

Implementation and Verification of BMPs for Reducing P Loading from the Everglades Agricultural Area

2006 Annual Report



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And
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By
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EXECUTIVE SUMMARY

The Everglades Regulatory Program, Chapter 40E-63, F.A.C. ("Rule 40E-63") mandates landowners in the Everglades Agricultural Area (EAA) to sponsor a program for Best Management Practices (BMP) research, testing and implementation. The University of Florida's Institute of Food and Agriculture Sciences (UF/IFAS) has conducted comprehensive research on BMP effectiveness and implementation in the EAA basin since 1992 under the Everglades Agricultural Area-Environmental Protection District (EAA-EPD) BMP Master Permit Scope of Work.

In March 2005, the South Florida Water Management District (SFWMD) approved a modification of the EAA-EPD Scope of Work (SOW). In the revised SOW new tasks were proposed for BMP research, testing and implementation. The tasks and objectives of this SOW are: 1) Statistical Evaluation of BMP Monitoring and Research Data with an objective to assess parameters that affect farm P discharge, to improve selection and application of existing BMPs; 2) BMP Outreach Consultation Program: A one-on-one consultation program on priority farm basins with an objective of enhancing the dissemination and implementation of BMPs to all growers in the EAA basin; and 3) Other Outreach and extension activities that include BMP training seminars and workshop and development and transmittal of extension publications on BMPs in the EAA.

This report documents the progress and achievements of the project, "Implementation and Verification of BMPs for Reducing P Loading from the Everglades Agricultural Area", described in the 2005/06 Scope of Work for UF/IFAS with the Everglades Environmental Protection District of the Everglades Agricultural Area (EAA-EPD). Major accomplishments of each task are summarized below.

1. Farm BMP Consultation Program:

Before the BMP consultation program began farm visits, background information was collected from the SFWMD and evaluated to observe BMP performance differences across EAA sub-basins. There are several factors that may affect total P loads at the farm and sub-basin level. Variations in total P loads and BMP performance may be related to geographical location, soil depth and composition, rainfall distribution, Lake Okeechobee irrigation water quality, hydrology and cropping systems. It is important to understand that there are inherent differences in EAA farms and these differences may affect BMP performance.

Soils of the EAA - Most of the soils in the EAA are classified as organic (soil order: Histosol). Organic soils in the EAA generally contain more than 85% organic matter by weight. With the exception of organic soils found adjacent to Lake Okeechobee, their

mineral content is generally less than 35%. The organic soils in the EAA are classified on the basis of their organic matter content, degree of decomposition of the organic material, depth of organic material over mineral layer, and composition of the mineral layer. The major soil series in the EAA with corresponding thickness of the organic layer are: Torry (>51 inches), Terra Ceia (>51 inches), Pahokee (36-51 inches), Lauderhill (20-36 inches), Dania (<20 inches), Okeechobee (>51 inches) and Okeelanta (16-40 inches).

The rate of soil subsidence in the EAA is an important issue since a considerable amount of organic soil has been lost since the initial drainage and cultivation of the area. The last complete survey of the organic soils of the EAA in 1988 showed that Lauderhill muck was the dominant soil series across the EAA. In 1988, the S-5A basin on average contained the deepest organic soils in the EAA, with the soil series dominated by Terra Ceia and Pahokee mucks. In contrast, the S-8 basin contained the shallowest soils series dominated by Lauderhill and Dania mucks. The central (S-2 basin) and south east (S-6 and S-7 basins) regions were dominated by the shallower soil series Lauderhill and Dania mucks. Soils from the North West (S-3 basin) region of the EAA were dominated by Pahokee and Lauderhill mucks. Torry mucks located around the SE borders of Lake Okeechobee have not show the same changes in depth as the other major soil series. Torry mucks have a high clay content which reduces the permeability of these soils keeping them wetter for longer periods. Furthermore, the lower organic matter content of Torry mucks allows these soils to subside at lower rate than the other organic soils of the EAA.

The total acreage of the shallower soil series Dania and Lauderhill mucks have significantly increased, influencing farm management practices for crop production across the EAA. Subsidence also complicates restoration efforts in the EAA as well as the efforts to manage the water conservation areas to the east and south of the EAA in a more natural condition.

Irrigation Water Quality - Water quality in the Lake Okeechobee has degraded over time due to high P loadings resulting from man-induced hydrologic and land-use changes over the past 60 years. The lake's total P concentrations have doubled over the last 50 years as a result of increased P inputs from the surrounding watersheds. During the last five years, total P concentrations of Lake Okeechobee have averaged 0.142 mg/L; average total P concentrations in the lake for WY2005 increased to 0.237 mg/L, reflecting the impacts of the hurricanes that resulted in significantly higher P loads and sediment re-suspension in the lake.

Determination if there is a relationship between P concentrations of the EAA inflow water (irrigation) from Lake Okeechobee and P loads leaving farms within each of the sub-

basins is important. Initial investigations into this possible relationship plotted monthly average EAA inflow canal water P concentration data from 2000 through 2005. A review of the data indicate that pumping structure S-352, which provides irrigation water to the S-5A sub-basin had the highest total P concentration irrigation water for the past six years. Annual adjusted sub-basin P loads were then plotted by Water Year and compared to irrigation water P concentrations and spring season monthly sub-basin rainfall amounts. In WY years that were preceded by dry spring conditions and thus high irrigation demand (spring months of 2001, 2002, and 2004) the S-5A basin subsequently incurred in relatively high sub-basin P loads compared to the other sub-basins. In WY years that were preceded by wetter spring conditions and less need for irrigation water (spring months of 2000 and 2003) the S-5A basin farms did not export the highest sub-basin P loads. This observation requires further investigation to verify if a relationship does exist and to what degree irrigation quality affects farm BMP performance. Research at the farm level to accurately measure and monitor irrigation and drainage is recommended.

Farm BMP Consultation Methodology – The process starts with an initial contact with the farm basin grower or operator. After initial contact, the BMP consultation program is explained in detail and an initial appointment to visit the farm is set up. Before the visit, farm data such as flow, P concentrations and load history are summarized for discussion purposes with the farm personnel. During the field visit, the summarized farm data from last five years is discussed as well as the farm's BMP program. Any other topics related to water quality that the farmer or water managers have in the in the area are also discussed. Written BMPs implementation guides are provided to the grower as additional information. Following the BMP discussion, IFAS personnel and farm personnel travel the farm to observe the different farm operations related to BMP implementation. At the end of the visit, recommendations are provided when applicable. At the same time farmers' concerns and feedback are collected for improving the program and educating IFAS personnel. During consultations with the grower, UF/IFAS personnel utilize a BMP checklist developed specifically for this program.

The Farm BMP Consultation Program has been well accepted by the growers. Farmers have been very cooperative and willing participants. The completion of the Farm BMP Consultation Program for the S-5A basin is on schedule to be completed this fiscal year with 70% of the total acreage (81,108 acres) presently completed. The remaining 30% (34,426 acres) is scheduled to be completed before September 30th, 2006.

General BMP Consultation Program Recommendations:

Canal cleaning – Sediments are a significant part of the total P exported off-farm in the EAA. Thus, any reduction due to BMPs will positively influence total P loads at the farm level. A regular canal cleaning program ensures that sediment accumulated in drainage

canals is removed from the drainage stream, reducing the likelihood it is exported off-farm. Canal cleaning should be conducted during quiescent periods and if possible in combination with irrigation to relocate re-suspended sediments to the back canal reaches of the farm. It is important to avoid any drainage pumping during or immediately after any canal cleaning operations to prevent the release of drainage waters high with suspended sediment material. Canal cleaning has the additional advantage of improving the hydraulic capacity of farm canals.

Floating aquatic weed control – In-stream biological growth in farm canals has been identified as one of the key contributors of particulate P in drainage waters of EAA farms. Therefore, limiting the growth of floating aquatic vegetation in farm canals, especially in reaches upstream of main drainage structures, is an important practice to reduce particulate P in farm drainage waters. IFAS recommends the use weed-retention booms and trash racks well upstream of main drainage structures to reduce the potential of particulate material being transport off the farm during drainage events. The installation distance of these structures vary depending on the size of the canal, but should be installed at least 400 to 1000 ft upstream of main drainage structures. Chemical control of severe infestations is not recommended, because dead plant tissue becomes part of the easily transported floc material that is generally high in P content. Mechanical harvesting of floating aquatic vegetation is recommended if economically feasible. However, herbicide spraying sometimes is the only option to achieve effective control. Subsequent use of chemical compounds should be limited to spot spraying of problem areas to keep the floating aquatic vegetation population to a minimum.

Drainage velocity control – Velocity is the key control parameter for reducing particulate P export. The various classes of sediment material present in a typical main drainage canals respond differently to changing hydraulic conditions. At low drainage velocities, only the light, easily transportable sediment material is re-suspended and transported. As velocity in the canal increases, sediments from sides and bottom of the canal are mobilized, resulting in higher amounts of sediment material being transport off the farm. In general, the light sediment material transported at the beginning of a drainage event is the freshest biologically deposited material, with the highest P content, while the heaviest sediment transported at higher velocities is the oldest most mineralized sediment material. Thus, controlling canal velocities during drainage events is an important practice to effectively reduce the amount of sediment material exported off the farm. However, recommended velocities are relative, in that they must be within the operating framework of the configuration and size of the farm pumps and canals. Two general recommendations that are often suggested to reduce water velocity are: i) to maintain minimum canal levels during drainage events, specific for individual farms and ii) to pump at a lower rate for longer periods of time after achieving a set canal level, rather than

pumping faster for shorter periods of time to drain down to a canal cutoff level. This can be accomplished by shifting to lower capacity pumps or reducing RPMs on the larger capacity pumps.

Proper BMP documentation – Most of the farmers visited in the S-5A basin have a thorough system of documenting of farm BMP implementation. However, this is an important issue that we remind growers regardless of any deficiencies. Proper documentation of all BMPs being implemented on the farm is a requirement by the SFWMD. District personnel conduct routine BMP verification visits to make certain that the BMPs listed in the farmers permit are being properly implemented. Recommendations were suggested for proper BMP documentation ranging from soil testing; fertilizer application rates, canal cleaning program, and pump operation logs.

BMP Consultation Program Conclusions – It can be concluded that the first year of this program has been a success in terms of grower participation and willingness to discuss their BMP program and water quality issues with IFAS personnel. All farmers are aware of the significance of the BMP program in the EAA and are willing to continue doing their share of the program to insure that the current success is maintained throughout the entire basin. Farmers have been receptive to new practices; especially those that can help them reduce particulate P export off their farms. Farmers also recognize the importance of continuing research on BMPs and other water quality issues in the basin and are willing to continue to provide their support to future projects. This positive outlook from growers is instrumental not only for the success of this project, but also to address all the challenges that the entire EAA basin is facing and insure that the BMP program will continue having the same success, so that the EAA can continue to be the important economic factor it represents for South Florida.

2. Compilation and Statistical Analysis of IFAS Data:

The UF/IFAS has over ten years of research and monitoring data on implementation and efficacy of BMPs in the EAA. From 1992 through 2002, with contributions from the Everglades Agricultural Area Environmental Protection District, the Florida Department of Environmental Protection, the Florida Sugar Cane Growers' Cooperative, the Florida Crystals Corporation, the United States Sugar Corporation, Roth Farms, Incorporated, and other participating growers, the UF/IFAS undertook several projects to implement and assess the efficacy of the proposed BMPs at the farm level, assess the contribution and transport of particulate P from the EAA canals, determine relationship between water table levels in the field and drainage, and monitor non-P species mainly specific conductance and ion concentrations in EAA canals.

The objectives of this task are to create a Microsoft Access database that includes all IFAS BMP research conducted in the EAA and to employ statistical analysis to assess parameters that affect farm P discharge and use the results to improve selection and application of existing BMPs. A secondary objective is to recommend future research studies to enhance BMP effectiveness and address other important water quality issues in the EAA.

Five IFAS datasets were combined into one comprehensive IFAS BMP database. The first dataset is from the Farm BMP Efficacy Study. This dataset contains flows, canal levels, rainfall, and drainage event P concentrations. The second dataset is from the Six-Farm Drainage and Water Table study. The third dataset contains monitoring data from all ten original research farms. The fourth dataset contains *in situ* water quality data from Hydrolab DataSondes© from main drainage canals of all ten research farms. The fifth dataset is from the Intensive Particulate Phosphorus Research Study from three research farms. This data set contains data on sources, transport mechanisms and control of particulate P.

All of the data sets have been reviewed and compiled into the database. The database has also been checked for accuracy. The second step of this task to be done in the second year is to consider the various statistical methods and employ the appropriate robust statistical methods. An exploratory analysis will be conducted to check datasets for consistency and derive standard statistical metrics. Depending on the statistical method we will test for normality and if necessary use transformations to approximate normal distributions. Environmental datasets are usually complex and unbalanced with non-linear relationships that vary in space and time. Therefore, linear regression models often fail to effectively describe landscape pattern such as the effect of different environmental variables on BMP performance. To assess the effect of multiple environmental factors on BMP performance and off-site P loads from farms or basins requires employing advanced multivariate techniques that can handle non-linear relationships. The techniques we are considering employing include Principal Component Analysis (PCA) and Classification and Regression Trees (CART).

3. BMP Training Workshops and Extension Publications:

Best Management Practices training seminars and workshops are designed by UF/IFAS faculty to cover all the different aspects of the BMPs in the EAA to insure uniform and successful implementation by EAA growers. The topics covered include a review of Rule 40E-63, Atrazine and Ametryn use and BMPs in the EAA, soil testing and plant analysis, fertilizer application, rainfall detention, sediment control, and particulate P research overview and results. A copy of typical materials covered and shared with growers is included in Appendix A.

From the period of March 2005 (start of new SOW) till June 30, 2006, a total of twelve BMP workshops and training seminars were conducted. These workshops are targeted for specific companies. One general workshop open to the public was given in October 2005. The workshops normally last approximately 4 hours and all aspects of the SFWMD BMPs of the EAA are covered.

Four extension publications were published online at the UF/IFAS EDIS extension web site <http://edis.ifas.ufl.edu/> in 2005/2006. These publications cover four BMPs in the EAA. Copies of these extension materials are made available during BMP training and also during the one-on-one farm consultation. Copies of all our BMP extension publications are included in Appendix B.

INTRODUCTION

The EAA basin, comprising approximately 450,000 permitted acres of productive cropland south of Lake Okeechobee, is located in the geographic center of the south Florida watershed. Waters from Lake Okeechobee to the north are released into the EAA basin for irrigation and are passed through the EAA basin to supply water to the Everglades Protection Area (Water Conservation Areas and Everglades National Park; Figure 1). Discharges of drainage waters from the EAA have been identified as contributors to the nutrient enrichment of the Everglades (Sievers et al., 2003). Concerns regarding the impact of elevated P concentration water and P loads on the fauna and the flora of the Everglades Protection Area prompted the state of Florida to enact the Everglades Forever Act (EFA) in 1994. The EFA mandated the South Florida Water Management District (SFWMD) to create and administer the Everglades Regulatory Program, Chapter 40E-63, F.A.C., which oversees and monitors the implementation of BMPs to reduce P loads emanating from farms in the EAA basin.

The highly productive agricultural land of the EAA is comprised of rich organic peat and muck soils. Sugarcane, vegetables and sod are grown in the EAA providing annually south Florida with jobs and over one billion dollars to Florida's economy (Florida Department of Agriculture and Consumer Services, 2004). The EAA basin as a whole is required by the EFA to achieve P load reductions of 25 percent or greater relative to a rainfall adjusted baseline P load average (derived from 1979 to 1988 monitoring data). Since January 1, 1995, BMP implementation has been mandatory for all farms that discharge drainage water into SFWMD conveyance canals. The SFWMD monitors EAA basin P loads via a network of monitoring stations, i.e. pump stations and structures that border the EAA. During the ten years since BMP program initiation, the EAA basin's annual P load reduction has averaged more than 50 percent. This reduction is equivalent to a retention on-farm of nearly 170 metric tons of P that would have been exported if BMPs had not been implemented. A list of the BMPs recommended by the SFWMD for implementation on EAA farms is presented in Table 1 (Adorisio et al., 2006). Each BMP is assigned a point value and each farm implements a suite of BMPs, which must sum to a total of 25 points or greater.

In addition to implementing a SFWMD-approved suite of BMPs, each farm monitors its daily rainfall and flow and P concentration of all discharge waters leaving the farm. Individual farm basin monitoring data is submitted to the SFWMD as required by each farm's BMP permit. A database containing daily flow, P concentration, and rainfall for each of the approximately 280 farm discharge structures of the EAA basin is maintained by the SFWMD.

The EFA mandates landowners in the EAA to sponsor a program of BMP research, testing and implementation. The University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) has conducted a BMP research project on ten farms in the EAA from 1992 through 2002. To encourage BMP optimization, research results are provided to the industry through extension and outreach programs sponsored by UF/IFAS. The UF/IFAS research project database contains detailed farm data, i.e., canal levels, flows, discharge water P concentrations, and land use maps. Although a large and fairly complete dataset of water quality monitoring data from the ten EAA farms over a ten-year period exists with the UF/IFAS, no studies have been conducted that investigate the effectiveness of individual BMPs or suites of BMPs over time and consider the geographic locations within the EAA basin explicitly. A comprehensive investigation that utilizes advanced statistical analyses and modeling techniques to quantify the effectiveness of BMPs over time and space should reveal the intricate bio-geophysical conditions that constrain and/or enhance BMP performance.

The success of the BMP program in the EAA is a direct result of the necessity to participate in the program, the enforcement of BMP implementation by the SFWMD, the economic incentive that basin-wide compliance offers to growers in the form of reduced Agricultural Privilege tax and the educational and research support of UF/IFAS. Since the success of the BMP program in the EAA is in part due to a continuous effort to update and refresh grower knowledge of effective BMP implementation, new methods that target improving BMP implementation and performance warrant evaluation. Previous educational efforts have mainly relied on grower participation in BMP training workshops conducted by UF/IFAS researchers. Water managers, grower representatives, and researchers hypothesized that further improvements in BMP performance in the EAA could be achieved by providing direct, on-farm, BMP consultation services of BMP researchers to all EAA growers.

The BMP consultation program has a goal of appraising and consulting cooperatively with each farm basin of the EAA within a five year period. The BMP consultation program will be evaluated via grower feedback and by tracking individual farm and sub-basin adjusted P loads pre- and post-consultation program. Concurrent with the BMP consultation program is a complementary effort by UF/IFAS researchers to update and complete an online set of publications that explain to growers the rationale and techniques of each BMP recommended by the SFWMD for the EAA. The publications are or will be made available online at the UF/IFAS website (<http://edis.ufl.edu>). The ongoing BMP training workshop program will continue and updated training modules have begun to be translated into Spanish for use in the Fall of 2006.

The Everglades Regulatory Program, Chapter 40E-63, F.A.C. ("Rule 40E-63") mandates landowners in the Everglades Agricultural Area (EAA) to sponsor a program for Best Management Practices (BMP) research, testing and implementation. The University of Florida's Institute of Food and Agriculture Sciences (UF/IFAS) has conducted a comprehensive research program regarding BMP effectiveness, testing and implementation in the EAA basin since 1992 under the Everglades Agricultural Area-Environmental Protection District (EAA-EPD) BMP Master Permit Scope of Work. The UF/IFAS conducted BMP research on ten representative farms in the EAA that covered the variability of soil, cropping systems, environmental, and management conditions in the EAA. Research was also conducted on particulate P source, transport and control in the EAA, specific conductance in EAA farm canals, and water table management. Detailed information on the BMP research can be found in the UF/IFAS Phase 12 Annual Report on Implementation and Verification of BMPs for Reducing P Loading in the EAA and EAA BMPs for Reducing Particulate P Transport (Daroub et al., 2004a). Final report on specific conductance was issued March 2004 (Daroub et al., 2004b). A final report on the EAA BMPs for reducing particulate phosphorus transport was submitted to the Florida Department of Environmental Protection June 2005 (Daroub et al., 2005).

In March 2005, the South Florida Water Management District (SFWMD) approved a modification of the EAA-EPD scope of work (SOW) required for the BMP research portion of the Master Permit for the EAA. In the revised SOW new tasks were proposed for BMP research, testing and implementation. The tasks and objectives of this SOW are:

Statistical Evaluation of BMP Monitoring and Research Data: The main objective of this task is to assess parameters that affect farm P discharge, correlate salient parameters and use result to improve selection and application of existing BMPs. This task is to be accomplished in two years. The first year includes assembling all the 10 yr UF/IFAS research data into one data base. The second year will include statistical analysis designed to address the main objective of this task. Another major objective in the second year is to identify gaps in the research and recommend future research projects to enhance BMP effectiveness.

Implement BMP Consultation Program: A one-on-one BMP consultation program that covers all farm basins with an objective of enhancing the dissemination and implementation of BMPs to all growers in the EAA basin. This outreach program targets all sub-basins and farms and attempts to complete all farm basins within the EAA basin within a five year period.

Conduct Outreach and Extension Activities: Continue to provide BMP training seminars and workshops to all growers in the EAA as part of the requirements in their individual

BMP permits to train farm personnel on BMP practices. Also to develop and publish materials and documents that explains to growers the BMPs of the EAA.

This report documents the progress and achievements of the project, "Implementation and Verification of BMPs for Reducing P Loading from the Everglades Agricultural Area", described in the 2005/06 SOW for UF/IFAS with the EAA-EPD. The SOW contains three specific tasks: 1) initiate and conduct a farm BMP consultation program, 2) assemble existing EAA research and monitoring data into one database, 3) provide tailored BMP training workshops to grower groups, and develop and publish BMP extension materials specific for the EAA.

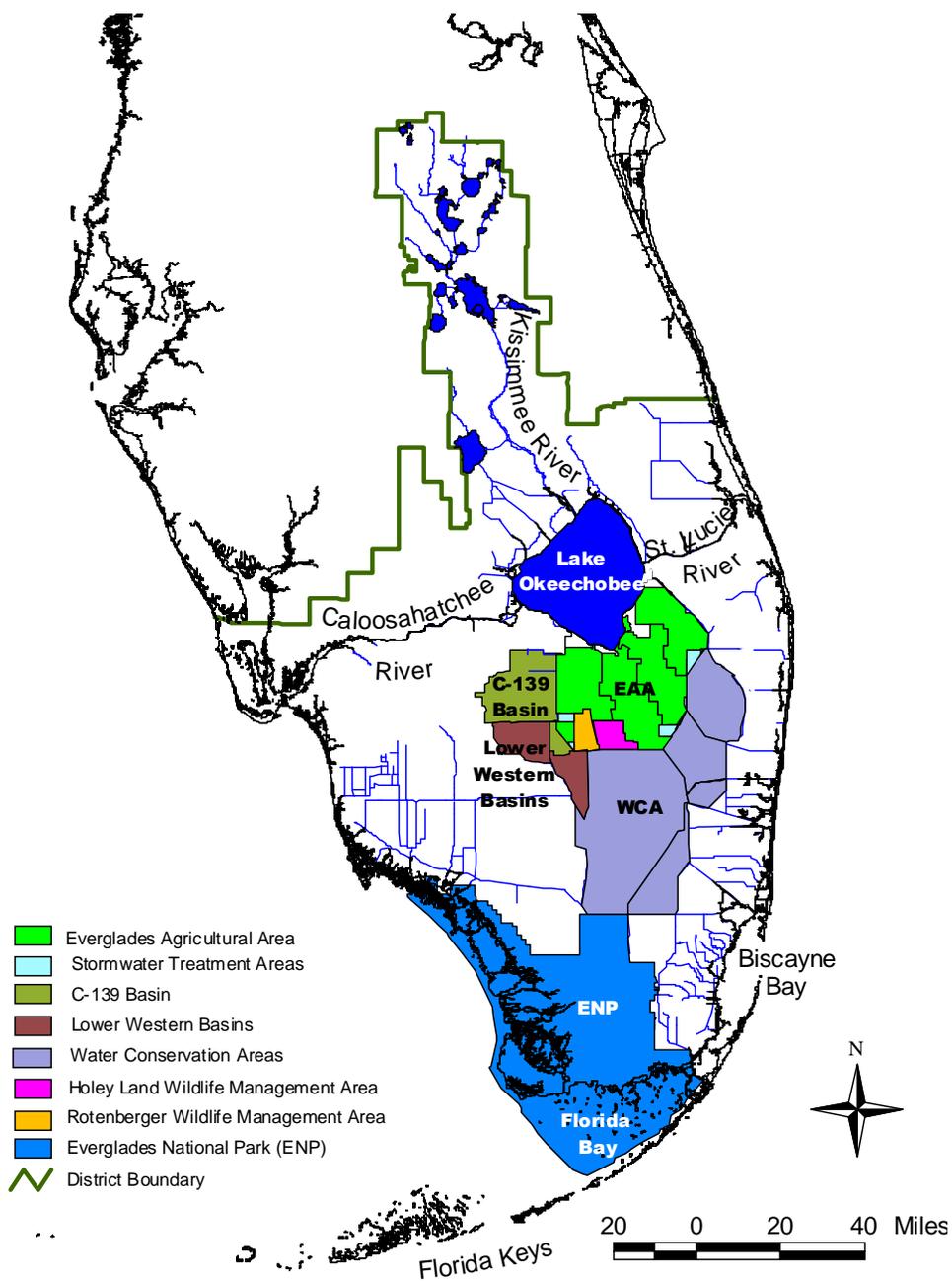
GOALS AND OBJECTIVES

The goal of this project is to develop a quantitative framework to identify and effectively extend to growers the knowledge required to choose and implement the most effective suites of BMPs to reduce P loads leaving their EAA farms via drainage water. Though the implemented point system has been invaluable to reduce P loads leaving the EAA basin, there is still uncertainty related to the uniformity of individual farm BMP implementation and the choice and efficacy of BMPs in the context of different farm conditions (e.g. irrigation water quality, soil type and soil depth, intensity of land use, etc.). Improved BMP selection and implementation at the farm level should further reduce farm and basin P loads. The specific tasks and objectives of this research and education project are:

Task 1: Statistical Evaluation of BMP Research and Monitoring Data: During the first year of the project, the 10+ years of IFAS BMP monitoring and research data will be assembled into one Microsoft Access data base. Other supporting data sets available from the SFWMD may also be linked and used as and when needed. Analysis of the data using various statistical analyses and modeling techniques will begin in the second year of the project.

Objective 1: Assess parameters that affect farm P discharge and correlate salient parameters and use the results to improve selection and application of existing BMPs.

Objective 2: Identify gaps in knowledge of BMP efficacy at the farm level and recommend research studies to enhance BMP effectiveness or investigate other important water quality issues that confront growers in the EAA.



(map courtesy of J. Vega, SFWMD)

Figure 1. Water management areas and drainage basins of South Florida.

Table 1. SFWMD list of Best Management Practices for the EAA.

BMP	PTS	DESCRIPTION
NUTRIENT CONTROL PRACTICES: MINIMIZES MOVEMENT OF NUTRIENTS OFF-SITE		
Nutrient Application Control	2 ½	Controlled application of nutrients with a 4' (1.2 m) setback from canals; banding, fertigation; and fertilizer placement near roots under plastic.
Nutrient Spill Prevention	2 ½	Formal spill prevention protocols: storage, handling, transfer, education and instruction.
Successive Vegetable Planting to Minimize P	2 ½	Successive planting of high P/low P demand crops to avoid P build up and no successive P application
Plant Tissue Analysis	2 ½	Determine plant nutrient requirements next growing season (crop specific)
Soil Test Analysis	5	Determine the P requirements of the soil and follow standard recommendations for application rates (crop specific).
Split Nutrient Application	5	Apply portions of P fertilizer throughout growing season without exceeding total recommendation.
Slow Release P Fertilizer	5	Specially formulated fertilizers that release P over growing season.
Reduced P Fertilization	5	P application rate is at least 30% below recommendation
WATER MANAGEMENT PRACTICES: MINIMIZES VOLUME OF OFF-SITE DISCHARGES		
½ Inch Rainfall Detained 1 inch Rainfall Detained	5 10	Delay discharge: based on measuring daily rain events using a rain gauge.
Improved Infrastructure	5	Re-circulate water inside farm boundaries to improve water quality prior to offsite discharge (e.g. rice and vegetables); fallow field flood water with no direct discharge (instead allow to "drain" via evapotranspiration, seepage, use as irrigation water); increasing water detention using properly constructed canal berms.
Water Table Management	5	Optimizing drainage and irrigation schedules and/or by using low volume irrigation methods to decrease discharge.
PARTICULATE AND SEDIMENT CONTROLS: MINIMIZES MOVEMENT OF PARTICULATES AND SEDIMENTS		
Any 2 on the list.	2 ½	<ul style="list-style-type: none"> • Leveling fields • Grassed swales/field ditch connections • Ditch bank berms • Aquatic weed control • Barriers at discharge locations • Sediment sump/trap in canals • Maintain forage to reduce soil erosion/range seedings • Soil stabilization through infrastructure improvements • Cover crops • Vegetated ditch banks
Any 4 on the list	5	
Any 6 on the list	10	
Any 8 on the list	15	
		<ul style="list-style-type: none"> • Slow drainage velocity near pumps • Canal cleaning program • Field ditch drainage sumps • Ditch bank stabilization

Task 2: Farm BMP Consultation Program: An intensive one-on-one BMP consultation program that consists of individual farm visits by UF/IFAS personnel to each farm basin in the EAA and discussions of BMP implementation with farm personnel.

Objective 1: Enhance the performance and implementation of BMPs by all growers in the EAA basin. This outreach program targets all farms in the EAA beginning with farm sub-basins of the S-5A basin and extending westward to other sub-basins of the EAA.

Task 3: Conduct BMP Outreach and Extension Activities: These include tailored BMP training seminars and workshops for grower groups, and the development and publication of extension materials on BMP implementation in the EAA.

Objective 1: Provide concise and updated BMP implementation information via workshops and publications to the EAA grower community. The information provided should explain in layman's terms the rationale and techniques of individual BMPs and recent BMP research results.

TASK I: FARM BMP CONSULTATION PROGRAM

Introduction

The continued success of the BMP program depends upon the unfaltering, diligent efforts by all involved parties, i.e., farm water quality personnel, farm managers, drainage pump operators, fertilizer applicators, land owners, UF/IFAS personnel, and SFWMD personnel. Even though the BMP program is nationally recognized for its admirable P load reduction record, changes within the EAA agricultural environment may affect BMP performance and the expected high P load reduction rates that have been achieved thus far. Some of the factors that may affect EAA basin BMP-based P load reductions include: increasing P concentrations of Lake Okeechobee water used for irrigation on EAA farms, possible reductions in the acreage planted to sugarcane and the concomitant increases in acreage planted to less water tolerant and/or higher P requirement crops, and the potentially negative impacts of soil subsidence on farm drainage volumes and drainage water quality. Under these impending uncertain and essentially uncontrollable conditions, the importance of proper and uniform BMP implementation across all EAA farm basins to ensure the continued success of the BMP program cannot be overstated.

There are a multitude of factors that may affect P load discharges at the farm level. Variations in farm P load discharge and BMP performance may be related to geographical location, soil depth and composition, rainfall distribution and quantity, Lake Okeechobee irrigation water quality, surface and near surface geology and hydrology, and past and present cropping practices. This section of the report investigates the EAA BMP performance in the last Water Year as outlined by the South Florida Environmental Report (SFWMD, 2006). We will also highlight some of the characteristics of the sub-basins that may affect BMP performance, i.e., soil depth, rainfall distribution, and water quality from Lake Okeechobee used for irrigation. The remainder of this section is devoted to describing the farm BMP consultation program, methodology, major findings, conclusions and recommendations provided. In the first year of the project (CY2005/06), UF/IFAS personnel focused on farm basins in the S-5A basin.

The objective of this task is to enhance implementation of BMPs by all growers in the EAA basin by consulting with growers on their individual farm BMP programs, addressing any concerns or issues they face, and providing them with specific recommendations to improve BMP performance on their farms (if any).

Background

The EAA basin is segregated into six sub-basins comprising approximately 205 farm basins (Figure 2). Information regarding the number of farm basins and acreage in each sub basin is presented in Table 2. Adjusted unit area P loads are also presented for the last three water years for relative comparison purposes.

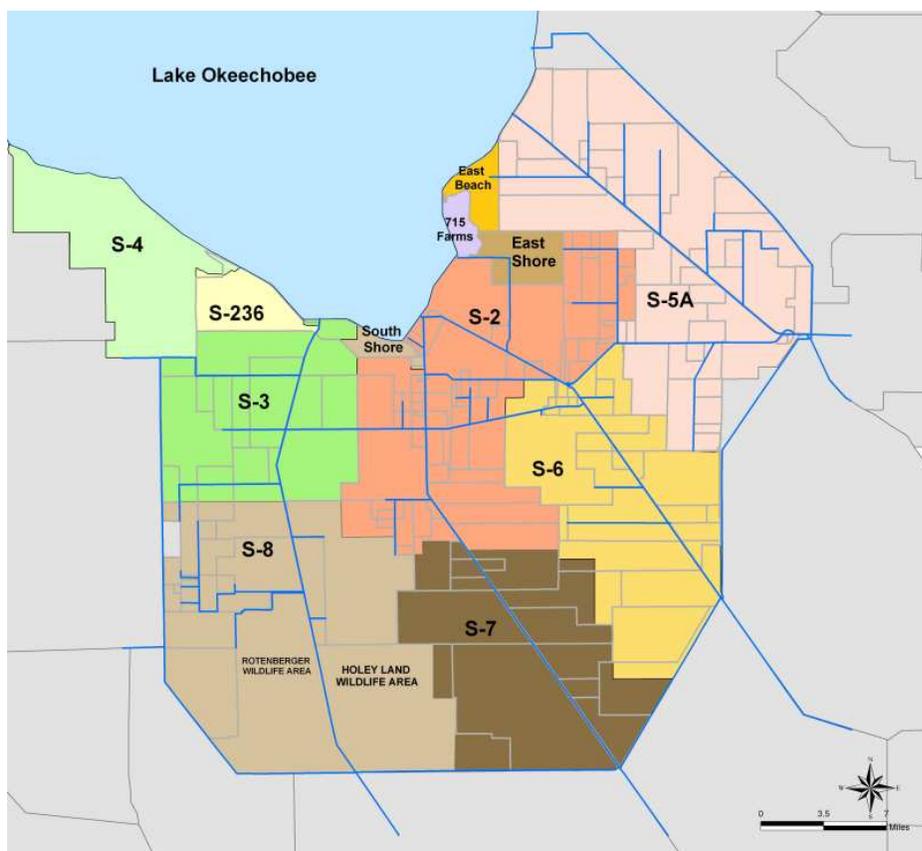
Table 2. EAA basin and sub-basin acreages and adjusted unit area loads (AUAL).

Sub-Basin or Basin Name*	Number of Farm Basins	Total Basin Acreage**	WY2003 AUAL	WY2004 AUAL	WY2005 AUAL
S-5A	47	110,210	1.62	0.89	1.03
S-6	61	121,636	1.10	1.25	0.73
S-7	58	113,554	1.08	0.54	0.57
S-8	39	104,999	1.05	0.42	0.39
EAA	205	450,400	1.21	0.79	0.69

Notes:

* Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

** Farm basin numbers and basin acreages as reported by SFWMD for WY2005.



(map courtesy of J. Vega, SFWMD)

Figure 2. The EAA basin with boundaries of the sub-basins.

SFWMD BMP Report WY2005 Highlights

The annual South Florida Environmental Report issued summarizes the environmental issues, projects and accomplishments in Everglades Restoration (SFWMD, 2006). Chapter 3 of the 2006 South Florida Environmental Report deals with P controls for the basins tributary to the Everglades Protection Area. The EAA is one of the tributary basins. Below is a summary of the major highlights of this chapter that partly focuses on the Everglades Regulatory Program Chapter 40E-63, F.A.C. (“Rule 40E-63”) as mandated by the Everglades Forever Act.

The goal of the Everglades Regulatory Program in the EAA basin under Rule 40E-63 is to reduce the total P loads discharged from the basin by 25%. Rule 40E-63 states that the use of Everglades Works of the District (EWOD) within the EAA basin requires a permit. Rule 40E-63 permits approve a permitted-implemented BMP plan and discharge monitoring plan for each sub-basin of farm. Compliance with the permit level plans is

based on annual implementation and monitoring reports and on site verifications (Adorasio et al., 2006). There are 33 EAA basin EWOD permits, including approximately 205 sub-basins and 286 privately owned water control structures discharging into the SFWMD canals in the EAA encompassing an area of approximately 500,000 acres. All EAA permittees are required to implement a comprehensive plan that includes selection of BMPs from primary categories.

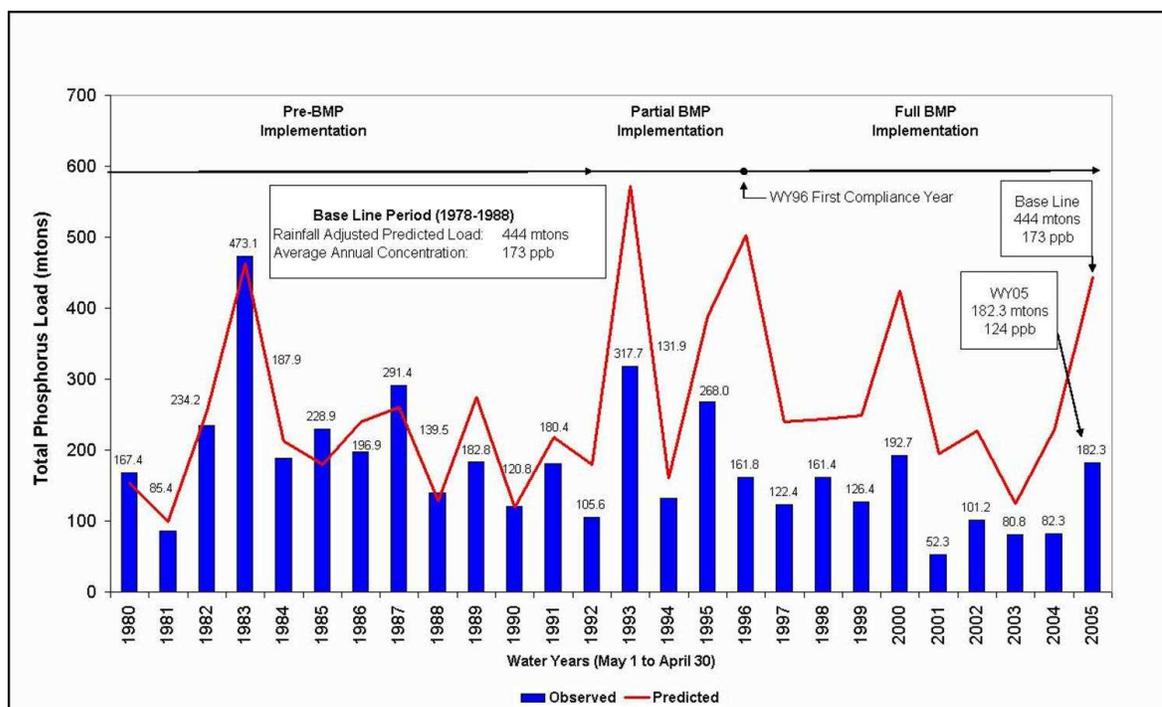
Rule 40E-63 also requires the SFWMD to collect monitoring data for the EAA basin for the purpose of determining primary compliance with the total P load reduction requirement. The EAA regulated area that is monitored is defined by the multiple hydrological drainage sub-basins (Fig. 2). For primary compliance, the EAA basin must demonstrate a 25% reduction in load annually compared to the pre-BMP base period. Data from the SFWMD district structures are used to calculate the measured total P load discharged from each EAA sub-basin. Primary compliance is determined by aggregating the total P load from each of the sub basins into a basin-wide total P load. A secondary method of program compliance measurement is through individual permit-level (farm-level) water quality monitoring conducted by the permitted. Because the EAA basin has met and exceeded the 25% reduction requirement each year since the program's inception, the secondary method of load compliance measurement has not been utilized.

At the beginning of water year 2005, 53 water control structures defined the boundary for the EAA. The number of water control structures was reduced to 25 as a result of hydraulic conveyance alterations (Adorasio et al., 2006). Discharge quantity is recorded at all current inflow and outflow points defining the boundary of the EAA basin. Flow estimates are determined for every structure and total P samples are collected at those structures in the EAA where concentrations are deemed to be representative of discharges for all boundary structures. All monitoring locations in the EAA basin are equipped with automatic samplers that are programmed to collect samples on a flow proportional basis. The samples are collected every seven days and composited at the end of each collection period. Grab samples are also collected as a back up source of data.

Water leaving the EAA basin through these structures is a combination of farm drainage water, urban runoff, and water passing through the EAA basin canals from external basins. The "pass through" water includes discharges from Lake Okeechobee and 298 District diversion areas. Separate accounting of total P loads from various sources is required to develop conclusions about total P loads originating from the EAA basin.

The predicted total P loads for the EAA basin are calculated using a regressed relationship between historical annual rainfall and runoff total P load observed during a

baseline period covering a nine year period, WY1980- WY1988. The EAA regression relationship was constructed to account for rainfall variation in both a spatial and temporal domain. The measured and calculated values are compared and a total P reduction % is calculated. In WY2005, measured total P load from the EAA was 182 metric tons compared to calculated P load (without BMPs) of 444 metric tons which equates to a 59% reduction in total P loads. Measured P concentration in WY 2005 was 124 ppb compared to 172 ppb base period concentration (Fig. 3). Although the data presented in the SFWMD report include total P concentrations, only load is used to determine compliance.



(figure courtesy of J. Vega, SFWMD)

Figure 3. Observed and predicted EAA basin total P loads from SFWMD, 2006.

Soils of the Everglades Agricultural Area

Most of the soils in the Everglades Agricultural Area (EAA) are classified as organic (soil order: Histosol). Organic soils in the EAA generally contain more than 85% organic matter by weight derived from hydrophytic vegetative residues. The organic soils from the EAA were formed over a 4,400-yr, period from partially decomposed remains of hydrophytic vegetation accumulated under anaerobic conditions (McDowell et al., 1969). Except for organic soils found adjacent to Lake Okeechobee, their mineral content is less than 35%. The organic soils in the EAA are classified on the basis of their organic matter

content, degree of decomposition of the organic material, depth of organic material over mineral layer, and composition of the mineral layer (Table 3).

Table 3. Characteristics of organic soils of the EAA.

Soil Series	Mineral Content	Thickness of Organic Layer	Thickness of Organic Layer	Underlying Material
	%	Inches	cm	
Torry	>35	>51	>130	Limestone
Terra Ceia	<35	>51	>130	Limestone
Pahokee	<35	36-51	92-130	Limestone
Lauderhill	<35	20-36	51-92	Limestone
Dania	<35	<20	<51	Limestone
Okeechobee	<35	>51	>130	Limestone
Okeelanta	<35	16-40	41-102	Sand

Drainage of organic soils for agricultural purposes results in the loss of soil through rapid breakdown of organic matter and results in subsidence. Subsidence of the organic soils in the EAA is caused by biological decomposition of soil organic matter. Subsidence has been reported to be the greatest during the first few years after drainage (Thomas, 1965). During this time soil organic matter oxidation occurs at a higher rate, but may decrease with time as the more readily decomposable matter is oxidized and more stable compounds remain. Although rate of subsidence may vary with soil type and cropping system, the fact remains that organic soil losses due to oxidation are considerable on drained and cultivated organic soils and are generally higher under warm, humid conditions.

The rate of soil subsidence in the EAA is an important issue since a considerable amount of organic soil has been lost since the initial drainage and cultivation of the area. The rate of soil subsidence has been investigated and documented by several authors. Steven and Johnson (1951) concluded that the rate of subsidence in the EAA would be approximately one foot per decade. Shih et al. (1979) reported a slightly higher subsidence rate of one inch per year across the EAA. More recent studies have re-measured surface elevation along base subsidence lines and concluded that the average subsidence rate has decreased to 0.57 inches during the last 19 years from initial measurements, and speculated that maintenance of higher water table in recent years was one of the major reasons for the reduction of subsidence rate (Shih et al., 1998).

Organic soils depths have also been measured across the EAA for the Soil Survey of Palm Beach County (McCollum et al., 1978) and in 1988 by the use of ground penetrating

radar (Cox et al., 1988). Organic soils from the EAA are classified in part by the depth of the organic material overlying a mineral layer, and their mineral content (Table 3, Fig. 4). The soil series in the EAA with corresponding thickness of the organic layer are: Torry (>51 inches), Terra Ceia (>51 inches), Pahokee (36-51 inches), Lauderhill (20-36 inches), Dania (<20 inches), Okeechobee (>51 inches) and Okeelanta (16-40 inches). It is noted that the S-5A basin has the deepest soils, while the S-7 and S-8 basins have the shallowest soils. The depth of the soil and proximity to the limestone bedrock may have a direct implication on drainage and quality of drainage water of these soils. Deeper soils will have more capacity to hold water, but at the same time the soil profile has more organic material to decompose, which may increase P concentrations in the water draining from the soil. Shallow soils on the other hand have less capacity to hold water, but the proximity to the underlying limestone bedrock increase the likelihood that soluble P will be adsorbed or precipitated upon interaction with limestone (CaCO_3) bedrock.

A comparison of the main soil series across the EAA during a time span of 15 yr shows the significance of soil subsidence in the EAA basin (Figs. 5 and 6). In 1973, Terra Ceia and Pahokee mucks were the dominant soil series across the EAA, accounting for 82% (496 000 acres) of the total acreage (Fig. 5) (McCullum et al., 1978). Soils from the S-5A basin were dominated by Terra Ceia. Pahokee Muck was the dominant series in the central (S-2 basin) and southern (S-8 and S-7 basins) regions of the EAA (Fig.5). Soils from the S-3 basin were dominated by Terra Ceia and Pahokee Mucks. However, by 1988, Lauderhill with a depth of 20-36 inches was the dominant soil series accounting for 39.6% (240 800 acres) of the total acreage. Total acreage of the Dania series also significantly increased from 0.2% in 1973 to 10.2% in 1988. In contrast, the total acreage of the deeper soil series Terra Ceia and Pahokee mucks decreased to 9.5 and 27.4%, respectively (Cox. et al., 1988). By 1988, more than three-quarters of the S-5A basin changed from the Terra Ceia muck to Pahokee muck. Similarly, the central (S-2 basin) and southern regions (S-8 and S-7 basins) of the EAA changed from Pahokee muck to the shallower Lauderhill and Dania mucks (Fig. 6). In the same way, soils from the S-3 basin changed from Terra Ceia and Pahokee mucks to Pahokee and Lauderhill mucks. Torry mucks located around the SE borders of Lake Okeechobee did not change in both surveys. Torry mucks have a high clay content which reduces the permeability of these soils keeping them wetter for longer periods. Additionally, the lower organic matter content of Torry mucks allows these soils to subside at lower rate than the other organic soils of the EAA (Cox et al., 1988).

Although 18 years have passed since the last comprehensive soil depth measurements in the EAA, a subsidence rate of 0.6 inches per year (Snyder, 2004) is today considered more accurate for prediction purposes. Using the subsiding rate of 0.6 inches per year, an additional organic layer of approximately 10-11 inches has been lost from 1988 to

2006. This means that the total acreage of the shallower soil series Dania and Lauderdale mucks have significantly increased, influencing farm management practices for sugar cane production across the EAA. Subsidence also complicates restoration efforts in the EAA as well as the efforts to manage the water conservation areas to the east and south of the EAA in a more natural condition.

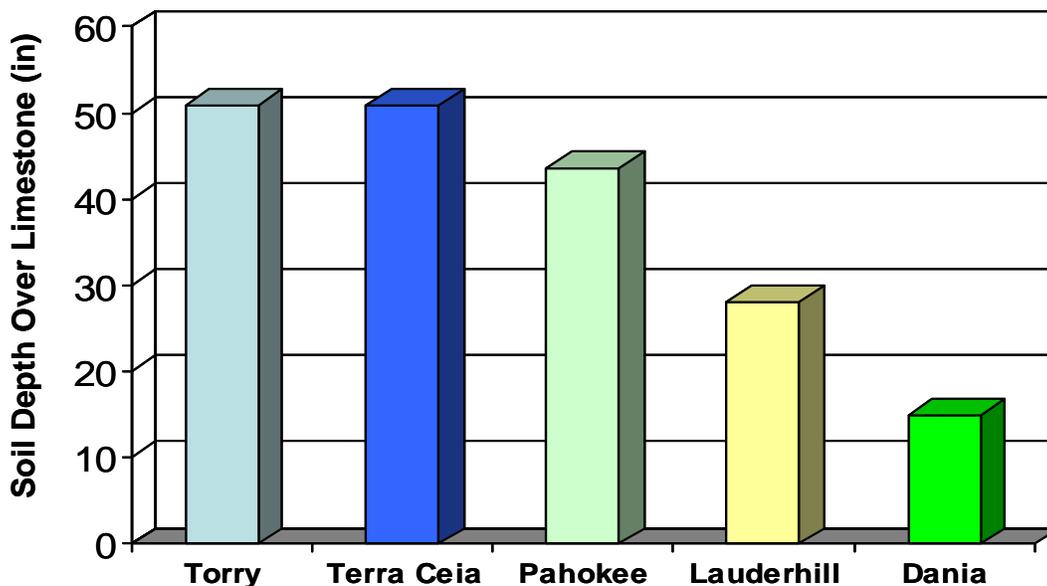
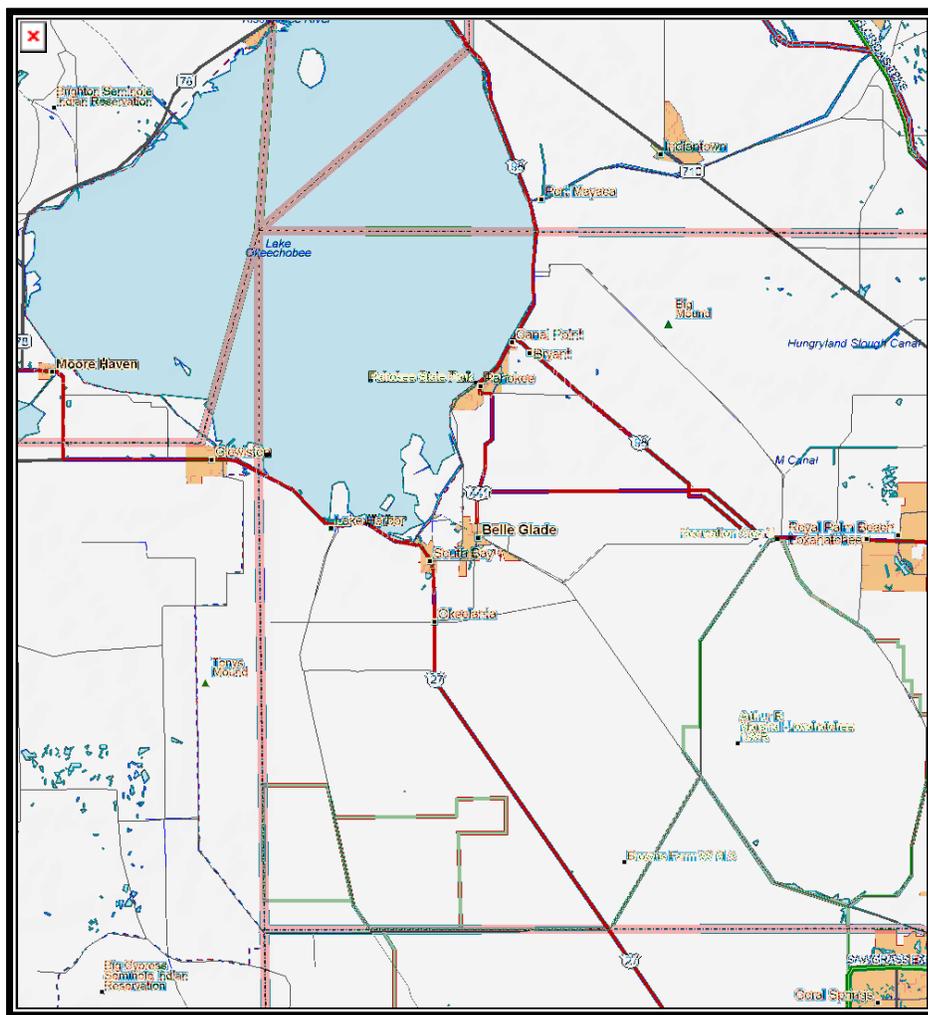
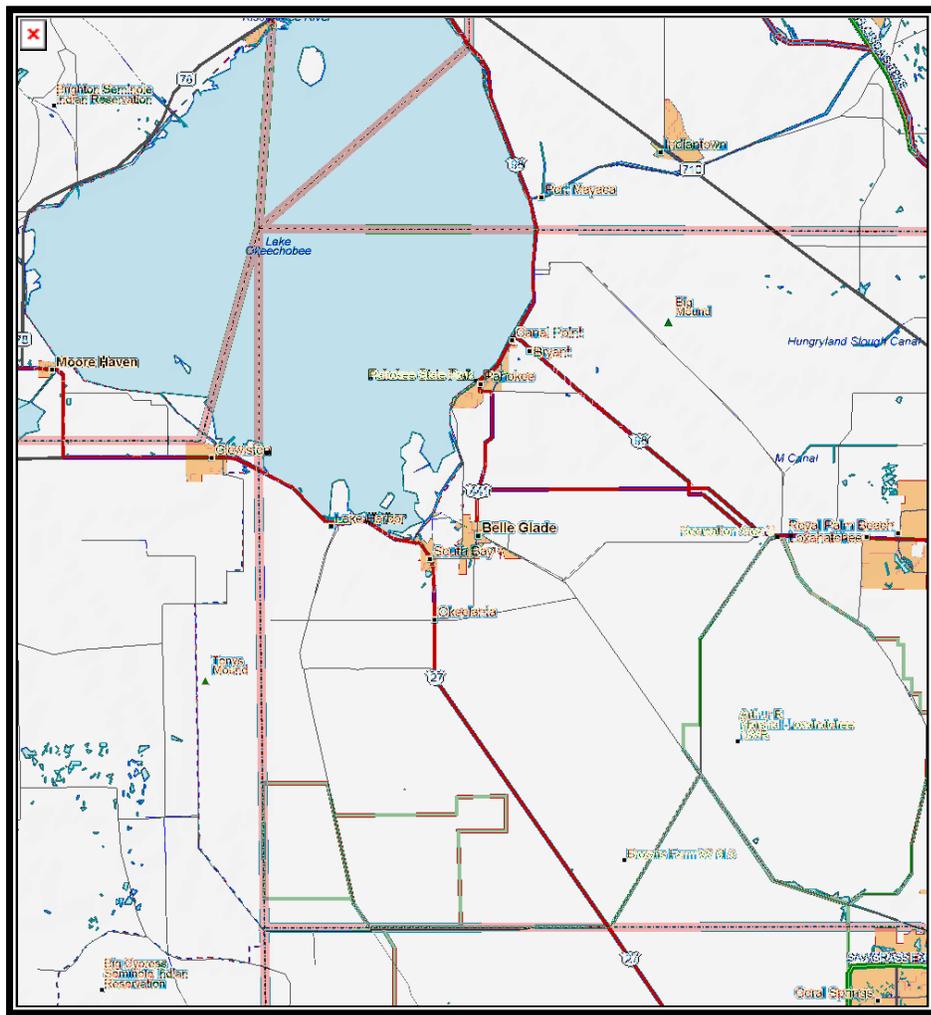


Figure 4. Classification of organic soils in the EAA according to thickness over limestone.



(created from McCollum et al., 1978)

Figure 5. Major organic soils in the EAA from soil survey of 1973.



(created from Cox et al., 1988)

Figure 6. Major organic soils in the EAA from soil survey of 1988.

Lake Okeechobee Irrigation Water Quality and EAA Sub-Basin P Loads

Lake Okeechobee is the largest freshwater lake in Florida and the second largest freshwater lake within the contiguous United States, second only to Lake Michigan, covering approximately 730 square miles. Lake Okeechobee is designated a Class I water that provides drinking water for urban areas, irrigation water for agricultural lands, recharge for aquifers, freshwater for the Everglades, habitat for fish and waterfowl, flood control, navigation, and many recreational opportunities.

Water quality in the lake has degraded over time due to high P loadings resulting from man-induced hydrologic and land use modifications over the past 60 years. Total P concentrations in the lake water increased during the 1970s and then remained relatively stable with a mean near 0.10 mg/L until 1995 (James et al., 2006). During the last five years, total P concentrations in Lake Okeechobee have averaged 0.142 mg/L. Average P concentrations in the lake for WY2005 increased to 0.236 mg/L, reflecting the impacts of the extreme hurricane season that resulted in considerably higher P loads and sediment re-suspension in the lake (James et al., 2006).

Determination of the relationship between P concentrations of the EAA inflow water (irrigation) from Lake Okeechobee and P loads leaving farms within each of the sub-basins is important. To begin initial investigations into this possible relationship, monthly average EAA inflow canal water P concentration data from the SFWMD DBHYDRO database were graphed for the years 2000 through 2005. A review of the data indicate that pumping structure S-352 had the highest total P concentration irrigation water in the past six years, followed by irrigation waters from pumping structure S-2 and S-351. Irrigation water from pump structure S-3 had the lowest average total P concentration (Figures 7, 9, 11, 13, and 15).

The annual adjusted sub-basin P loads were then plotted by WY to compare the effects of incoming irrigation water P concentrations and monthly sub-basin rainfall amounts (rough estimate of irrigation demand). In WY years that are preceded by dry spring conditions and thus high irrigation demand (spring months of 2001, 2002, and 2004) the S-5A basin incurred in relatively high sub-basin P loads compared to the other sub-basins (Figures 10, 12, and 16). In WY years that were preceded by wetter spring conditions and less need for irrigation water (spring months of 2000 and 2003) the S-5A basin did not have the highest sub-basin P loads (Figures 8 and 14). This interesting observation is just that and requires further investigations to verify if the relationship does actually exist. Research at the farm level to accurately measure and monitor irrigation and drainage is recommended to verify irrigation water quality effects on farm P loads.

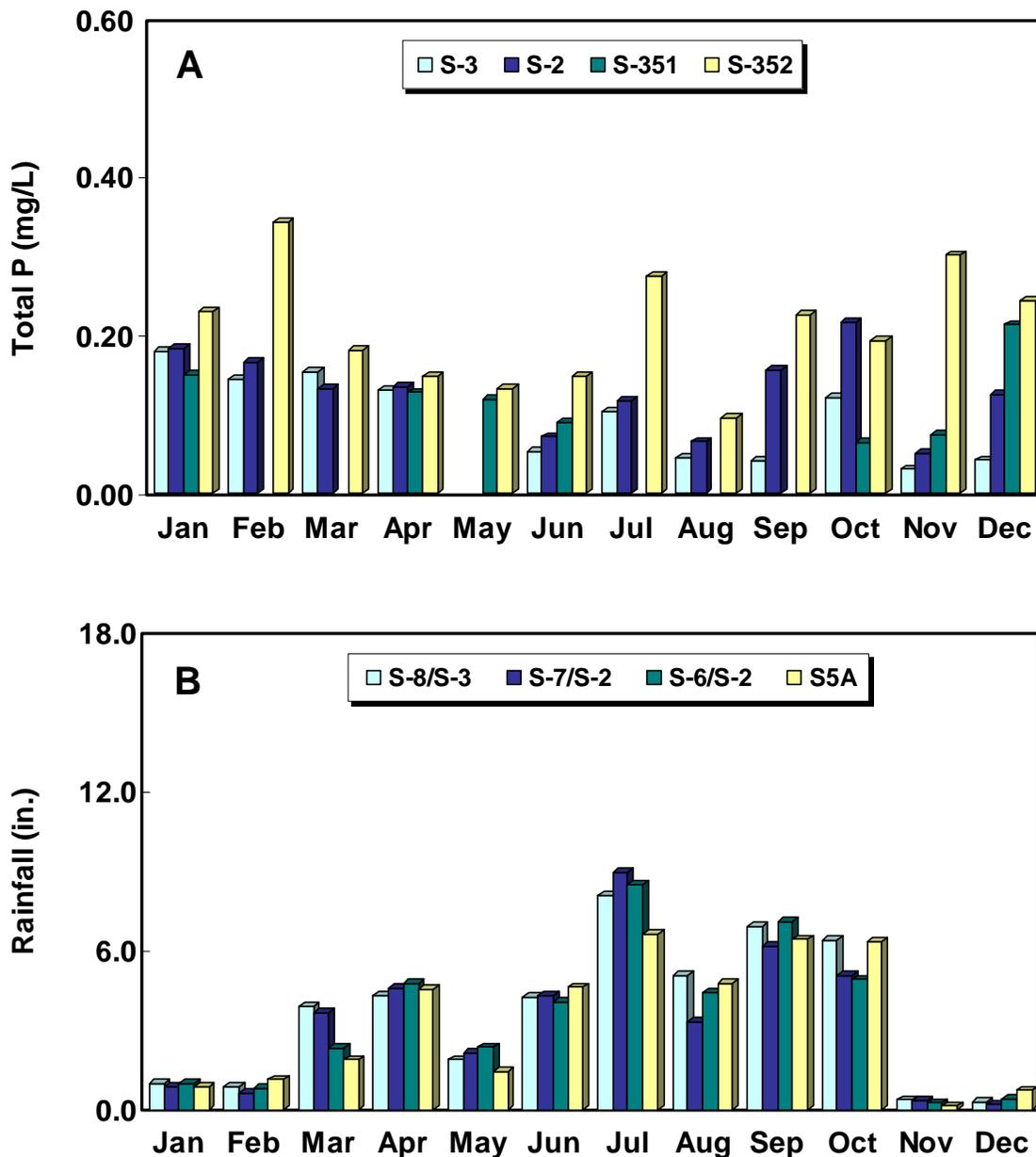


Figure 7. Monthly average EAA inflow canal water P concentrations (A) and sub-basin rainfall (B) for 2000.

Note: the following sub-basins received irrigation water via the corresponding structures: S-8 sub-basin via S-3, S-7 sub-basin via S-2, S-6 sub-basin via S-351/S-2, and S-5A via S-352.

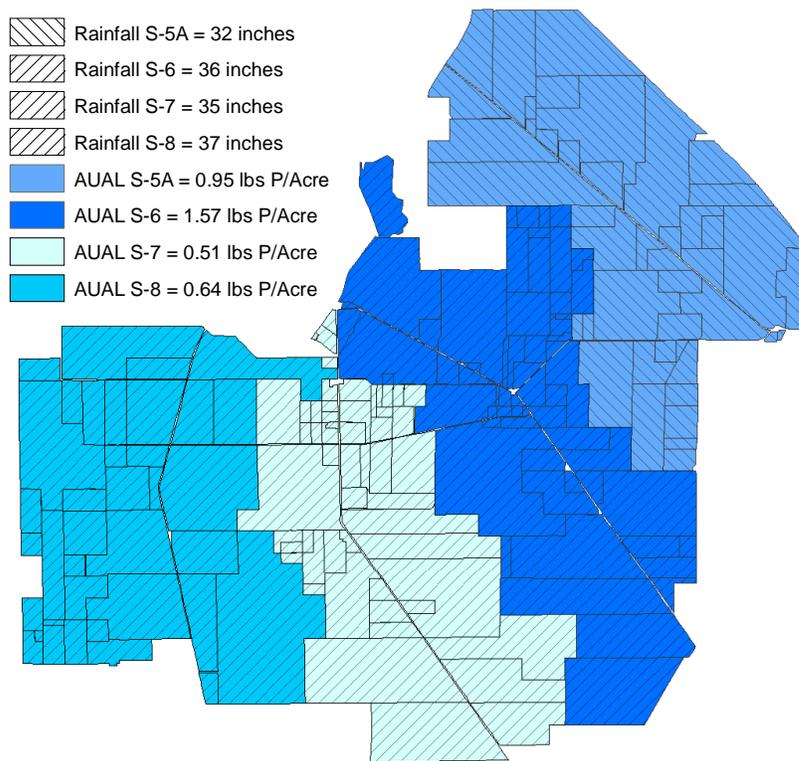


Figure 8. Rainfall and adjusted unit area load by EAA sub-basin for WY2001.

Note: Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

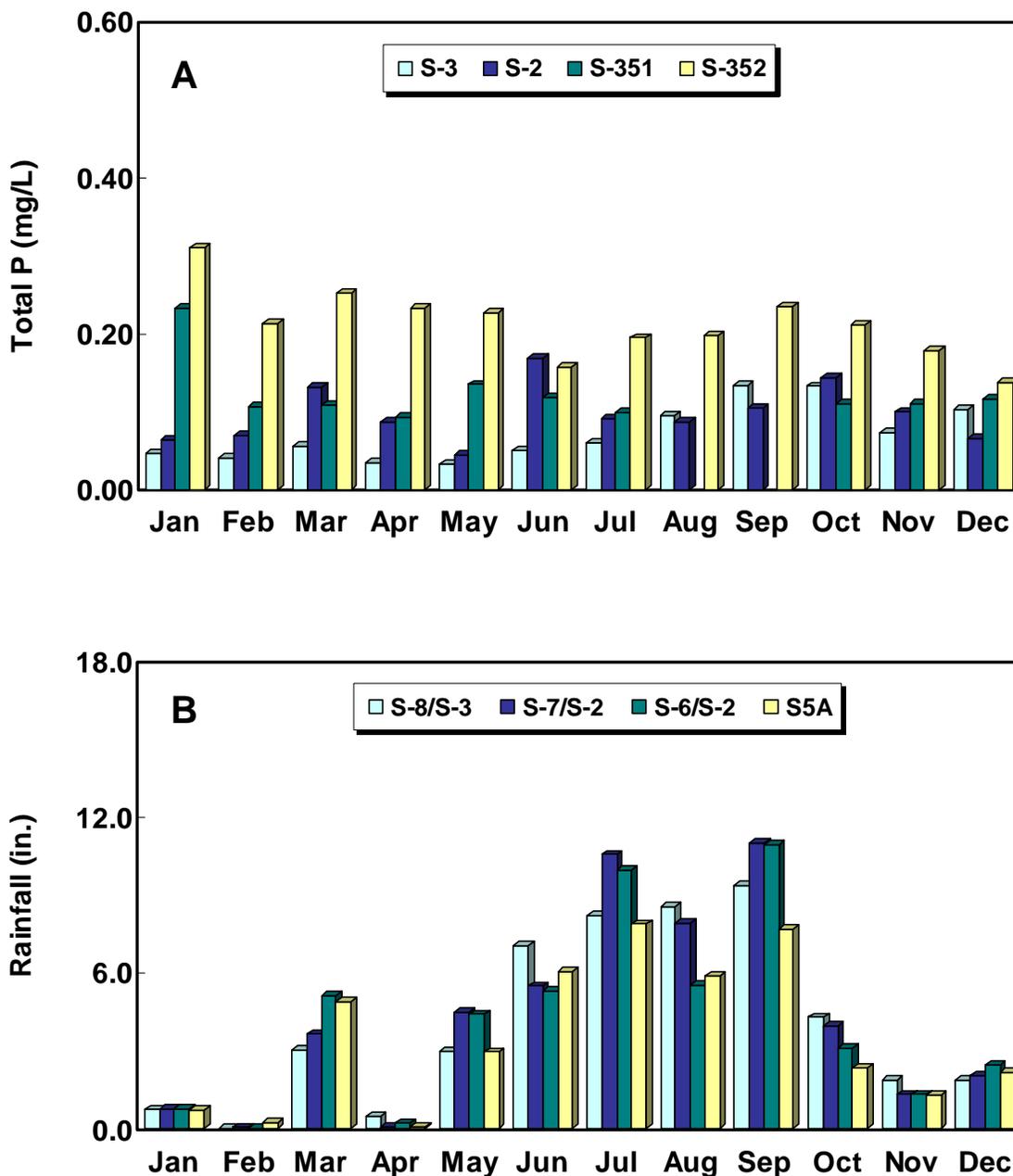


Figure 9. Monthly average EAA inflow canal water P concentrations (A) and sub-basin rainfall (B) for 2001.

Note: the following sub-basins received irrigation water via the corresponding structures: S-8 sub-basin via S-3, S-7 sub-basin via S-2, S-6 sub-basin via S-351/S-2, and S-5A via S-352.

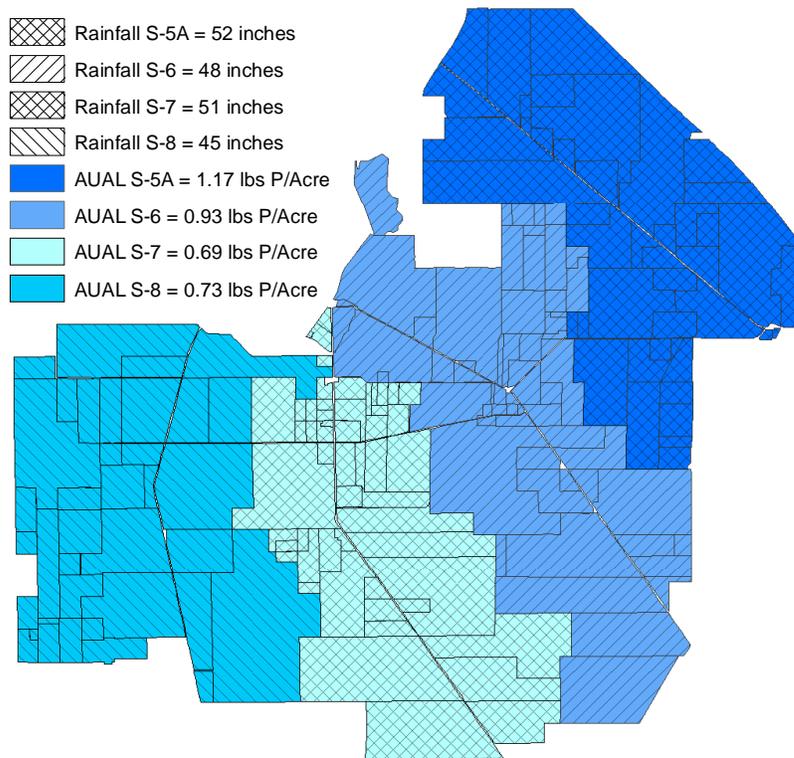


Figure 10. Rainfall and adjusted unit area P load by EAA sub-basin for WY2002.

Note: Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

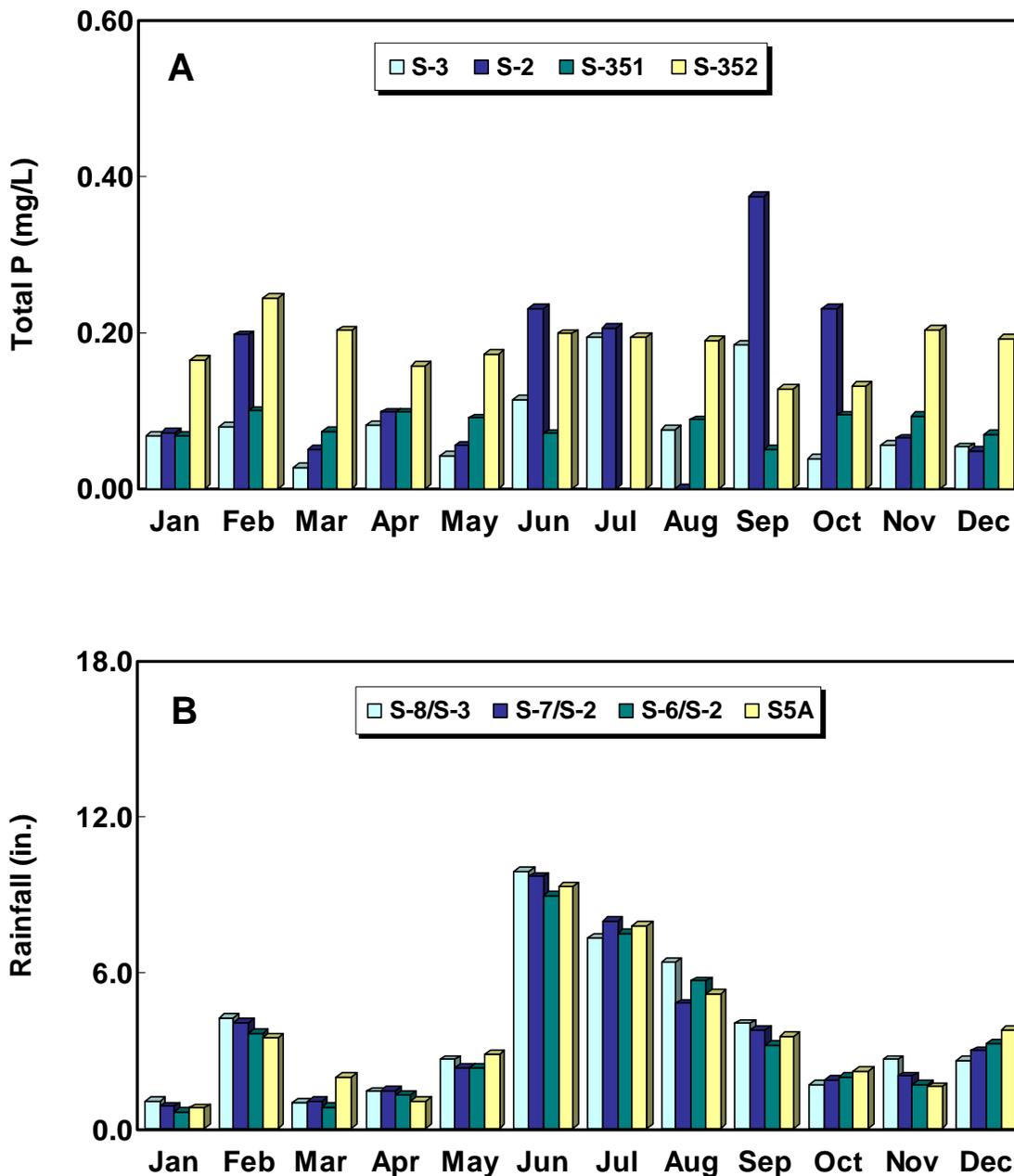


Figure 11. Monthly average EAA inflow canal water P concentrations (A) and sub-basin rainfall (B) for 2002.

Note: the following sub-basins received irrigation water via the corresponding structures: S-8 sub-basin via S-3, S-7 sub-basin via S-2, S-6 sub-basin via S-351/S-2, and S-5A via S-352.

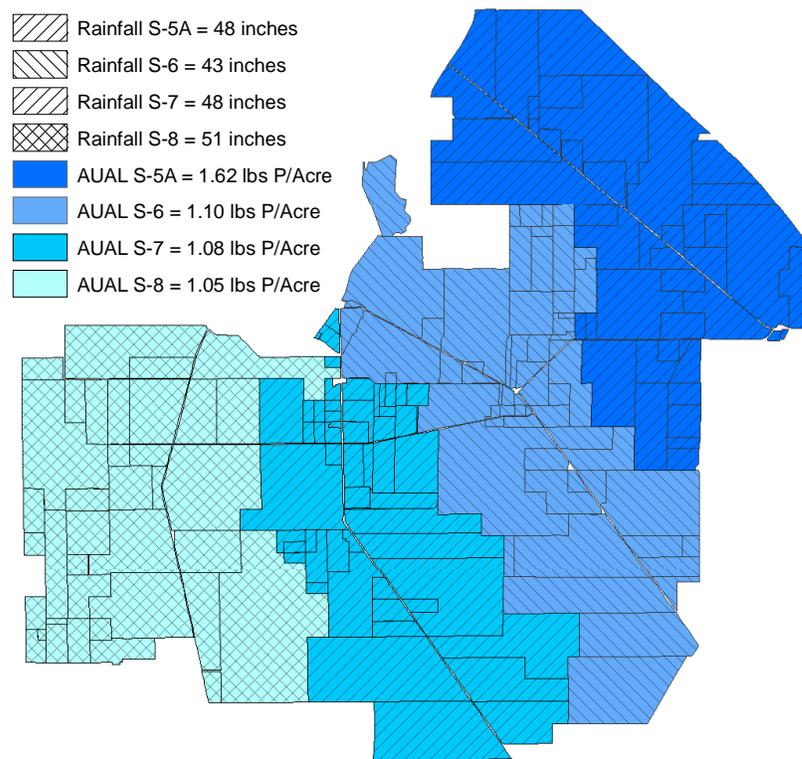


Figure 12. Rainfall and adjusted unit area P load by EAA sub-basin for WY2003.

Note: Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

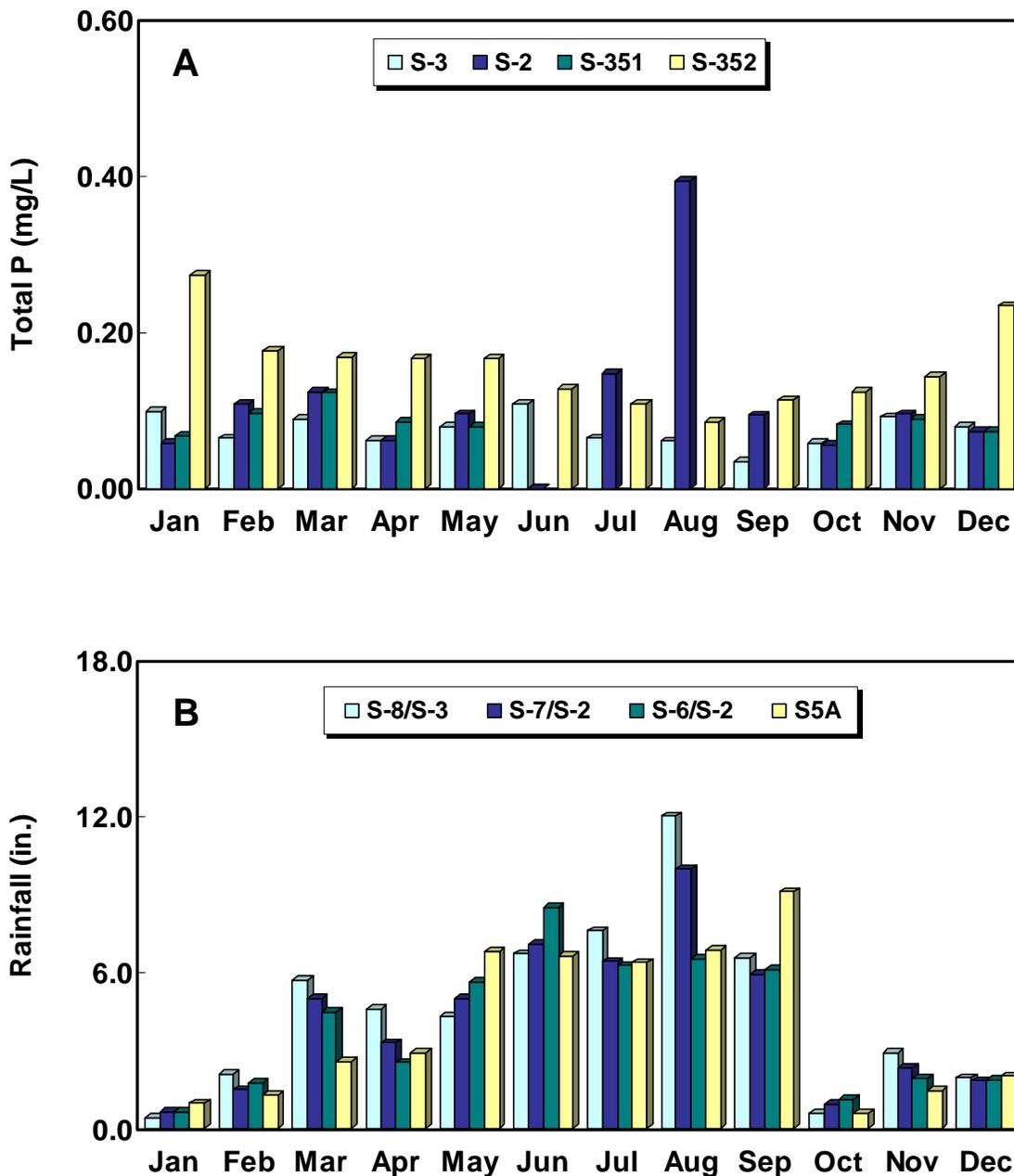


Figure 13. Monthly average EAA inflow canal water P concentrations (A) and sub-basin rainfall (B) for 2003.

Note: the following sub-basins received irrigation water via the corresponding structures: S-8 sub-basin via S-3, S-7 sub-basin via S-2, S-6 sub-basin via S-351/S-2, and S-5A via S-352.

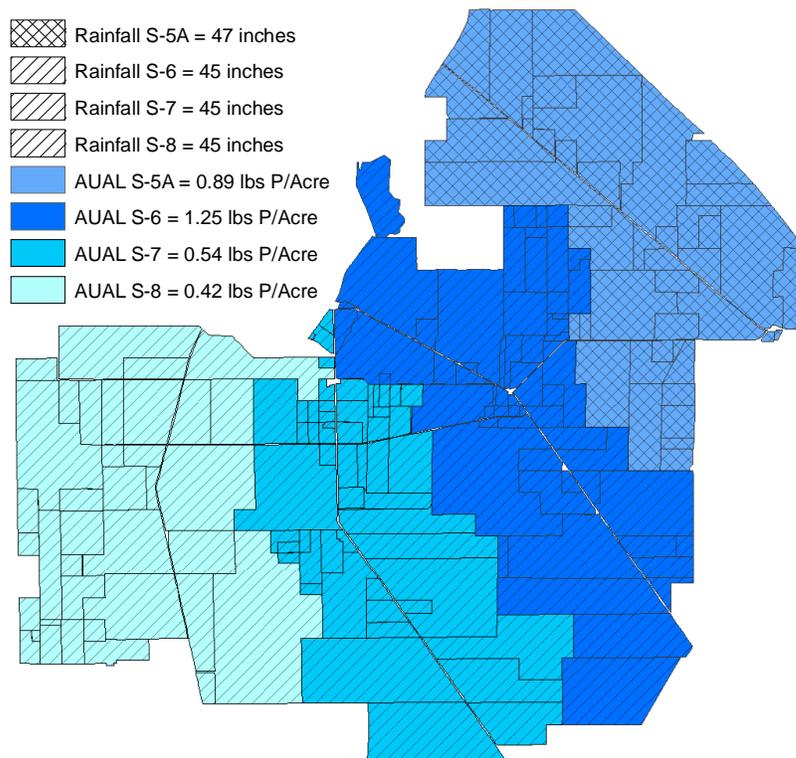


Figure 14. Rainfall and adjusted unit area P load by EAA sub-basin for WY2004.

Note: Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

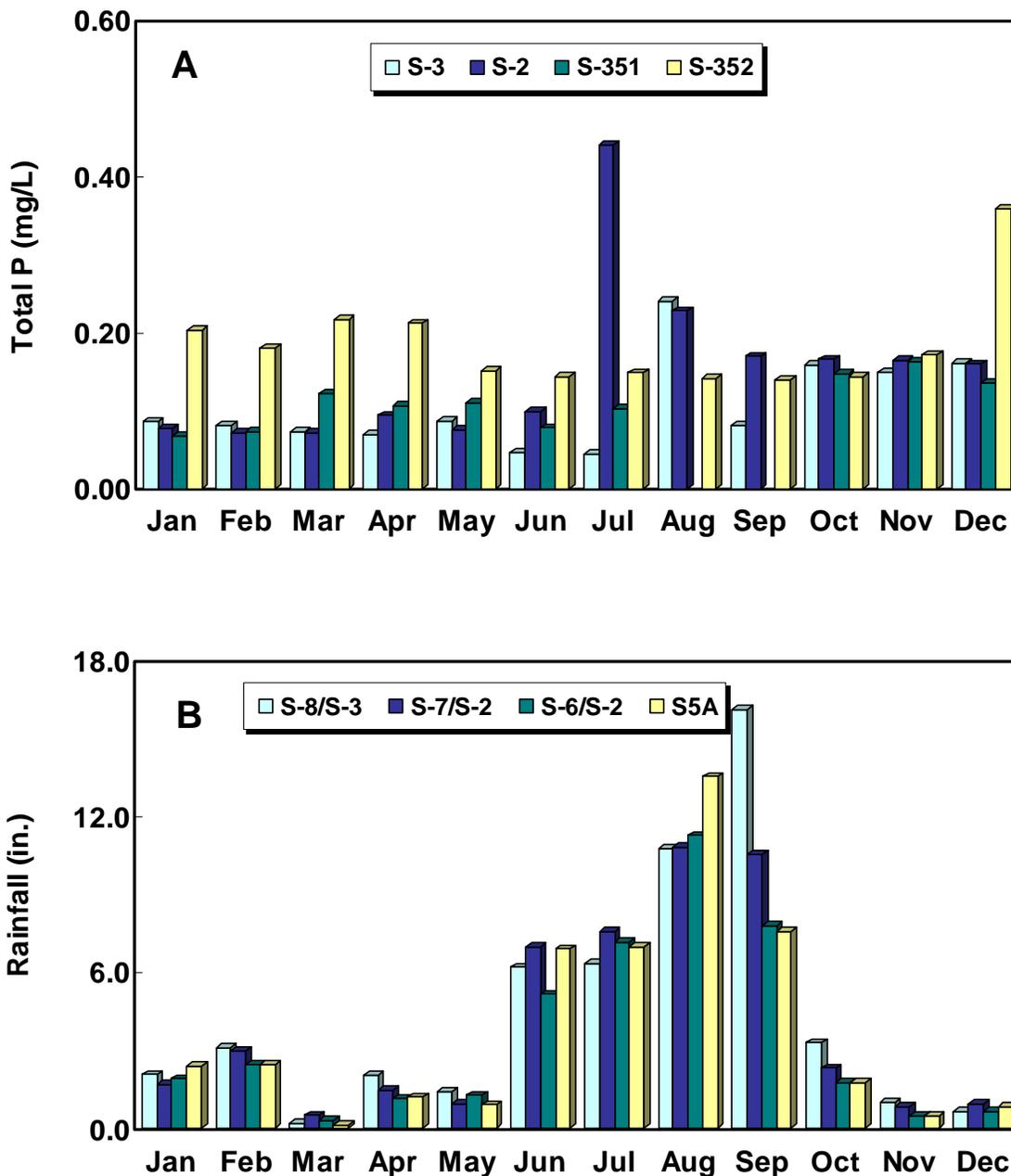


Figure 15. Monthly average EAA inflow canal water P concentrations (A) and sub-basin rainfall (B) for 2004.

Note: the following sub-basins received irrigation water via the corresponding structures: S-8 sub-basin via S-3, S-7 sub-basin via S-2, S-6 sub-basin via S-351/S-2, and S-5A via S-352.

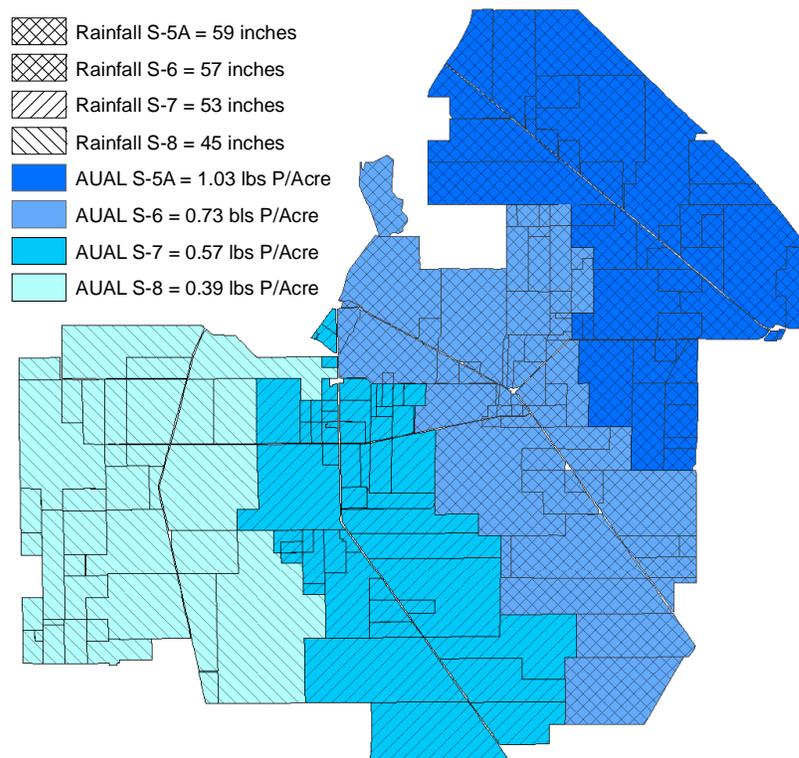


Figure 16. Rainfall and adjusted unit area P load by EAA sub-basin for WY2005.

Note: Sub-basin S-6 includes the NE portion of S-2 sub-basin, sub-basin S-7 includes the SW portion of S-2 sub-basin, and sub-basin S-8 includes the S-3 sub-basin.

Methodology

The farm BMP consultation program strives to appraise the BMP program of each farm basin within the EAA and provide recommendations to improve performance when possible. The steps involved in appraising a farm BMP program and recommending changes in BMP implementation are outlined below:

- 1) Initial farm basin selection and contact
 - a) contact via phone or intermediary
 - b) explain IFAS' farm BMP consultation program
 - c) setup initial appraisal appointment
- 2) BMP permit data collection and review
 - a) review and summarize farm basin flow, concentration, load history
 - b) review and summarize SFWMD permit and related documentation
- 3) Appraisal and consultation with grower
 - a) visit farm and observe farm operations with farm personnel
 - b) discuss with grower implementation of farm BMPs
 - c) review farm P load history and SFWMD BMP reviews with grower
 - d) provide written BMP implementation guides to grower
 - e) explain specific recommendations, if any
 - f) obtain feedback on recommendations from grower

During the consultation discussions with the grower interview and farm visits UF/IFAS researchers utilize and refer to a BMP appraisal checklist to ensure that most of the factors that affect farm BMP performance are appraised and investigated. A copy of the BMP appraisal checklist is presented below:

Farm BMP Consultation Program Checklist

- 1) BMPs of the farm basin – BMP implementation
 - a) BMPs as implemented by Grower(s)
 - b) BMPs identified on SFWMD permit
 - c) BMP trainings attended, who, when, where
 - d) cursory visual check of BMPs during farm visit
- 2) Drainage water P concentration – sampling precision and accuracy
 - a) intake line location and tubing change out schedule
 - b) auto sampler operation, sampler calibration, sample bottle size, etc.

- c) sample handling and processing method
- 3) Drainage water volume – volume precision and reduction
 - a) pump capacities and drainage volume calculation equations; pump data collection frequency during pumping event
 - b) reporting procedures, data submission
 - c) check of actual vs. calculated flow – flow meter
 - d) pump logs and operations, calibrated ranges for pump on sheet; personnel and procedures
 - e) pump operation criteria: on/off pumping set to canal levels, pumps/flow adjusted to canal levels
 - f) rainfall to pumping ratios by event, by year, by rains
 - g) identified and potential seepage problems
 - 4) Canal information – particulate P supply and export
 - a) main canal sediment depth and type
 - b) cross-sectional area in main canal
 - c) cross-sectional area vs. reported flows (estimated velocities)
 - d) aquatic weed management in main and secondary canals
 - e) canal cleaning program, canal cleaning techniques
 - 5) Farming operations – general P supply: fertilizers, soil, irrigation water
 - a) field cropping histories and documentation
 - b) P fertilization program: soil sampling, soil testing and recommendation
 - c) irrigation practices
 - d) field water table management
 - 6) General farm information and description:
 - a) farm basin ID
 - b) farm basin size
 - c) drainage and irrigation structures
 - d) structure pumps and capacities
 - e) past and current crops grown
 - f) historical farm P load parameters and statistics

The BMP appraisal checklist is comprised of six main topic areas: BMP implementation methods, farm physical layout, farming operations, farm drainage volume and flow, farm drainage water P concentration, and farm canal characteristics and management. Each of the main topic areas are discussed informally with farm personnel to provide researchers with a general understanding of farm operations and management. Select

topics are discussed in detail if the related farming practices are not clearly understood by researchers and/or they are perceived by researchers to potentially have a negative affect on BMP performance.

After the initial farm operations and BMP implementation discussion a farm site visit is conducted by the group of researchers and farm personnel. The group visits the farm's water control structures and drainage water sampling installations, observes the farm's canal configuration and conditions and the cropped and fallow fields. During the site visit farm personnel have an opportunity to question researchers regarding any issues or problems with BMP implementation and to educate and receive feedback from researchers concerning any farmer-established, alternative BMP practices or modifications to BMPs.

Results

The one-on-one Farm BMP Consultation Program has been well accepted by the growers. Farm managers have been very cooperative and willing participants during the farm visits. The one-on-one Farm BMP Consultation Program started visiting farms in the S-5A basin with some visits in the S-6 basin. The completion of the one-on-one Farm BMP Consultation Program for the S-5A basin is on schedule with 70% of the total acreage (81,108 acres) already completed. The remaining 30% (34,426 acres) is scheduled to be completed before September 30th, 2006. Table 4 lists the farms in the S-5A basin and the associated acres.

Table 4. Total acreage of farms located in the S-5A basin.

Farm GIS ID	2004 acres	Farm GIS ID	2004 acres
50-002-01*	5656	50-047-07	3494
50-002-02*	9285	50-049-01	1909
50-004-01*	909	50-054-01	7508
50-006-01*	397	50-054-02	960
50-007-02*	5717	50-054-03	1227
50-013-01	1363	50-054-04	3684
50-015-01*	3276	50-059-01	9614
50-015-02*	2554	50-059-02	1768
50-016-01	1497	50-059-03	710
50-018-01	5902	50-059-04	306
50-018-02	6594	50-061-08	375
50-018-03	9062	50-061-15	6760

50-018-12	1655	50-061-17	1598
50-018-13	594	50-064-01	899
50-025-01*	824	50-064-03	145
50-035-02*	1634	50-064-04	1150
50-035-03*	205	50-065-03	3752
50-037-01*	1755	50-065-05	930
50-038-01	1285	50-065-06	454
50-040-01*	216	50-065-08	628
50-040-02*	499	50-068-01	2616
50-044-01	2169	50-068-02	1998
Completed acres	81,108 (70%)		
*Remaining acres	34,426 (30%)		
Total acres	115,535		

Summary of BMP Consultation Program Recommendations

Canal cleaning – Sediments are a major part of the total P load leaving EAA farms, thus, any practice to reduce the amount of sediments in drainage canals will positively influence total P loads at the farm level. Canal cleaning should be conducted during quiescent periods and if possible in combination with irrigation to relocate re-suspended sediments to the back of the farm. Economics or lack of equipment makes it difficult to regularly clean all major canals throughout the farm. However, it is recommended to regularly clean canal sections directly upstream of main drainage structures. It is important to avoid any drainage pumping during or immediately after cleaning operations to prevent the release of drainage waters of high sediment concentration. The importance of canal cleaning is emphasized during farm visits not only to reduce sediment transport and total P loads, but also to improve hydraulics and storage capacity of farm canals.

Floating aquatic vegetation control – In-stream biological growth in main farm canals is one of the major contributors of particulate P in drainage waters leaving EAA farms. Thus, limiting the growth of floating aquatic vegetation in main canals, especially upstream of drainage structures, is a very important particulate P and sediment control practice. An aggressive aquatic weed control is the most effective way at reducing the main source of easy transportable high P content organic material. It is recommended to use weed-retention booms and trash racks well upstream of main drainage structures to reduce the potential of particulate P transport off the farm during drainage events. The installation distance of these structures vary depending on the size of the canal, but should be installed at least 200-300 m (650-1000 ft) upstream of main drainage structures. Use of herbicides to control heavy infestations is not recommended, because dead plant tissue becomes an easily transported floc material source high in P content. Mechanical

harvesting of floating aquatic vegetation is recommended if economically feasible. However, herbicide spraying sometimes is the only option to achieve a broad control and reduce the growth of aquatic vegetation. Subsequent use of herbicide compounds should be limited to spot spraying of problem areas to keep the aquatic vegetation population to a minimum.

Velocity control – Velocity is the key control parameter for reducing particulate P export. The various classes of sediment material present in a typical main drainage canals respond different to changing in hydraulic conditions. At low velocity, only the light, flocculent easily transportable sediment material will be re-suspended and transported. As velocity in the canal increases, turbulence levels increases and the forces responsible to dislodge sediment material from the canal bottom increase, resulting in higher amounts of sediment transport off the farm. In general, the light sediment material transported at the beginning of a drainage event is the freshest biologically deposited material, with the highest P content, while the heaviest sediment transported at higher velocities is the oldest most mineralized sediment material. Thus, controlling canal velocities during drainage events is an important practice to positively reduce the amount of sediment material exported off the farm. However, recommended velocities are relative, in that they must be within the operating framework of the configuration and size of the farm canals.

Two recommendations are often suggested to reduce drainage water velocity. The first one deals with maintaining a minimum canal level that it is farm specific. Canals should not be pumped to a level less than recommended or specified in the BMP permit. Low canal levels may lead to high drainage velocity in the canal that will result in sediment erosion and subsequent transport with drainage water off the farm. The second recommendation suggested is to pump at a lower rate for longer periods of time, rather than pumping faster for shorter periods of time to drain a given volume of water. This can be accomplished by shifting to lower capacity pumps or reducing RPMs on the larger capacity pumps.

Proper BMP documentation – Most of the farmers visited in the S-5A basin have a detailed system of documenting their BMPs practices. However, this is an important subject that we remind growers regardless of any deficiencies. Proper documentation of all BMPs being implemented in the farm is a requirement by the SFWMD. District personnel conduct routine BMP verification visits to ensure that the BMPs listed in the farmers permit are being properly implemented. Recommendations were given for proper BMP documentation ranging from soil testing, fertilizer application rates, canal cleaning program, and pump operation logs.

Location of auto samplers - Auto samplers should be located in the canals as to give an accurate representation of what is being pumped off the farm. Water sampled too far downstream from main drainage structures may give a poor representation of the actual P concentration of drainage water exiting the farm. More appropriate locations for auto samplers were suggested to a grower.

Innovations in water sample collection are positive signs of the interest of growers on water quality in the basin. Some farms have a variation of the typical float technique commonly used by most growers. This sampling variation requires that the water sample is directly extracted from the shaft of the drainage pump before it is discharged off the farm. Water samples coming from the pump-shaft are delivered to a container made out of PVC material that is called "pot", where the intake of the automatic water collect the samples at the specified sampling time. The advantage of this technique is a better sampling representation of water being discharge off the farm, less maintenance, and reduction of missed samples events regularly associated with the float sampling technique.

Grower Concerns

During our farm visits and discussion with growers, opportunities were raised for the growers to voice some of their concerns:

Irrigation water from Lake Okeechobee – Hurricanes from the last few years have negatively impacted water quality from Lake Okeechobee. Average total P load into the lake during the last five years (2001-2005) has averaged 580 metric tons per year, which is more than four times higher than the recently established Total Maximum Daily Load (TMDL) of 140 metric tons that has been established to be necessary to achieve the target goal for the lake of 40 parts per billion (James et al., 2006). Total P loading for Water Year 2005 was extremely high (950 metric tons), and directly related to the unprecedented high number of hurricanes in 2004 which drastically impacted the Lake Okeechobee watershed. Thus, large total P loads and high sediment re-suspension in the lake are impacting the quality of water being released south of the lake. Farmers from the S-5A basin are concerned that high P concentrations of irrigation waters from the West Palm Beach (WPB) Canal are negatively impacting their annual P loads. During one of the farm visits, a main canal irrigating from the WPB Canal was turbid and full of duckweed (*Lemna sp.*). The grower acknowledged that lately, that was a very common occurrence with irrigation water from the WPB canal.

Cleaning and maintenance of public main and public lateral canals connecting to WPB Canal – There are some canals connecting some farms in the S-5A basin to the WPB Canal that are used to transport water during drainage and irrigation events. However,

they do not belong to a particular grower, thus nobody is responsible for cleaning or any other maintenance practices in those canals. These canals are generally infested with aquatic vegetation and full of organic sediments. The concern of these growers is that quality of irrigation water coming from the WPB Canal and drainage water leaving the farms is being negatively affected by these sediments and weed infestations in these canals.

Seepage – This is a major concern of growers that have farms bordering structures such as STA-1W and large district canals such as the West Palm Beach canal. Continuous seepage into these farms usually requires frequent and sometimes daily drainage pumping, which negatively affects their farm's annual P load. There are not clear guidelines to address this problem, although farmers have devised several methods to deal with excess seepage. One method observed was the installation of automatic pump operations that efficiently drain fields without over-draining other areas of their farm. Other methods employ keeping some fields permanently wet to slow and reduce rate of seepage of water from off-farm.

Case Study of Farm P Load Reduction

A previous UF/IFAS research farm is used as an example for this case study. This farm represents a medium size (1285 acres) sugarcane farm in the S-5A basin, with occasional rotational cover crops. The grower has two, high capacity (9,000-28,000 gpm range) and one lower capacity (5,000-8,500 gpm range) single speed electrical pumps, which can be operated with automatic on-off level control. Historically, particulate P has accounted for 50% of the total P discharged. This grower makes an effort to keep aquatic vegetation away from the main drainage pump station. Discharge is controlled by selection of either the high or low capacity pumps. Level control in this farm is practiced by automatic shut down and start-up of the chosen pump at canal level set points. This generally leads to minimum allowable canal levels, and also creates short periods of pump cycling. The imposition of level control also insures that canal velocities will not exceed a certain maximum, which can be detrimental to the annual P load of the farm.

Data from Fig. 19 shows that total dissolved P (TDP) concentrations in this farm have been slightly decreasing during last few years; however the particulate P fraction has shown an increase during the same period, resulting in higher total P concentrations. The farmer has made some adjustments to his drainage program to solve this problem. Figure 20 shows the profiles of a drainage event in 2003. This event started mid day on April 26 in response to rainfall (1.61 inches) that occurred during the previous 24 hours. Canal level steadily increased due to rainfall. On April 26, the grower started pumping using the large capacity pump, steadily lowering the canal level in the farm. There were some additional raining events on April 27 and 28 and May 1, that required some additional

pumping, however pumping from April 28 to the end of the event was done with the small capacity pump (Fig. 20). During this event, the large capacity pump accounted for 42% of total flow, while the small capacity pump accounted for 58%. The significance of these two pumps is shown in the different P fractions measured during that event. The use of the large capacity pump at the beginning of the event created stronger turbulence and higher velocities considerably increasing particulate P in the water column as noted in the higher total P ($TP=0.142 \text{ mg L}^{-1}$) concentrations during this part of the drainage event compared to those observed in the later stages of the event where the small capacity pump was used ($TP=0.063 \text{ mg L}^{-1}$). Drainage from the large pump was responsible for 57.5% of the total P load of the event, with 81% coming from particulate P. In contrast, the drainage from the small pump accounted for 42.5% of the total P load, with the higher contribution coming from the TDP fraction (74.4%). During the last two years, the grower has been able to do some more adjustments to the on-off level controls to further reduce sediment export from his farm. Currently, the large capacity pump is only run during extreme rainfall events, while relying on the on the small pump for most of the farms drainage.

During the consultation visits with this grower, discussion centered on the on-off level controls and canal levels maintained to minimize velocity and sediment transport off the farm. Also emphasized was the importance of having a regular canal cleaning program that will improve the hydraulic capacity of the canals as well as reduce sediment total P loads.

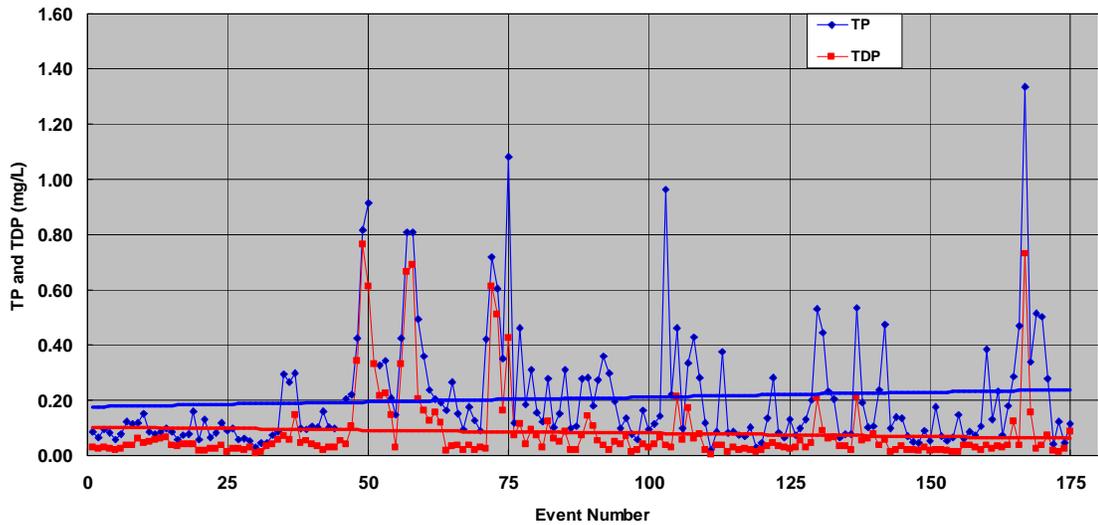


Figure 17. Total P and total dissolved P concentrations in drainage waters from a previous UF/IFAS research farm.

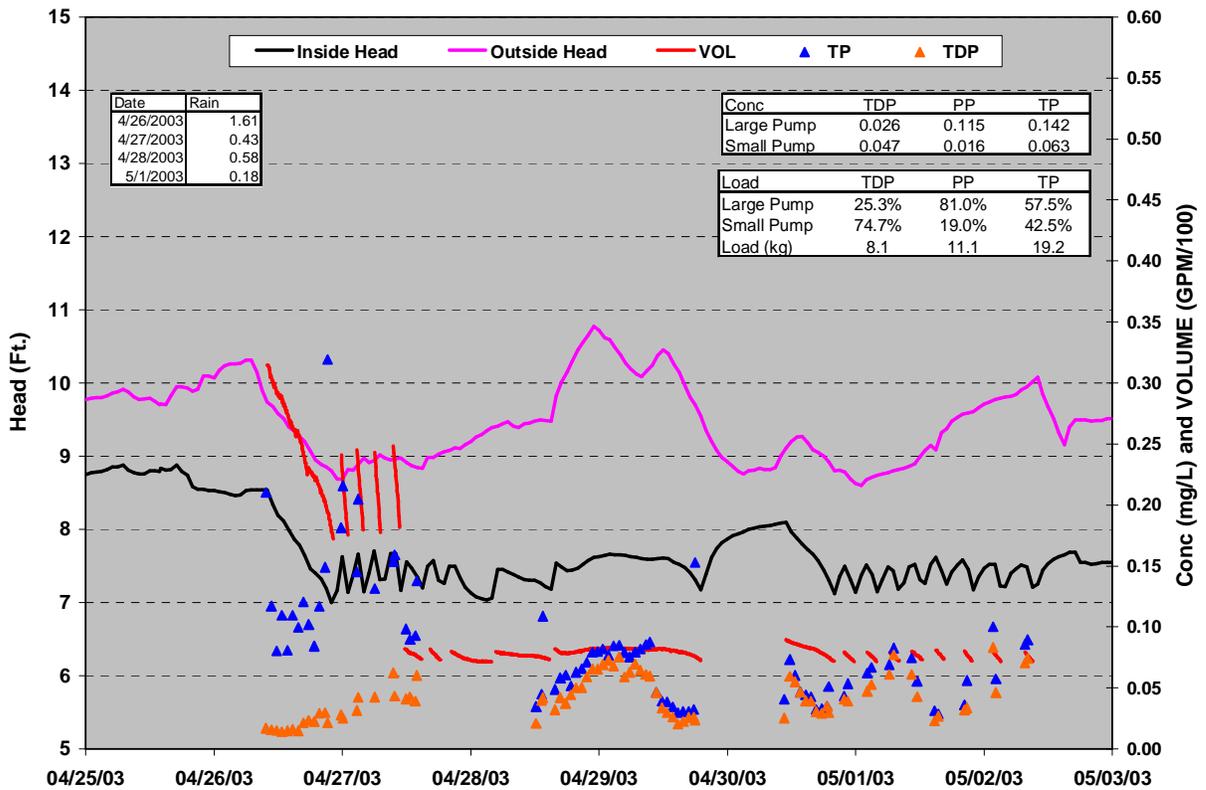


Figure 18. Flow, canal levels, total P and total dissolved P profiles from a typical drainage event of a previous UF/IFAS research farm.

Farm Improvements to Impact Water Quality

Farm improvements used in this section refer to farm practices or farm management decisions that have had a positive impact on improving water quality of drainage water leaving the farm.

Merging of two farm basins to improve water management – Two farms from the S-5A basin were merged by necessity in order to improve management for sugarcane production. By merging these two farms, the manager will have more flexibility to re-circulate drainage water within the farm, decreasing the necessity to pump more often, and consequently considerably reducing the volume of water drained off the farm. The farmer believes that by re-circulating drainage water, he will be able to reduce the annual P load off the farm.

Pump and canal improvements – Several farmers have been pro-actives in making improvements on their canal system to enhance water management within the farm. Several farms have invested in installing new culverts connecting field ditches to main canals, improving drainage and irrigation within the farm. Other improvements include new pumps and enlargement of main canals that will improve the overall farm water management. At the same time, these canal improvements allow them to better re-circulate water within the farm, decreasing the need to drain more often. Increasing the canal capacity throughout the farm also allows them to be in compliance with the ½ in or 1 inch water retention BMP. Installation of new pumps and dredging of the Glades View Canal is also showing early benefits for the farms located in that basin. A farmer claims that pumping due to seepage problems in that area have decreased substantially. However, decrease in seepage may be directly related to the temporal drainage of STA-1W done by the SFWMD for repairs.

Proposed Future BMP Research Areas

One of the benefits of conducting this task is the improved abilities of the concerned researchers to identify priority research areas that affect water quality in the EAA. From the first year's work we have identified three topics that we think are worthy of further scrutiny and discussion.

The first topic concerns the **effects of irrigation water quality on farm P loads**. Initial water samples of irrigation water that were collected from the past two spring seasons have shown that many samples had P concentrations above 200 ppb. We have identified several farms that would be suitable candidates to conduct a study to measure irrigation water effects and contributions to farm P load discharge.

A second research topic resulting from the BMP farm consultation program is the **management of farm main canals to improve BMP performance**. From past research results it is known that: floating aquatic weeds provide an ample supply of easily transportable particulate P; floating aquatic weeds reduce light penetration into the canal water profile resulting in anaerobic conditions; and many farm canals have sizable sediment P inventories. Of interest are the interactions between the anaerobic conditions caused by floating aquatic weed growth in farm canals and the P contained in the canal sediment inventory. We propose research be conducted that determines the effects of floating aquatic weeds on P flux from canal sediments.

The third research area is the determination of the benefits derived and the efficacy of **hydraulic cleaning of farm canals**. The development of simple and economical hydraulic methods that remove sediments from canal bottoms and place them on flooded fields should benefit crop production and farm water quality. Organic sediments recovered from canal bottoms reduce off-farm P loads as well as replace some organic matter to fields that are slowly subsiding due to organic matter decomposition.

Conclusions

The first year of the Farm BMP Consultation Program has been positively accepted by the growers of the S-5A basin. All growers have been very cooperative and willingly have taken the time to meet with IFAS personnel to discuss their BMP program and other issues related to water quality. In general it can be concluded that:

- a). All farmers are aware of the significance of the BMP program in the EAA and are committed to continue doing their share of the BMP program to insure that the current success is maintained throughout the entire basin.
- b). Farmers are very receptive to testing modifications of their practices, especially those related to particulate P and sediment control in main canals.
- c). Farmers recognize the importance of continued research on BMP and other water quality issues and are willing to contribute and collaborate with researchers on future projects.

In summary it can be concluded that the first year of this program has been a success in terms of grower participation and willingness to listen to modifications of their practices that may be more effective and appropriate for their BMP program. The positive attitude encountered during the BMP training seminars has been carried over to the farm consultation program. This positive outlook from the growers allows them to adapt and

face all the future challenges that south Florida agriculture is facing and ensure that the BMP program will continue having the same success, thus EAA agriculture can continue to be good a steward of the land as well as an important economic sector in South Florida.

TASK II: STATISTICAL EVALUATION OF EXISTING EAA DATABASES:

Introduction

Drainage water leaving the EAA is first pumped into one of seven large Stormwater Treatment Areas (STAs) located on the EAA's periphery. The STAs were designed and constructed to remove P from drainage water through biological, chemical and physical processes. Stormwater Treatment Areas have been successful in reducing EAA basin water P concentrations and loads with outflow P concentrations of 12 ppb reported for STA-6 and 14 ppb for STA-2 during Water Year 2004 (Goforth et al., 2005). However, the STAs are known to vary in their effectiveness, mostly as a result and function of load and flow (and possibly age).

As a direct result of state-mandated, basin-wide BMP implementation, significant reductions in P loads discharged from the EAA basin have been achieved (SFWMD, 2006). Additional reductions in P loads from the farms within the EAA basin will serve to improve the performance of STAs, especially those STAs functioning at or above design capacity.

Farmers of the EAA implement a chosen suite of BMPs that range from soil testing, fertilizer application methods and slow release P fertilizers to sediment controls and rainfall detention (Table 1). Some commonly adopted BMPs throughout the EAA are soil testing and application of P fertilizer at rates recommended according to the soil test. Adoption of sediment control practices also varies at different farms. The EAA is delineated into six sub-basins according to the canal system which drains and irrigates the EAA basin. Each sub-basin is evaluated separately, but compliance is based on the EAA basin as a whole. These sub-basins vary greatly with regard to their respective P load exports (Adoriso et al., 2006).

To preserve and restore the ecosystem of the Everglades it is essential to understand and quantify the ability of individual BMPs in reducing the impact of high-intensity agricultural land uses. Our conceptual approach to address these issues is rooted in understanding the spatial distribution of environmental factors and how they change through time.

Identification and extension of the most effective suites of BMPs tailored to farms and sub-basins will improve and optimize BMP implementation throughout the EAA basin. Determination of the most effective suite of practices for a specific farm, i.e. soil type, crops grown, geographic location, farm size, etc., has the potential to provide managers and farmers with an important and effective tool to achieve additional P load reductions. Further reductions in P loads emanating from the EAA will allow the downstream STAs to perform at their optimum levels for P removal. The optimization of both systems, which includes EAA off-farm discharge as well as STA performance, will be integral to achieving the goal of 10 ppb P in the waters of the WCAs and the Everglades National Park.

Compilation of IFAS BMP research database

The UF/IFAS has over ten years of research and monitoring data on implementation and efficacy of BMPs in the EAA. From 1992 through 2002, with contributions from the Everglades Agricultural Area Environmental Protection District, the Florida Department of Environmental Protection, the Florida Sugar Cane Growers' Cooperative, the Florida Crystals Corporation, the United States Sugar Corporation, Roth Farms, Incorporated, and participating growers, the UF/IFAS undertook several projects to implement and assess the efficacy of the suggested BMPs at the farm level, assess the contribution and transport of particulate P from the EAA canals, determine relationship between water table levels in the field and drainage, and monitor non-P species mainly specific conductance and ion concentrations in EAA canals,

Ten farms, representative of EAA soils, geography, crop systems, and water management practices, were chosen for BMP implementation and testing in 1992. From January 2002 to early 2005, three farms remained in the project. The three farms were intensely monitored with hourly data obtained for P concentrations, flows, rainfall, canal levels, and loads. Appropriate BMPs were selected and implemented at each site. An extensive array of monitoring instruments was installed at each site to track changes in P concentrations, drainage water discharge, and ultimately, P loads. Over time, additional BMPs have been added at sites where applicable, and growers have adjusted the implemented practices to fit their unique situations. The effects of the implemented practices have been assessed by the monitoring program. The UF/IFAS has published many reports on this research (Daroub et al., 2004a, Daroub et al., 2004b, Daroub et al., 2005). The foundation of the IFAS BMP research data originates from the ten farm BMP efficacy study initiated in 1992 and completed in 2002. Complementary data sets include the farm drainage and water table study, the farm TDP/PP monitoring study, the ten farm specific conductance study, and an intensive three farm particulate P study.

The objectives of this task is to create a Microsoft Access database that includes all IFAS BMP research conducted in the EAA and to employ statistical analysis to assess parameters that affect farm P discharge and use the results to improve selection and application of existing BMPs. Another objective is to recommend future research studies to enhance BMP effectiveness and address other important issues in the EAA.

Five IFAS monitoring data sets were consolidated into one comprehensive IFAS BMP database (Table 2). The IFAS BMP research and monitoring data sets and relationships are illustrated in Figure 21. The first data set is from the farm BMP efficacy study. The data includes five minute flow discharges, hourly canal levels and rainfall, and drainage event composite P concentrations from the ten monitored farms within the EAA. The data set came from research and monitoring the BMP efficacy study of ten farms in the EAA from 1992 to 2001. The ten farms were spaced across the EAA and represent different farms sizes, types, and soil types. Also included in this dataset are monthly farm crop maps.

The second data set is the six-farm drainage and water table study conducted from 1995 through 1999. Hourly water table measurements from multiple locations (field wells, field ditches, and farm canals) within each of six farms were recorded on strip chart recorders and digitized into spreadsheets. The third data set comprises monitoring data from all ten farms that measured concentrations of dissolved and total P in farm drainage waters from 1997 through 2002. Composite drainage water samples were collected in iced sample containers and retrieved daily for P analysis.

The fourth data set includes in situ water quality readings recorded by Hydrolab DataSondes[®] positioned on the main farm canals of the ten BMP farms. Data collection began in 1997 on three farms and expanded to all ten farms in 1998; monitoring ended in 2002. The fifth and last data set includes the intensive research on the sources, transport mechanisms, and control of particulate P on three farms located in the north, eastern, and western EAA. Two were sugarcane farms; the third farm was mixed cropping system including sugarcane, vegetables and sod. Total P, total dissolved P and suspended solids were measured from drainage water samples of hourly composites. Particulate P was calculated as the difference between total P and total dissolved P.

All of the data sets have been reviewed and compiled into the database. The database has also been checked for accuracy. The second step to be done in the second year is to consider the various statistical methods and employ the appropriate methods.

Dataset	Description	Data Period
Farm BMP Efficacy Study	Five-min drainage flows, hourly rain and canal levels	1992-2002
Farm Water Table Study	Five-min drainage flows, hourly rain and canal levels	1995-1999
Farm TP/TDP/PP Study	Event composite drainage water P concentration	1996-2002
Specific Conductance Study	Hourly specific conductance, pH, temperature, ORP, DO, turbidity	1997-2002
Farm Particulate P Study	Five-min drainage flows, hourly rain, P concentrations, TSS, and canal levels	2000-2005

DATA SOURCES FOR IFAS BMP RESEARCH DATABASE

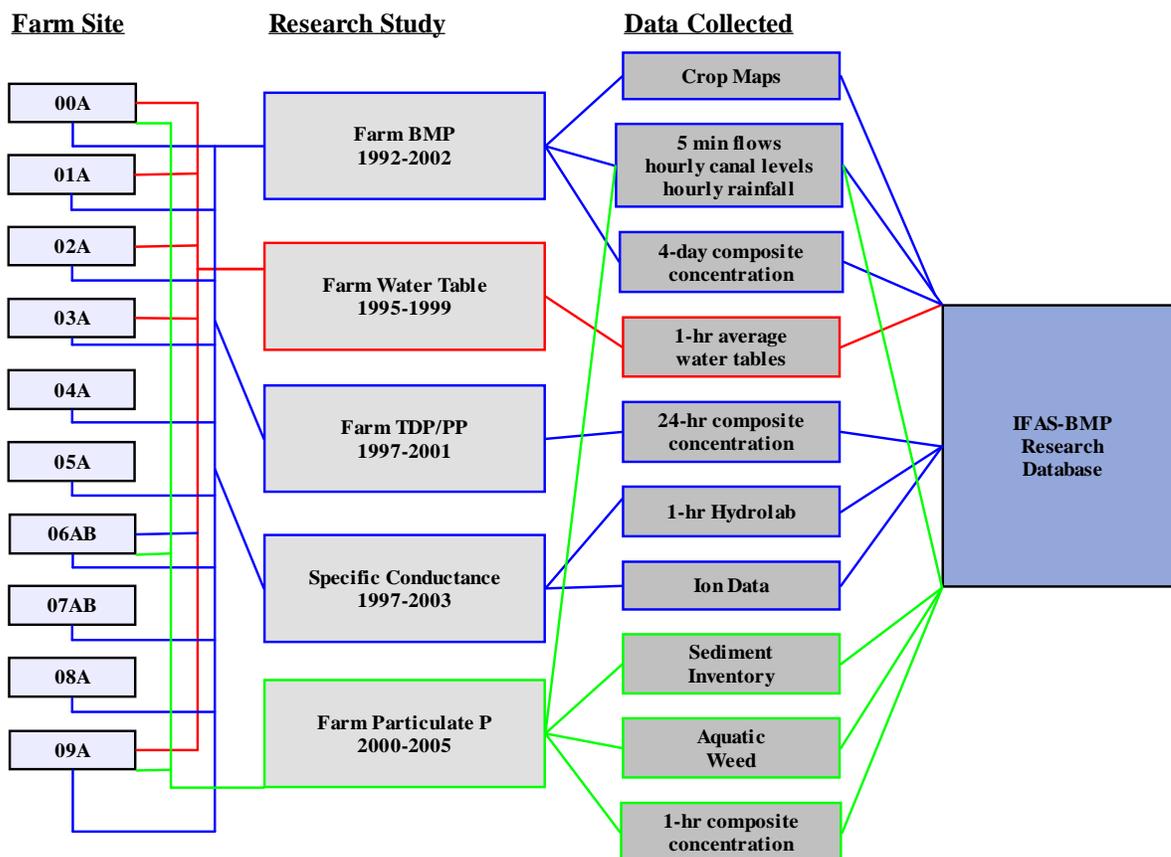


Figure 19. Diagram of IFAS-BMP-EAA research database structure.

Dataset Statistical Analyses

We have discussed EAA farm data with IFAS geo-statisticians in Gainesville and have identified several analyses that are most appropriate. The analyses methods with highest potential for success employ a variety of multivariate statistical methods including data reduction, data mining and predictive modeling techniques.

Pre-processing: The data comprise variables that will be assumed to be static throughout the analyses (e.g. soil type, farm boundaries) because they are considered relatively invariant in time. Other data are time variant and dependent on geographic position (e.g. implementation of specific BMPs, land uses management) and will be treated accordingly. The most dynamic data are the monitored flow and concentration data. Dependent on the statistical method used we will aggregate data in space and/or in time. For example, average annual P loads will be derived for each monitoring station that aggregate observations through time. In contrast, soil characteristics for each farm can be lumped in space based on farm boundary layers.

The data types are complex ranging from continuous data (e.g. flow measurements), categorical data (e.g. land use) to indicator data (e.g. presence/absence of land use practice). Transformations will be used to preserve as much of the information content as possible for each analyses. For example, soil types for each farm can be expressed as categorical data (e.g. soil type 1, soil type 2, etc.), as percentages (e.g. % soil type 1, % soil type 2 within farm) or as spatial data layers that preserve the spatial distribution and connectivity of soil map units. For comparative analysis data need to be standardized. For example, to compare P loads for different farms (or sub-basins) loads need to be standardized by area to derive annual unit loads.

An exploratory analysis will be conducted to check datasets for consistency (e.g. outliers, potential measurement errors) and derive standard statistical metrics (e.g. mean, median, standard deviation). Depending on the statistical method we will test for normality and if necessary use transformations to approximate normal distributions.

Analyses: Least squares linear regression and multiple regressions are among the most commonly used analytical techniques of agronomists, ecologists and soil scientists. Linear models are associated with assumptions about the statistical distribution of a response variable, the form of variance structure and the independence of observations which are often difficult to meet with environmental data. Furthermore, environmental datasets are often complex and unbalanced with non-linear relationships that vary in space and time. Therefore, linear regression models often fail to effectively describe landscape pattern such as the effect of different environmental variables on BMP

performance. To assess the effect of multiple environmental factors on BMP performance and off-site P loads from farms or basins requires employing advanced multivariate techniques that can handle non-linear relationships. The techniques we are considering employing include Principal Component Analysis (PCA) and Classification and Regression Trees (CART).

TASK III: BMP TRAINING WORKSHOPS

Best Management Practices training seminars and workshops are designed by UF/IFAS faculty to cover all the different aspects of the BMPs in the EAA to insure uniform and successful implementation by EAA growers. The topics covered include a review of Rule 40E-63, Atrazine and Ametryn use and BMPs in the EAA, soil testing and plant analysis, fertilizer application, rainfall detention, sediment control, and particulate P research overview and results. A copy of typical materials covered and shared with growers is in **Appendix A**.

From the period of March 2005 (start of new SOW) till June 30, 2006, a total of twelve BMP workshops and training seminars were conducted. These workshops are targeted for specific companies. One general workshop open to the public is also given once a year. The workshops normally last around 3 ½ to 4 hours where all aspects of the SFWMD BMP table is covered. In addition, findings from research conducted by UF/IFAS are shared with participants. The presentations are given by S.H. Daroub, T.A. Lang and O.A. Diaz. Information regarding the wise use of the pesticides Ametryn and Atrazine are also presented by Curtis Rainbolt, weed scientist at the Everglades Research and Education Center (EREC). In addition, other IFAS faculty with expertise on the specific BMP topics presents current research results. Faculties that have presented BMP talks in the past year include Dr. Mabry McCray, Agronomist, Dr. Alan Wright, Soil Scientist and Dr. Cody Gray, Aquatic Weeds Scientist. Continuing education units (pesticide and certified crop advisor) are offered to participants. Materials covered as well as lists of attendees in each workshop have been already sent to the SFWMD. A list of workshops conducted is:

1. One BMP workshop was conducted for **Sugar Cane Growers Cooperative** on May 10, 2005 with 47 participants.
2. Two BMP workshops was conducted for **Okeelanta Corporation** on May 24, 2005 (am and pm session) with at total of 40 participants
3. Two BMP workshops were conducted for **Sugar Farms Cooperative** on June 8, 2005 (am and pm session) with 17 participants
4. Two BMP workshops were conducted for **U.S. Sugar Corporation** on September 28 and 29, 2005 with 42 participants.

5. An **open workshop** was also conducted on October 13, 2005. The workshop was open to everyone who missed earlier workshops. A total of 28 participants attended the workshop. Advertisement for the workshop was sent through mail and email.
6. Two training sessions were conducted for 18 participants from **Sugar Farms Cooperative** on May 23, 2006.
7. Two training sessions were conducted for 20 participants from **Okeelanta Corporation** on May 25, 2006
8. One training session was conducted for 13 participants from **Sugarcane Growers Cooperative** on June 1st, 2006.

TASK IV: DEVELOPMENT OF BMP EXTENSION MATERIALS

Four extension publications were published online at the UF/IFAS EDIS extension web site <http://edis.ifas.ufl.edu/> in 2005/2006. These publications cover four different BMPs in the EAA. Copies of these extension materials are made available during BMP training and also during the one-on-one farm consultation. Full copies of these extension publications can be found in **Appendix B**. A list of all extension publications on BMPs of the EAA follows:

1. Lang, T.A., S.H. Daroub, O.A. Diaz, and M. Chen. 2006. Best Management Practices in the Everglades Agricultural Area: Fertilizer Application Control. EDIS SL232/SS451 <http://edis.ifas.ufl.edu/SS451>
2. Diaz, O.A., S.H. Daroub, R.W. Rice, T.A. Lang, and M. Chen. 2005. Best Management Practices in the Everglades Agricultural Area: Fertilizer Spill Prevention. EDIS SL231/SS450 <http://edis.ifas.ufl.edu/SS450>
3. Daroub S.H., O.A. Diaz, T.A. Lang, and M. Chen. 2005. Best Management Practices in the Everglades Agricultural Area: Soil Testing. EDIS SL225/SS 445 <http://edis.ifas.ufl.edu/SS445>.
4. Diaz, O.A., T.A. Lang, S.H. Daroub, and M. Chen. 2005. Best Management Practices for the Everglades Agricultural Area: Controlling Particulate Phosphorus and Canal Sediments. EDIS SL232/SS 448 <http://edis.ifas.ufl.edu/SS448>
5. Daroub S.H., J.D. Stuck, T.A. Lang, and O.A. Diaz. 2002. Particulate phosphorus in the Everglades Agricultural Area: II- Transport Mechanisms. EDIS SI198/SS417 <http://edis.ifas.ufl.edu/SS417>
6. Daroub S.H., J.D. Stuck, T.A. Lang, and O.A. Diaz. 2002. Particulate phosphorus in the Everglades Agricultural Area: I- Introduction and Sources. EDIS SL197/SS410 <http://edis.ifas.ufl.edu/SS410>

CONCLUSIONS

Differences in farm P loads and BMP performance of EAA farms is directly related to factors such as basin location, soil depth, rainfall distribution, irrigation water quality, and past and present cropping practices. Soil depth is an important factor that influences farm management practices for crop production. Results from the last complete soil survey of the soils of Palm Beach County in 1988 showed distinct changes from the original deeper soils series. From results based on previous surveys and current projections, the S-5A basin has the deepest soils while the S-7 and S-8 basins have the shallowest soils. The depth of the organic soil profile and subsequent proximity to the underlying bedrock will have an effect on water quality leaving these farms. Deeper soils have more capacity to hold water, but at the same time there is more potential to release P bound in soil organic matter via decomposition. In contrast, shallower soils have less capacity to hold water, though, the proximity to the underlying bedrock increases the likelihood that a part of the soluble P fraction may be adsorbed or precipitated as a result of interaction with the underlying limestone.

Irrigation water quality also plays a role on farm P loads. Water quality from Lake Okeechobee has degraded during the past 60 years due to high nutrient load inputs from surrounding watersheds. Average P loads into the lake during the last five years has averaged 580 metric tons, which is considerable higher than the established TMDL of 140 metric tons. High sediment re-suspension and overall higher loads due to the hurricanes in 2004 and 2005 have further deteriorated the lakes water quality, which ultimately has a negative impact on the farms relying on this water for irrigation. Water quality data indicate that lake water discharged through structure S-352 into the West Palm Beach Canal (S-5A sub-basin) showed the highest total P concentration during the last six years, followed by structures S-2 (S-2 and S-6 sub-basins) and S-351 (S-2 and S-7 sub-basins). Structure S-3 (S-3 and S-8 sub-basins) showed the lowest average total P concentration of lake water discharged south to the agricultural area. Preliminary observations revealed that sub-basin farm P loads appear to be related to irrigation demand and irrigation water quality. In years with dry spring months, the S-5A basin was observed to have relatively higher annual adjusted unit area P loads; in years with higher rainfall in spring, the S-5A sub-basin was observed to have annual adjusted unit area P loads similar to other sub-basins.

The first year of the Farm BMP Consultation Program can be cataloged as a success and positive step forward to ensure the continued success of the BMP program of the EAA growers. First year conclusions from this program show the awareness of all farmers of the significance that the BMP program has on the present and future of agriculture in the EAA and the South Florida ecosystem. Farmers are receptive to implementing modifications to their farm BMP programs in order to reduce their total farm P loads.

The statistical evaluation of existing EAA datasets is underway. Five major IFAS datasets have been reviewed and compiled into one comprehensive database. The IFAS dataset is ready for the second phase which includes the use of various statistical methods. The entire dataset will be analyzed for inconsistency using an exploratory analysis, and thus derive standard statistical metrics. Depending on the statistical methods, the data will be test for normality and if necessary transformations will be done to approximate normal distributions. Multivariate techniques will be used to handle non-linear relationships, thus we can asses the effect of multiple environmental factors that may affect BMP performance.

The BMP training workshops have received a positive response from all participants. The BMP workshops are tailored to fit the needs of individual companies. The topics covered include the most commonly used BMPs in the basin. One of the main accomplishments of these workshops is to provide to growers the latest information about BMP implementation at the farm level. However, an additional benefit is the development of more open interaction between growers and IFAS researchers. These accomplishments can be rated by grower's interest and active interaction during the different presentations. From March of 2005 to June 30, 2006, a total of twelve BMP workshops have been conducted. One general workshop was given in October 2005 to accommodate farmers that missed their company workshop. A Spanish version of current BMP training workshop will be added in the Fall 2006 to cover all Spanish speaking participants. In addition, four extension publication covering major BMPs in the EAA have been published during the past year. Copies of these extension publications are made available during BMP training workshops and the one-on-one farm consultation program.

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APPENDIX A. BMP WORKSHOP TRAINING MATERIALS

Presentations used in BMP training workshops are presented in this Appendix. The BMP training workshops last for about 4 hours and cover all aspects of BMPs in the EAA as described in the SFWMD BMP table. In addition, latest UF/IFAS research findings are presented and discussed with participants. Both pesticide CEUs and Certified Crop Advisor CEUs are offered.

APPENDIX B. BMP EXTENSION PUBLICATIONS

Attached are copies of extension publications published in 2002- 2006. These publications can also be found on line at <http://edis.ifas.ufl.edu/>

1. Lang, T.A., S.H. Daroub, O.A. Diaz, and M. Chen. 2006. Best Management Practices in the Everglades Agricultural Area: Fertilizer Application Control. EDIS SL232/SS451 <http://edis.ifas.ufl.edu/SS451>
2. Diaz, O.A., S.H. Daroub, R.W. Rice, T.A. Lang, and M. Chen. 2005. Best Management Practices in the Everglades Agricultural Area: Fertilizer Spill Prevention. EDIS SL231/SS450 <http://edis.ifas.ufl.edu/SS450>
3. Diaz, O.A., T.A. Lang, S.H. Daroub, and M. Chen. 2005. Best Management Practices for the Everglades Agricultural Area: Controlling Particulate Phosphorus and Canal Sediments. EDIS SL228/SS 448 <http://edis.ifas.ufl.edu/SS448>
4. Daroub S.H., O.A. Diaz, T.A. Lang, and M. Chen. 2005. Best Management Practices in the Everglades Agricultural Area: Soil Testing. EDIS SL225/SS 445 <http://edis.ifas.ufl.edu/SS445>.
5. Daroub S.H., J.D. Stuck, T.A. Lang, and O.A. Diaz. 2002. Particulate phosphorus in the Everglades Agricultural Area: II- Transport Mechanisms. EDIS SL198/SS417 <http://edis.ifas.ufl.edu/SS417>
6. Daroub S.H., J.D. Stuck, T.A. Lang, and O.A. Diaz. 2002. Particulate phosphorus in the Everglades Agricultural Area: I- Introduction and Sources. EDIS SL197/SS410 <http://edis.ifas.ufl.edu/SS410>



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