	0	0	0	0	26	2
Sugarcane	1914	33983	0	0	33983	32095	0	0	0	0	0	32095	1888
Unimproved Pasture	807	0	136	0	136	0	127	0	0	0	0	127	9
Water Bodies	55	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	1628	0	0	0	0	0	0	0	0	0	0	0	0
Total	9857	48212	3968	0	52180	32289	5558	301	606	0	0	38754	13426

Table D-17: Phosphorus Budget by Land Use in the S-131 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Aquaculture	193	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	103	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	14	145	0	0	145	44	0	0	0	0	0	44	101
Forested Uplands	135	0	0	0	0	21	0	0	0	0	0	21	-21
Improved Pasture	1434	5290	1414	0	6704	0	2009	112	225	0	0	2346	4358
Ornamentals	4	96	0	0	96	62	0	0	0	0	0	62	34
Other Urban	2	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	11	0	2	0	2	0	2	0	0	0	0	2	0
Residential - High Density	39	47	2213	0	2260	0	0	0	0	0	6	6	2254
Residential - Low Density	91	68	570	0	638	0	0	0	0	0	3	3	635
Residential - Mobile Home Units	29	0	1187	0	1187	0	0	0	0	0	0	0	1187
Sugarcane	453	8039	0	0	8039	7593	0	0	0	0	0	7593	446
Truck Crops	0	19	0	0	19	2	0	0	0	0	0	2	17
Unimproved Pasture	98	0	16	0	16	0	15	0	0	0	0	15	1
Water Bodies	68	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	225	0	0	0	0	0	0	0	0	0	0	0	0
Total	2899	13704	5402	0	19106	7722	2026	112	225	0	9	10094	9012

Table D-18: Phosphorus Budget by Land Use in the S-133 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Abandoned Dairy	89	327	87	0	414	0	124	7	14	0	0	145	269
Aquaculture	4	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	125	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	65	675	0	0	675	204	0	0	0	0	0	204	471
Forested Uplands	825	0	0	0	0	129	0	0	0	0	0	129	-129
Golf Course	32	329	0	0	329	0	0	0	0	0	0	0	329
Improved Pasture	4100	15121	4043	0	19164	0	5744	320	644	0	0	6708	12456
Ornamentals	4	104	0	0	104	67	0	0	0	0	0	67	37
Other Urban	986	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	153	0	26	0	26	0	24	0	0	0	0	24	2
Residential - High Density	251	301	14153	0	14454	0	0	0	0	0	39	39	14415
Residential - Low Density	507	375	3157	0	3532	0	0	0	0	0	17	17	3515
Residential - Medium Density	1175	1606	30096	0	31702	0	0	0	0	0	172	172	31530
Residential - Mobile Home Units	225	0	9314	0	9314	0	0	0	0	0	0	0	9314
Sod Farm	517	9755	0	0	9755	0	0	0	35047	0	0	35047	-25292
Unimproved Pasture	337	0	57	0	57	0	53	0	0	0	0	53	4
Water Bodies	386	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	605	0	0	0	0	0	0	0	0	0	0	0	0
Total	10386	28593	60933	0	89526	400	5945	327	35705	0	228	42605	46921

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Table D-19: Phosphorus Budget by Land Use in the S-135 Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Aquaculture	40	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	355	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	254	2626	0	0	2626	793	0	0	0	0	0	793	1833
Forested Uplands	377	0	0	0	0	59	0	0	0	0	0	59	-59
Improved Pasture	2037	7511	2008	0	9519	0	2853	159	320	0	0	3332	6187
Ornamentals	157	4169	0	0	4169	2685	0	0	0	0	0	2685	1484
Other Urban	313	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	35	0	6	0	6	0	6	0	0	0	0	6	0
Residential - Low Density	239	177	1491	0	1668	0	0	0	0	0	8	8	1660
Residential - Medium Density	60	82	1535	0	1617	0	0	0	0	0	9	9	1608
Residential - Mobile Home Units	57	0	2355	0	2355	0	0	0	0	0	0	0	2355
Sugarcane	2743	48692	0	0	48692	45988	0	0	0	0	0	45988	2704
Unimproved Pasture	109	0	18	0	18	0	17	0	0	0	0	17	1
Water Bodies	199	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	345	0	0	0	0	0	0	0	0	0	0	0	0
Total	7320	63257	7413	0	70670	49525	2876	159	320	0	17	52897	17773

G:\sfwd\sfwdpbud\pbudget\tables.xls 99093.00

Table D-20: Phosphorus Budget by Land Use in the S-154 Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Abandoned Dairy	30	110	29	0	139	0	42	2	5	0	0	49	90
Citrus	5	57	0	0	57	17	0	0	0	0	0	17	40
Dairy	1599	9321	110422	179	119922	0	1022	0	0	32983	0	34005	85917
Field Crops	1	22	0	0	22	18	0	0	0	0	0	18	4
Forested Uplands	444	0	0	0	0	70	0	0	0	0	0	70	-70
Improved Pasture	6839	25222	6743	0	31965	0	9582	533	1074	0	0	11189	20776
Ornamentals	8	215	0	0	215	139	0	0	0	0	0	139	76
Other Urban	188	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	509	0	85	0	85	0	80	0	0	0	0	80	5
Residential - High Density	31	37	1762	0	1799	0	0	0	0	0	5	5	1794
Residential - Low Density	815	603	5077	0	5680	0	0	0	0	0	28	28	5652
Residential - Medium Density	63	86	1611	0	1697	0	0	0	0	0	9	9	1688
Residential - Mobile Home Units	78	0	3220	0	3220	0	0	0	0	0	0	0	3220
Unimproved Pasture	334	0	56	0	56	0	52	0	0	0	0	52	4
Water Bodies	77	0	0	0	0	0	0	0	0	0	0	0	0
Total	12795	35673	129005	179	164857	244	10778	535	1079	32983	42	45661	119196

Table D-21: Phosphorus Budget by Land Use in the S-154C Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Barren Land	68	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	2	19	0	0	19	6	0	0	0	0	0	6	13
Forested Uplands	39	0	0	0	0	6	0	0	0	0	0	6	-6
Improved Pasture	686	2531	677	0	3208	0	962	54	108	0	0	1124	2084
Other Urban	1	0	0	0	0	0	0	0	0	0	0	0	0
Water Bodies	16	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	70	0	0	0	0	0	0	0	0	0	0	0	0
Total	882	2550	677	0	3227	12	962	54	108	0	0	1136	2091

Table D-22: Phosphorus Budget by Land Use in the S-65A Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	307	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	629	6517	0	0	6517	1968	0	0	0	0	0	1968	4549
Commercial Forestry	2407	0	0	0	0	378	0	0	0	0	0	378	-378
Field Crops	41	1613	0	0	1613	1331	0	0	0	0	0	1331	282
Forested Uplands	5151	0	0	0	0	809	0	0	0	0	0	809	-809
Golf Course	33	338	0	0	338	0	0	0	0	0	0	0	338
Improved Pasture	13015	47998	12832	0	60830	0	18233	1015	2043	0	0	21291	39539
Other Urban	189	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	5139	0	863	0	863	0	807	0	0	0	0	807	56
Residential - Low Density	58	43	358	0	401	0	0	0	0	0	2	2	399
Residential - Mobile Home Units	48	0	2006	0	2006	0	0	0	0	0	0	0	2006
Truck Crops	238	49851	0	0	49851	4517	0	0	0	0	0	4517	45334
Unimproved Pasture	5232	0	879	0	879	0	821	0	0	0	0	821	58
Water Bodies	113	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	9225	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	41825	106360	16938	0	123298	9003	19861	1015	2043	0	2	31924	91374

Table D-23: Phosphorus Budget by Land Use in the S-65B Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	557	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	335	3468	0	0	3468	1047	0	0	0	0	0	1047	2421
Commercial Forestry	1353	0	0	0	0	212	0	0	0	0	0	212	-212
Field Crops	476	18777	0	0	18777	15491	0	0	0	0	0	15491	3286
Forested Uplands	3881	0	0	0	0	609	0	0	0	0	0	609	-609
Improved Pasture	10027	36981	9887	0	46868	0	14049	782	1574	0	0	16405	30463
Other Urban	518	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	18859	0	3168	0	3168	0	2961	0	0	0	0	2961	207
Sod Farm	28	533	0	0	533	0	0	0	1914	0	0	1914	-1381
Unimproved Pasture	619	0	104	0	104	0	97	0	0	0	0	97	7
Water Bodies	112	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	15166	0	0	0	0	0	0	0	0	0	0	0	0
Total	51931	59759	13159	0	72918	17359	17107	782	3488	0	0	38736	34182

Table D-24: Phosphorus Budget by Land Use in the S-65C Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Barren Land	372	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	1765	18276	0	0	18276	5518	0	0	0	0	0	5518	12758
Field Crops	9	337	0	0	337	278	0	0	0	0	0	278	59
Forested Uplands	1078	0	0	0	0	169	0	0	0	0	0	169	-169
Improved Pasture	10260	37840	10117	0	47957	0	14375	800	1611	0	0	16786	31171
Other Urban	165	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	1125	0	189	0	189	0	177	0	0	0	0	177	12
Residential - Low Density	10	7	60	0	67	0	0	0	0	0	0	0	67
Truck Crops	26	5515	0	0	5515	500	0	0	0	0	0	500	5015
Unimproved Pasture	864	0	145	0	145	0	136	0	0	0	0	136	9
Water Bodies	177	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	4558	0	0	0	0	0	0	0	0	0	0	0	0
Total	20409	61975	10511	0	72486	6465	14688	800	1611	0	0	23564	48922

Table D-25: Phosphorus Budget by Land Use in the S-65D Basin

		IMPORTS (kg/yr)				EXPORTS (kg/yr)							Net
LAND USE	Area (ha)	Fertilizer	Feed	Cleaners	Total	Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Import (kg/yr)
Abandoned Dairy	97	358	96	0	454	0	136	8	15	0	0	159	295
Barren Land	263	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	2143	22194	0	0	22194	6701	0	0	0	0	0	6701	15493
Dairy	1405	8190	97023	157	105370	0	898	0	0	28981	0	29879	75491
Field Crops	85	3339	0	0	3339	2755	0	0	0	0	0	2755	584
Forested Uplands	1710	0	0	0	0	268	0	0	0	0	0	268	-268
Improved Pasture	23887	88095	23553	0	111648	0	33466	1863	3750	0	0	39079	72569
Ornamentals	13	356	0	0	356	229	0	0	0	0	0	229	127
Other Urban	289	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	2758	0	463	0	463	0	433	0	0	0	0	433	30
Residential - Low Density	454	336	2828	0	3164	0	0	0	0	0	15	15	3149
Residential - Medium Density	15	20	383	0	403	0	0	0	0	0	2	2	401
Residential - Mobile Home Units	5	0	211	0	211	0	0	0	0	0	0	0	211
Truck Crops	1316	274987	0	0	274987	24918	0	0	0	0	0	24918	250069
Unimproved Pasture	724	0	122	0	122	0	114	0	0	0	0	114	8
Waste Treatment / Disposal	64	0	0	0	0	0	0	0	0	0	0	0	0
Water Bodies	1016	0	0	0	0	0	0	0	0	0	0	0	0
Total	47187	397875	124679	157	522711	34871	35047	1871	3765	28981	17	104552	418159

Table D-26: Phosphorus Budget by Land Use in the S-65E Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Abandoned Dairy	266	981	262	0	1243	0	373	21	42	0	0	436	807
Barren Land	256	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	1190	12327	0	0	12327	3722	0	0	0	0	0	3722	8605
Dairy	835	4869	57677	94	62640	0	534	0	0	17228	0	17762	44878
Field Crops	48	1899	0	0	1899	1566	0	0	0	0	0	1566	333
Forested Uplands	992	0	0	0	0	156	0	0	0	0	0	156	-156
Improved Pasture	4876	17984	4808	0	22792	0	6832	380	766	0	0	7978	14814
Ornamentals	5	134	0	0	134	86	0	0	0	0	0	86	48
Other Urban	153	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	175	0	29	0	29	0	27	0	0	0	0	27	2
Residential - High Density	14	16	771	0	787	0	0	0	0	0	2	2	785
Residential - Low Density	190	140	1181	0	1321	0	0	0	0	0	6	6	1315
Residential - Medium Density	34	47	876	0	923	0	0	0	0	0	5	5	918
Truck Crops	835	174547	0	0	174547	15817	0	0	0	0	0	15817	158730
Unimproved Pasture	581	0	98	0	98	0	91	0	0	0	0	91	7
Water Bodies	221	0	0	0	0	0	0	0	0	0	0	0	0
Total	11799	212944	65702	94	278740	21347	7857	401	808	17228	13	47654	231086

Table D-27: Phosphorus Budget by Land Use in the S-191 Basin

LAND USE	Area (ha)	IMPORTS (kg/yr) Fertilizer	Feed	Cleaners	Total	EXPORTS (kg/yr) Harvest	Liveweight	Hay	Sod	Milk	Septic	Total	Net Import (kg/yr)
Abandoned Dairy	1863	6870	1837	0	8707	0	2610	145	292	0	0	3047	5660
Aquaculture	73	0	0	0	0	0	0	0	0	0	0	0	0
Barren Land	22	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	1313	13594	0	0	13594	4105	0	0	0	0	0	4105	9489
Dairy	4621	26934	319080	518	346532	0	2953	0	0	95308	0	98261	248271
Field Crops	212	8375	0	0	8375	6910	0	0	0	0	0	6910	1465
Forested Uplands	5084	0	0	0	0	798	0	0	0	0	0	798	-798
Golf Course	192	1974	0	0	1974	0	0	0	0	0	0	0	1974
Improved Pasture	23846	87944	23512	0	111456	0	33408	1860	3744	0	0	39012	72444
Ornamentals	159	4226	0	0	4226	2721	0	0	0	0	0	2721	1505
Other Urban	244	0	0	0	0	0	0	0	0	0	0	0	0
Poultry	20	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland	900	0	151	0	151	0	141	0	0	0	0	141	10
Residential - Low Density	1678	1242	10457	0	11699	0	0	0	0	0	57	57	11642
Residential - Medium Density	253	346	6488	0	6834	0	0	0	0	0	37	37	6797
Residential - Mobile Home Units	14	0	599	0	599	0	0	0	0	0	0	0	599
Sod Farm	417	7869	0	0	7869	0	0	0	28272	0	0	28272	-20403
Truck Crops	215	44841	0	0	44841	4063	0	0	0	0	0	4063	40778
Unimproved Pasture	2312	0	388	0	388	0	363	0	0	0	0	363	25
Water Bodies	634	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	4596	0	0	0	0	0	0	0	0	0	0	0	0
Total	48668	204215	362512	518	567245	18597	39475	2005	32308	95308	94	187787	379458

Appendix E

P-Budget User Manual
Contents of Pbudget.hlp

for

The South Florida Water Management District

by

Mock, Roos & Associates, Inc.

June 2002

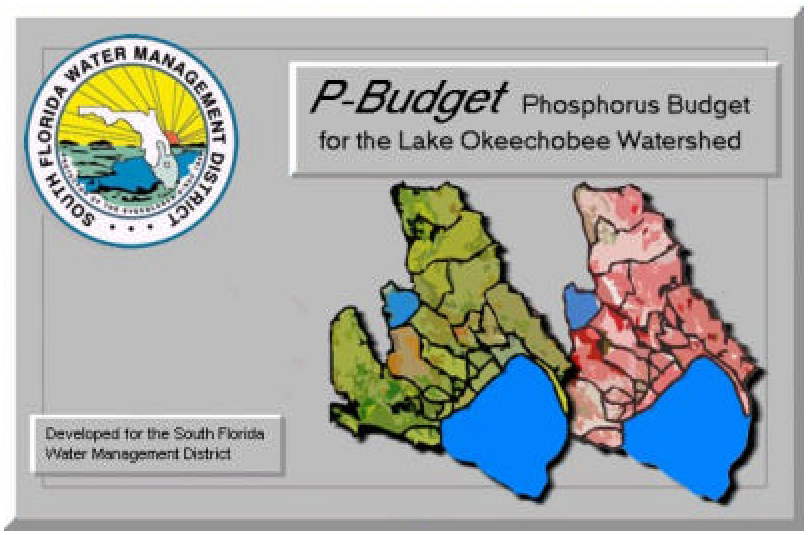
Contents for P-Budget, *printed 6/20/2002 9:05:23 AM*

Contents

What is P-Budget?

P-Budget allows engineers and planners to view the results of a phosphorus budget study of the Lake Okeechobee watershed with tables and maps, edit phosphorus import or export parameters on landowners parcels, and create Phosphorus Control Management Plans (PCMPs) to evaluate phosphorus control alternatives.

The purpose of the study was to update the 1991 phosphorus budget for the Lake Okeechobee watershed. The original study was performed to estimate the amount of net phosphorus entering the basins that discharge to Lake Okeechobee based on land use practices and hydrologic factors.



Lake Okeechobee is centrally located in the southern portion of Florida. It is fed from the north by the Kissimmee River and discharges to the south through the Caloosahatchee and various tributaries that connect to the Everglades. Over the years the impacts from farming have increased the total phosphorus loading to the Lake. Recent changes in technology and agricultural practices have helped reduce the amount of phosphorus entering the Lake somewhat but the problem still exists.

By determining which land uses contribute the most phosphorus to the land, solutions can be derived to help eliminate this problem. This interface is designed to allow planners to create "what if" scenarios to target particular land use practices in an attempt to reach mandated reductions. This interface will also help keep phosphorus management information up to date, which eliminates the need to do an extensive restudy every 10 years.

There are three basic sets of parameters maintained by the interface - default, current and PCMP. Default parameters represent the results of the P-Budget update, which include average values per land use. Current parameters reflect changes that represent a landowner's individual practices. If a landowner's practices differ enough from what is considered average, the effects of those practices can be entered and applied over the extent of the landowner's property. These changes are permanent unless removed. PCMP parameters represent a stored set of parameters that is based on proposed or potential changes in land use practices within a selected extent. The extent can be any number of basins or permits or the entire watershed.

All models will be limited by their ability to represent reality. Therefore, it is important for users to understand the assumptions and related limitations for any model they attempt to use. Though, P-Budget is based on scientific research and measured data, it can not possibly account for every process that exists. Even if it could account for these processes, there would always be insufficient data to parameterize it. Therefore, the user is encouraged to learn and understand these limitations prior to using the model by thoroughly reviewing the final report of the P-Budget update.

P-Budget was developed by Mock, Roos & Associates, Inc. in West palm Beach, Florida for the South Florida Water Management District to assess phosphorus within the Lake Okeechobee watershed.

System Requirements

P-Budget's interface uses ESRI's ArcView 3.2a with Spatial Analyst 1.1 (or 2.0). The interface will not run on any other versions of ArcView or Spatial Analyst at this time. P-Budget is designed to run on Windows 95, 98, Me and NT operating systems.

It is recommended that your computer meet the following specifications:

200 megabytes of free hard disk space (100 megs minimum)
128 megabytes of RAM (64 megs minimum)
500 mHz co-processor (200 mHz minimum)
1024x768 screen resolution (600x800 minimum)

Because of the complexity of the Grid operations within the model, it is recommended that P-Budget be installed on the fastest computer available.

Installation

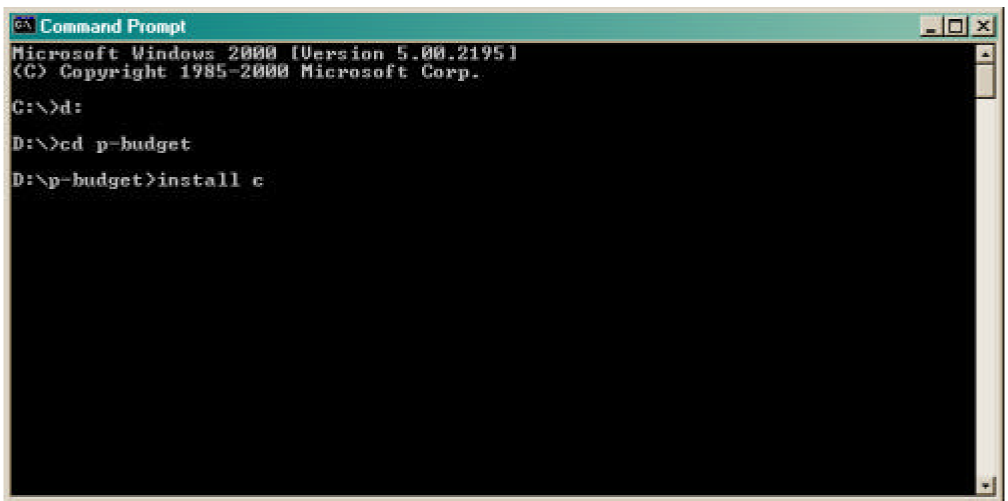
Before installing, make sure you have ArcView 3.2a installed
with Spatial Analyst 1.1 or 2.0

To install P-Budget:

Insert the CD in your CD ROM drive
Open a DOS Prompt window
Type the CD ROM drive letter followed by a colon (e.g. d:)
Type cd\p-budget
Type Install DestinationDrive Path
(Examples: Install c, Install g pbud, Install d gis/programs)

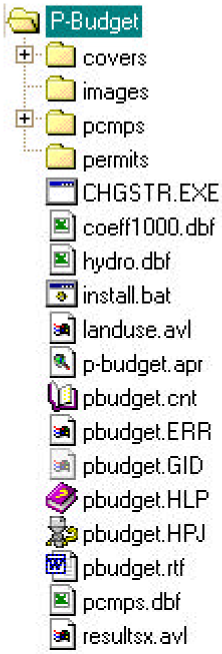
This procedure will copy all of the files from the CD to your computer and will also edit several ArcView apr files which include the correct file path reference information. This may take a few minutes.

At the end of this installation, close the DOS Prompt window.



File and Grid Management

Once installed, the file structure for P-Budget is as follows:



The install.bat and chgstr.exe files are used for installing P-Budget. The coeff1000.dbf and hydro.dbf files are database files that include the default phosphous related parameters for land use practices and hydrologic elements, respectively. The landuse.avl and resultsx.avl files are ArcView legend files used to produce consistent input and output legends. The pcmps.dbf file is a datebase file including attribute information for saved PCMPs. P-budget.apr is the ArcView project file that includes the P-Budget interface. The remaining files in the root P-Budget folder (pbudget.*) are associated with the help user manual which can be accessed through the P-Budget interface or by double clicking pbudget.hlp.

The **covers** folder contains ArcView shapefiles and ARC/INFO GRID data including land use and base maps. It also includes output grids of phosphous in g/ha for each phosphous component as described below:

fertgridFertilizer import
feedgridFeed import
clnrsgridCleaners import
harvgridHarvest export
livewgridLiveweight export
haygridHay export
sodgridSod export
milkgridMilk export
septgridSeptic system export
imp_gridTotal import
exp_gridTotal export
p_gridNet import

There are three sets of these grids stored in the covers folder. A set with a "t" suffix, a set with an "x" suffix and a set with no suffix. The set with no suffix represents a backup copy of the most recently saved output based on current land use practices. The "t" set is created for intermediate calculations. The "x" set represents the selected PCMP. If no PCMP is open, the "x" set is equal to the backup set (no suffix) The p_grid is loaded as a theme called All Results in the right view with a suffix that ends with a number that changes each time the grid is replaced. This is necessary to work around a problem in ArcView. ArcView can not delete themes and their source grids at the same time, i.e., during the same script operation. Therefore, the grid is given a new name each time the theme is replaced. The unused grids are deleted everytime P-Budget is opened so that the numbers can be used again and to clean up the hard disk.

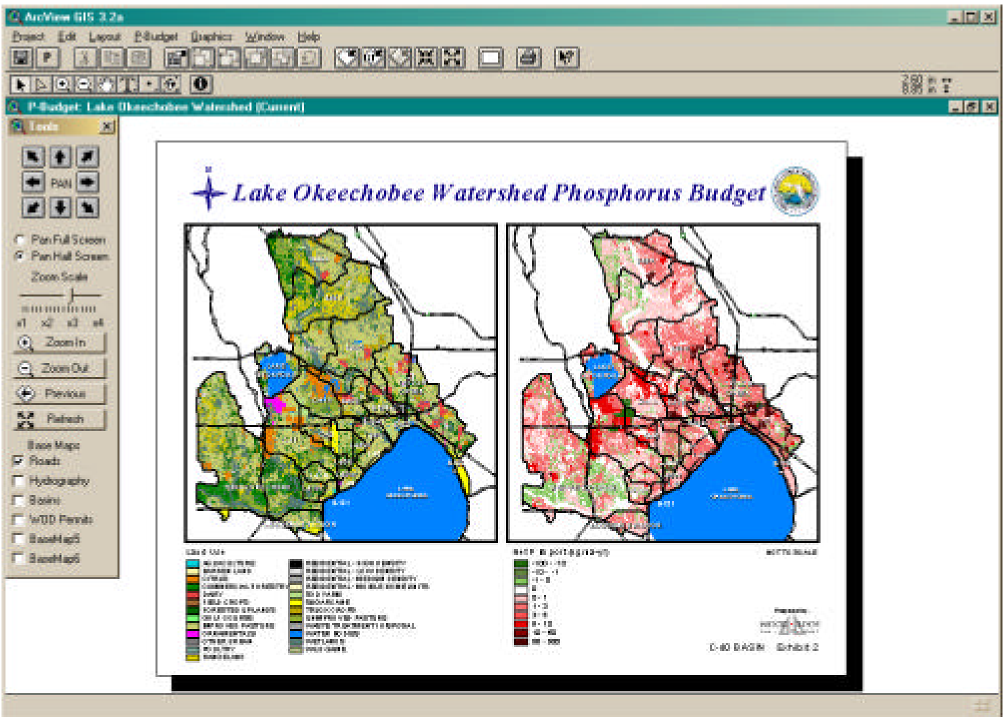
The **images** folder contains bitmaps of land uses that are utilized when editing phosphous related parameters associated with land use practices (see Edit Current Landowner Practices). The folder also contains miscellaneous graphics including logos and the P-Budget opening screen.

The **pcmps** folder contains folders, named after saved pcmps, that include databases and phosphous component grids reflecting phosphous parameters based on proposed or potential changes to land use practices (see Phosphorus Control Management Plans).

The **permits** folder contains database files of phosphous parameters based on th land use practices of individual landowners (see Edit Current Landowner Practices).

Getting Started

To get started, open ArcView and navigate to the P-Budget folder where P-Budget was installed. Open P-Budget.apr. An opening screen will appear for a few seconds. Then a layout will appear with two view ports, legends and display tools on the left side of the screen. This layout entitled "P-Budget: Lake Okeechobee Watershed" serves as the main screen for the interface. By default, the left view port is set to display the existing (or current) land use and the right view port is set to display the P-Budget results based on the set current parameters.



The functionality of ArcView has been preserved. Experienced ArcView users may want to utilize other features within the project such as views, tables or charts. This can be done without interfering with the operation of the interface.
When the user is finished utilizing other ArcView features, simply press {bmc pbud004.bmp} to return the main display.

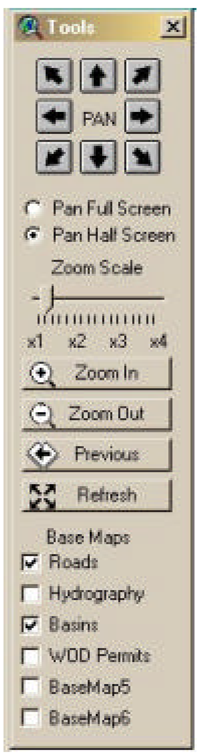
Display Tools

The display tools on the left side of the screen provide the user with a variety of means to view the land use and output grids. It is important to note that these tools control the two view ports simultaneously. The standard ArcView buttons at the top of the screen also include panning and zooming, but these buttons will perform those functions on the entire layout.

The zooming options provided with P-Budget include zooming in and out based on a scale that can be set by the user. The default scale is set at 1.5 (or 50%). The zoom in and out buttons cause the screen to zoom in or out from the center of the map view. The pan buttons allow the user to re-center the screen based on the selected direction. The user can pan a full screen or half screen.

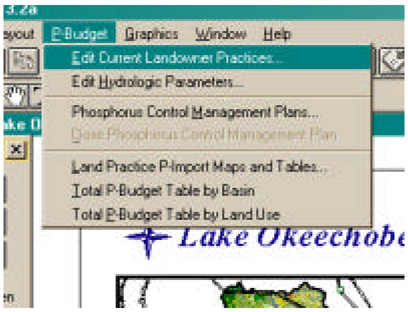
The Previous button provides a means of going back to the previous extent and the Refresh button returns the user back to the original default extent of the primary basin.

Base map coverages have been provided which overlay onto the current display to provide geographic reference. The coverages can be turned on or off at any time.

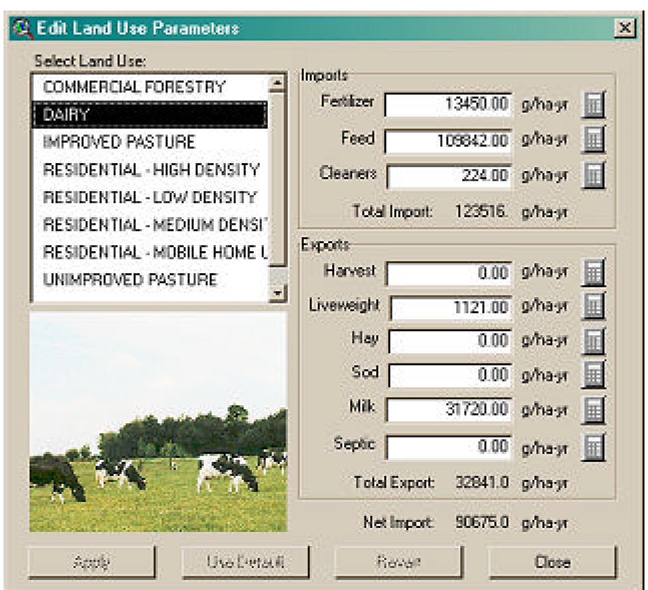


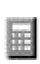
Edit Current Landowner Practices

If a landowner's practices differ enough from what is considered average, the effects of those practices can be entered and applied over the extent of the landowner's property. These changes are permanent unless removed.



By selecting Edit Current Landowner Practices... from the P-Budget option of the main menu, the user is provided with a list of WOD (Works of the District) permits. These permits represent contiguously owned farms. Permits/farms were used because it is assumed that the landowner will conduct practices consistently throughout his or her land. The user may choose any one of the permits in the list and press Apply. A dialog box will appear with a list of the land uses that exist with the permit area. The right side of the dialog box includes parameter values for the import and export components for the selected land use. Each land use has been characterized into phosphorus import and export components. When selecting a land use, a picture of the land use will appear in the bottom left corner of the dialog box and the previously saved parameters will appear to the right. If the permit has never been edited before, the values will reflect default parameters stored in the coeff1000.dbf file.



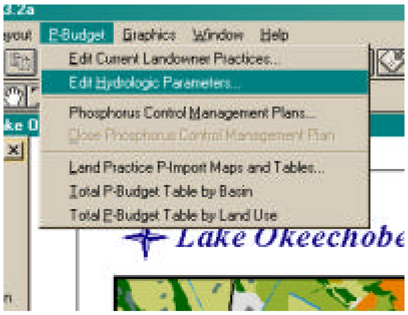
Calculators  have been provided next to each phosphorus component to assist the user in calculating the phosphorus import or export for that component. Once a change has been made, the buttons along the bottom will become activated. The

Apply button will register the change and calculate the total import, total export and net import for the selected land use. The Use Default button will replace the values with the default values from the coeff1000.dbf file. The Revert button will return the previously saved values. After pressing Apply to register the changes, other land uses may be selected and edited in a similar manner. When finished, the Close button will ask the user to confirm the changes. The changes will be saved in a dBase file located in the permits folder and named after the permit, e.g., 47-00086-Q.dbf. Several grids of the permit extent will be created, one per phosphous component along with grids for total import, total export and net import. These grids will be "burned" onto larger grids of the same type that cover the entire watershed. The grids are stored in the covers folder and are added as themes to the Right View document.

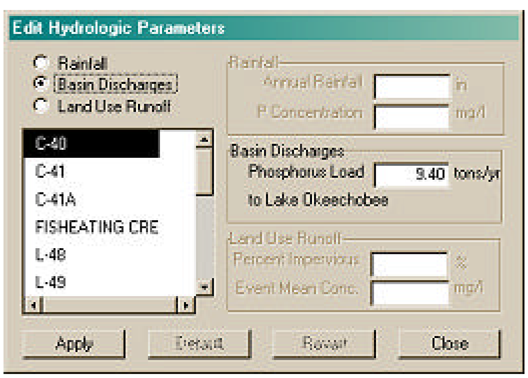
To remove the changes, do not simply delete the dBase file or grids. Instead, open the permit press the Use Default and Apply buttons for each land use, then close. At this time, the corresponding dBase file in the permits folder may be deleted, though it is not necessary to do so.

Edit Hydrologic Parameters

Hydrologic parameters include phosphous from rainfall, basin discharges and land use runoff. By selecting Edit Hydrologic Parameters... from the P-Budget option on the main menu, a dialog box will appear that includes radio buttons in the top left corner allowing the user to choose which hydrologic component to edit.



Different portions of the dialog box will be enabled depending on the selected component. Basin Discharges and Land Use Runoff include lists of basins and land uses, respectively. Previously saved values will appear in the text boxes to the left depending on selection with the list box. If the previously saved values do not match the default values as determined in the P-Budget study update, the Default button will be enabled allowing the user to replace the values with the default parameters. If the user wishes to undo a change that has been made, but not yet saved, the Revert button can be used. Changes are registered by pressing Apply which will store the values in a temporary database field until saved. If changes have been made, the user will be prompted to save the changes when pressing the Close button.



Phosphorus loads in Basin Discharges are stored as attributes in the basins.shp file in the following fields:

BASINP Phosphous Load in Basin Discharge in tons/yr - Saved
DEFP Phosphous Load in Basin Discharge in tons/yr - Default
TMPP Phosphous Load in Basin Discharge in tons/yr - Temporary

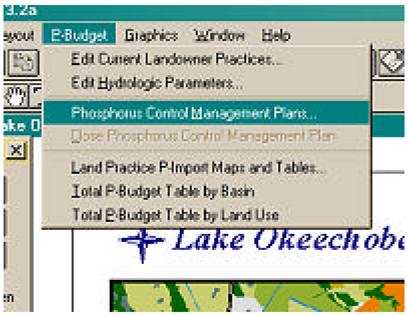
The suffix Saved reflects previously saved values that are used for output calculations. Default reflects default values taken from the P-Budget study update. Temporary reflects values that are entered into the Edit Hydrologic Parameters dialog box. These values are copied into the Saved field if the user chooses to save the changes when closing.

Hydrologic parameters for rainfall and land use runoff are saved in hydro.dbf. Saved, Default and Temporary fields are utilized in a similar manner as described above. Values are stored for each land use within the following fields:

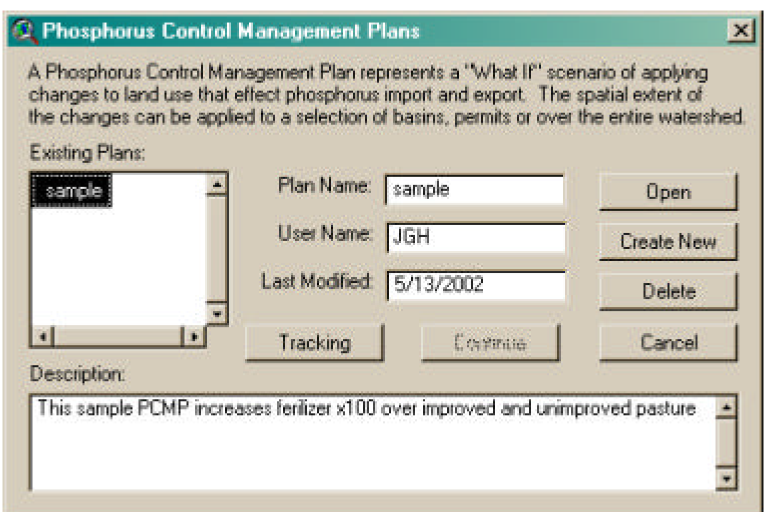
LU_IMP	Percent Impervious - Saved
LU_EMC	Event Mean Concentration - Saved
DEF_IMP	Percent Impervious - Default
DEF_EMC	Event Mean Concentration - Default
TMP_IMP	Percent Impervious - Temporary
TMP_EMC	Event Mean Concentration - Temporary
RAINFALL	Average Annual Rainfall in inches - Saved
RAIN_DEF	Average Annual Rainfall in inches - Default
RAIN_TMP	Average Annual Rainfall in inches - Temporary
RAINFALLP	Phosphorus Concentration in Rainfall - Saved
RAINP_DEF	Phosphorus Concentration in Rainfall - Default
RAINP_TMP	Phosphorus Concentration in Rainfall - Temporary
RUNOFF_V	Runoff Volume in inches per grid cell
RUNOFF_P	Runoff Phosphorus in grams/ha per grid cell

Phosphorus Control Management Plans (PCMPs)

Phosphorus Control Management Plans (PCMPs) represent proposed or potential changes in land use practices within a selected extent. By creating a PCMP, the user can assess the effects of altering land use practices such as fertilizer application.

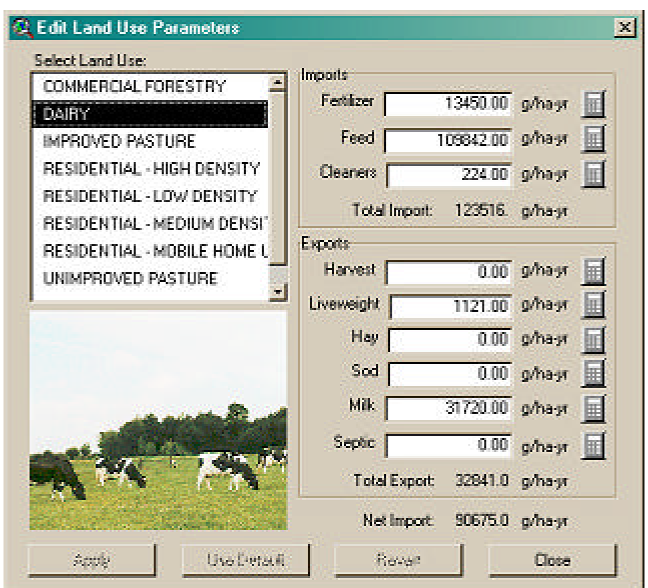


By selecting Phosphorus Control Management Plans... from the P-Budget option on the main menu, a dialog box will appear that includes a list box of previously saved plans. Attributes associated with the selected plan will appear to the right and bottom of the list box including the plan name, user name, date and description. The selected plan can be opened or deleted. The Tracking button displays a list of the land use practices with edited coefficients. A new plan can be created by pressing Create New. The user is then prompted to enter the plan name, user name and description before pressing the Continue button.



After pressing Continue, the user is prompted to select a spatial extent. The extent can be any number of basins or permits or the entire watershed. Multiple basins or permits can be selected by using the shift key while selecting.

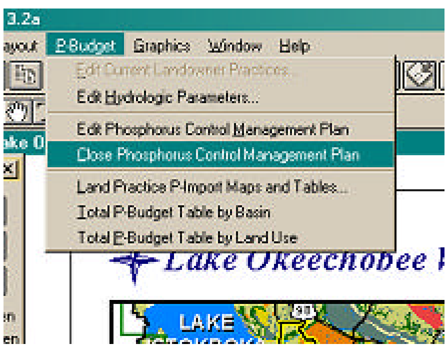
After the extent is chosen and the Apply button is pressed, the dual views will zoom to the selected extent which will be outlined with a yellow and black border. The title of the layout will also change to identify the name of the plan that is currently open. A dialog box will appear with a list of the land uses that exists with the selected area. The right side of the dialog box includes parameter values for the import and export components for the selected land use. Each land use has been characterized into phosphous import and export components. When selecting a land use, a picture of the land use will appear in the bottom left corner of the dialog box and the default parameters will appear to the right. Note that when opening a previously saved PCMP, the step to select an extent is skipped and the parameter values will reflect the previously saved values.



Calculators have been provided next to each phosphorus component to assist the user in calculating the phosphorus import or export for that component. Once a change has been made, the buttons along the bottom will become activated. The

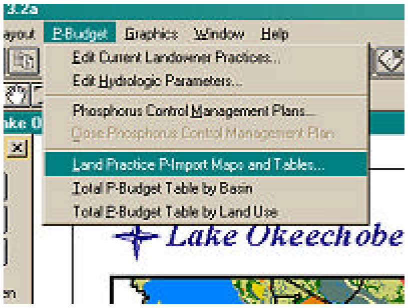
Apply button will register the change and calculate the total import, total export and net import for the selected land use. The Use Default button will replace the values with the default values from the coeff1000.dbf file. The Revert button will return the previously saved values. After pressing Apply to register the changes, other land uses may be selected and edited in a similar manner. When finished, the Close button will ask the user to confirm the changes. The changes will be saved in a dBase file located in the pcmps folder and named with the pcmp name. Several grids of the selected extent will be created, one per phosphorus component along with grids for total import, total export and net import. These grids will be "burned" onto larger grids of the same type that cover the entire watershed. The grids are stored in the P-Budget\pcmp*pcmpname* folder. The grids are then copied to the P-Budget\covers folder and renamed with an "x" suffix. See File and Grid Management for details.

The phosphorus coefficients can be edited again by selecting the Edit Phosphorus Control Management Plan from the P-Budget option on the main menu. To close the PCMP, simply select Close Phosphorus Control Management Plan. These options are only available when a PCMP is open. When the PCMP is closed, the phosphorus component grids in the P-Budget\covers folder are replaced with the previously saved current land practice grids. The title of the layout also reverts back to indicate "current" land practices.



Land Practice P-Import Output

Maps and tables can be generated for the current or selected PCMP for land practice related phosphous import by selecting Land Practice P-Import Maps and Tables from the P-Budget option of the main menu.



The user will be asked to select a spatial extent which may include any number of basins or permits or the entire watershed. Once the Apply button is selected, new grids are generated and displayed in the left and right views that include clipped portions of the maps based on the selected extent. The views are then automatically repositioned to fit to the new extent.

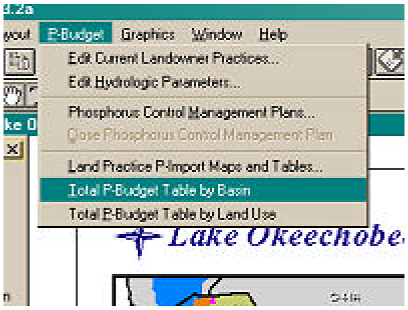
A table will appear that includes each land practice related to phosphous import and export for each land use with the selected extent. The table is stored in DBF format in the P-Budget folder and is called landp.dbf. This file is replaced each time that the table is created.

Land Practice Net Phosphorus Import (kg/yr)

Land Use	Hectares	Fertilizer	Feed	Cleaners	Imports	Harvest	Liveweigh	Hay	Sod	Milk	Septic	Exports	Net_Impor
AQUACULTURE	2	0	0	0	0	0	0	0	0	0	0	0	0
BARREN LAND	772	0	0	0	0	0	0	0	0	0	0	0	0
CITRUS	9360	96941	0	0	96941	29269	0	0	0	0	0	29269	67672
COMMERCIAL FORESTRY	24	0	0	0	0	4	0	0	0	0	0	4	-4
FIELD CROPS	214	8430	0	0	8430	6955	0	0	0	0	0	6955	1475
FORESTED UPLANDS	4770	0	0	0	0	749	0	0	0	0	0	749	-749
IMPROVED PASTURE	18711	67322	18449	0	85771	0	26214	1459	2938	0	0	30611	55160
ORNAMENTALS	2590	68971	0	0	68971	44414	0	0	0	0	0	44414	24557
OTHER URBAN	623	0	0	0	0	0	0	0	0	0	0	0	0
RANGELAND	1827	0	307	0	307	0	287	0	0	0	0	287	20
RESIDENTIAL - LOW DENSIT	580	859	976	0	1835	0	0	0	0	0	20	20	1815
RESIDENTIAL - MEDIUM DEI	33	990	568	0	1558	0	0	0	0	0	5	5	1553
RESIDENTIAL - MOBILE HOM	45	0	1511	0	1511	0	0	0	0	0	0	0	1511
SOD FARM	2986	56324	0	0	56324	0	0	0	202369	0	0	202369	-146045
SUGARCANE	2684	47659	0	0	47659	45013	0	0	0	0	0	45013	2646
TRUCK CROPS	43	8954	0	0	8954	811	0	0	0	0	0	811	8143
UNIMPROVED PASTURE	4309	0	724	0	724	0	677	0	0	0	0	677	47
WATER BODIES	416	0	0	0	0	0	0	0	0	0	0	0	0
WETLANDS	6215	0	0	0	0	0	0	0	0	0	0	0	0

Total P-Budget Tables

Two tables can be generated for the current or selected PCMP for total phosphous budget net import by selecting Total P-Budget Table by Basin or Total P-Budget by Land Use from the P-Budget option of the main menu.



The "by Basin" table includes the land practice phosphous (imports, exports and net import) and the hydrologic phosphous components (rainfall, runoff and discharge to lake) and calculates the onsite storage of phosphous (Runoff_P - P_to_Lake). The table is stored in DBF format in the P-Budget folder and is called tpbas.dbf. This file is replaced each time that the table is created.

Total Phosphourus Budget per Basin (tons/yr)

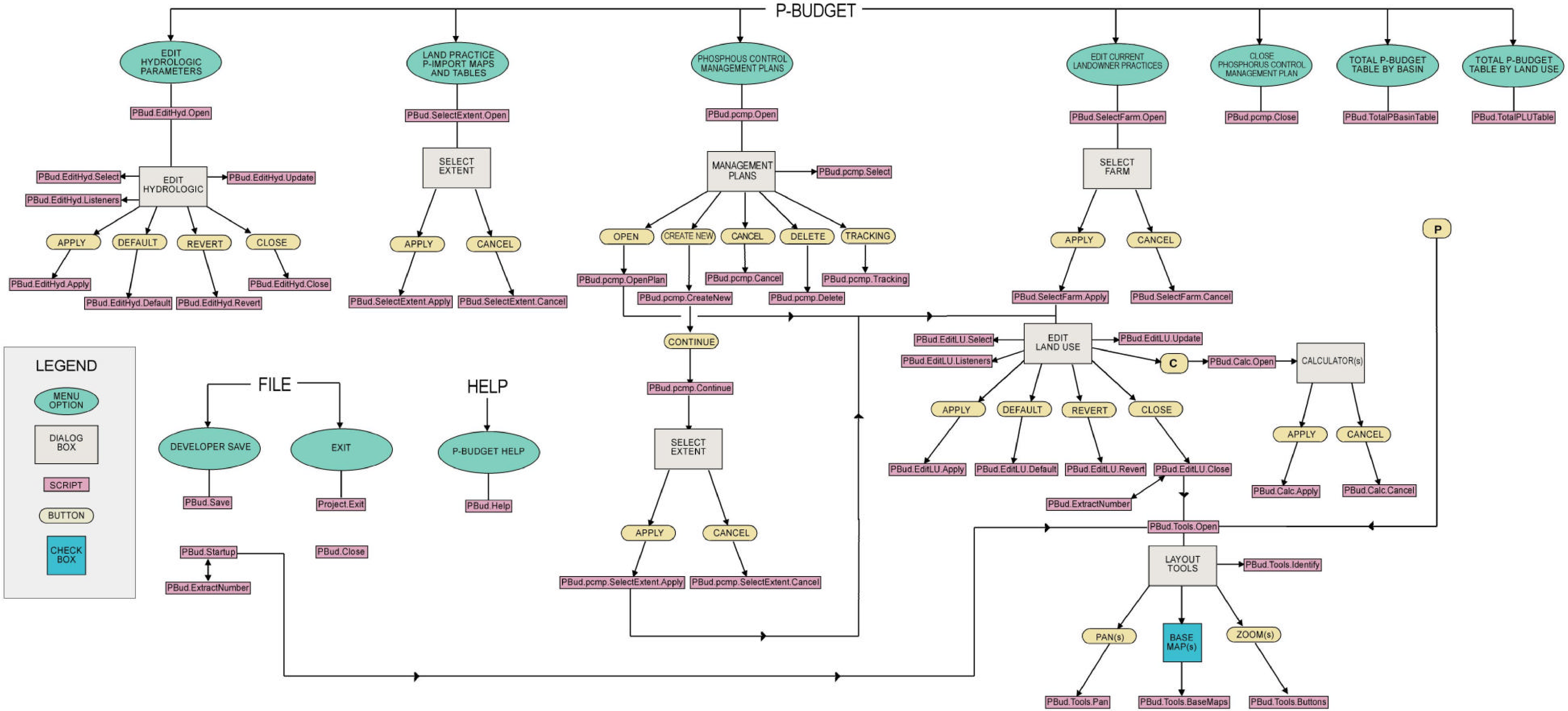
Basin	Imports	Exports	Net_Import	Rainfall_P	Runoff_P	P_to_Lake	Onsite_P
S-65A	298	45	253	18	86	6	80
S-65B	159	33	126	22	64	6	58
S-65D	764	129	635	20	193	41	152
S-65C	105	27	78	9	43	11	32
C-41A	140	80	60	10	43	12	31
S-154	274	70	204	5	92	30	62
FISHEATING CREEK	585	120	465	49	199	51	148
S-65E	426	70	356	5	94	26	68
C-41	562	178	384	16	103	29	74
S-133	118	49	68	4	27	6	21
C-40	138	162	-25	8	31	9	22
S-154C	4	1	2	0	2	0	2
L-59E	18	6	11	2	13	2	11
S-135	122	61	61	3	17	4	13
L-48	46	12	34	4	21	8	13
L-59W	7	3	4	1	5	2	3
L-60E	3	1	2	1	3	0	3
L-61E	12	4	7	2	9	1	8
L-49	23	8	14	2	10	2	8
L-60W	3	1	2	1	2	0	2
L-61W	9	3	6	2	7	1	6
S-131	53	13	40	1	10	1	9
TAYLOR CREEK	1181	272	908	21	320	86	234
NICODEMUS SLOUGH	57	42	14	4	16	0	16
LAKE ISTOKPOKA	82	11	72	8	31	7	24

The "by Land Use" table is similar but does not include the phosphous discharge to the lake (P_to_Lake) because that information is only available by basin. On-site storage is also not included since it is dependent on P_to_Lake. The table is stored in DBF format in the P-Budget folder and is called tplu.dbf. This file is replaced each time that the table is created.

Total Phosphourus Budget per Land Use (tons/yr)

Landuse	Imports	Exports	Net_Import	Rainfall_P	Runoff_P
RANGELAND	9	9	1	21	12
IMPROVED PASTURE	1188	335	853	79	568
WETLANDS	0	0	0	40	54
FORESTED UPLANDS	0	11	-11	27	61
DAIRY	1204	320	884	4	369
BARREN LAND	0	0	0	2	3
OTHER AGRICULTURE	118	8	109	0	14
OTHER URBAN	0	0	0	3	23
UNIMPROVED PASTURE	6	5	0	13	19
TRUCK CROPS	1901	135	1766	3	224
CITRUS	307	87	221	11	31
WATER BODIES	0	0	0	6	9
GOLF COURSE	4	0	4	0	0
SOD FARM	77	278	-200	2	5
ORNAMENTALS	84	54	30	1	7
COMMERCIAL FORESTRY	0	0	0	0	1
WASTE TREATMENT / DISP	0	0	0	0	0
SUGARCANE	169	160	9	4	5
AQUACULTURE	0	0	0	0	0
POULTRY	0	0	0	0	0
WILD GAME	0	0	0	0	0
RESIDENTIAL - MOBILE HOM	30	0	30	0	1
RESIDENTIAL - LOW DENSIT	26	0	26	3	28
RESIDENTIAL - MEDIUM DEN	43	0	42	1	7
RESIDENTIAL - HIGH DENSI	19	0	19	0	1

P-BUDGET ARCVIEW INTERFACE DESIGN SCHEMATIC



Appendix F

SAMPLE DAIRY REPORT FROM FDEP

YEAR	DAIRY	AVG MILK HERD	FEED P (TONS)	FERT P (TONS)	TONS P IMPORT	TONS P EXPORT	NET P (TONS)
1999	B-4	639	21.0	7.4	28.4	4.4	24.1
1999	BISHOP BROS	748	28.2	2.0	30.1	6.2	23.9
1999	BUTLER OAKS	815	27.8	7.8	35.6	6.4	29.2
1999	C & C	401	3.2	1.8	5.0	3.5	1.5
1999	C&M RUCKS	1196	45.4	11.2	56.6	1.1	55.6
1999	DAVIE 1	958	14.7	4.7	22.1	10.0	12.1
1999	DAVIE 2	958	14.7	4.7	22.1	10.1	12.0
1999	DRY LAKE 1	928	27.9	2.2	33.4	10.6	22.8
1999	DRY LAKE 2	716	27.3	2.1	31.8	10.0	21.8
1999	FLYING G	1163	76.9	7.5	84.4	9.3	75.1
1999	HW RUCKS 1	752	24.6	0.0	24.6	7.0	17.6
1999	HW RUCKS 2	760	27.0	0.0	27.0	6.9	20.2
1999	HW RUCKS 3	700	28.3	0.0	28.3	7.2	21.1
1999	LARSON 1	1026	39.3	0.0	39.3	9.1	30.1
1999	LARSON 2	733	34.0	11.2	45.2	8.3	36.9
1999	LARSON 5	1712	57.8	6.5	64.3	21.2	43.1
1999	LARSON 8	1688	59.2	18.8	78.0	22.4	55.6
1999	MCARTHUR 1	1609	49.7	3.3	55.4	17.4	38.0
1999	MCARTHUR 2	1607	59.5		59.5	16.3	43.2
1999	MCARTHUR 3	1506	48.5	0	48.8	16.7	32.1
1999	MCARTHUR 4	1600	53.1	1.6	54.9	16.1	38.8
1999	NEW PALM	729	25.3	1.9	26.7	7.5	19.2
1999	PW BISHOP	485	8.6	0.9	9.5	4.2	5.3
1999	TRIPLE G	689	22.0	1.1	23.1	5.8	17.3