UF/IFAS ANNUAL REPORT: EVERGLADES AGRICULTURAL AREA BEST MANAGEMENT PRACTICES

EXECUTIVE SUMMARY

The Everglades Agricultural Area (EAA) basin covers approximately 500,000 acres of rich organic soil located south of Lake Okeechobee. The area is one of Florida's most important agricultural regions planted mainly to sugarcane with less than 20% of the acreage planted to vegetables, sod and rice. The Best Management Practices (BMP) Regulatory Program in the EAA is mandated by the State of Florida legislation. The full implementation of Agricultural BMPs by EAA growers since 1996 have consistently reduced total phosphorus (P) loads from the EAA basin. The overall effectiveness of BMPs in the EAA is demonstrated by comparing measured total P discharges from the South Florida Water Management District (SFWMD) structures for each Water Year to the pre-BMP base period of October 1, 1978 through September 30, 1988. The EAA basin is required to reduce P loads by 25 percent when compared to the pre-BMP base period. The EAA basin has been in compliance since Water Year 1996, and has exceeded the required 25 percent reduction each year. In Water Year 2003, a 35 percent reduction in total P load was achieved from the EAA basin.

UF/IFAS BMP Project Background

The University of Florida / Institute of Food and Agricultural Science (UF/IFAS) Agricultural BMP research and education program to reduce P concentrations and loads began in 1986. A definition of BMP pertinent to the EAA was defined as: ***An alternative management practice that is technically feasible, economically viable, socially acceptable, and scientifically sound, that when implemented, will lead to reduced P concentrations and loads leaving farms in the EAA, while not threatening the viability of the agricultural industry***.

In 1986, the UF/IFAS entered into a research contract with the SFWMD, the Florida Sugar Cane League, the Florida Sugar Cane Growers' Cooperative, the United States Sugar Corporation, the Florida Crystals Corporation, the Florida Fruit and Vegetable Association, and Roth Farms, Incorporated. The objective of the research was to determine what agricultural practices could be changed to reduce the P concentrations and loads leaving EAA farms. The primary foci of the study were to determine the effects of fertilizer rates and application methods and water management practices on drainage water P loads and concentrations. Potential BMPs were screened using large field plots. Results of this initial work showed that sugarcane fertilizer related practices did not lead directly to short-term P concentration and load increases since application amounts are low. Vegetable crop fertilization practices, however, were found to be capable of causing short-term P spikes given certain hydrologic and cultivation conditions. Banding fertilizer for vegetable crops at reduced rates, and using proper fertilizer handling and application methods for all crops, could lessen the occurrences of fertilizer related short-term increases in P concentrations and loads. The study also showed that water management practices greatly affected both P concentrations and loads. Obviously, pumping less water off farms yielded large and immediate reductions in P loads. However, drainage rates and uniformity could also greatly affect P loads and concentrations positively or negatively. It was, therefore, determined that a combination of improved drainage uniformity and a reduction in drainage pumping could yield significant reductions in P concentrations and loads for all crops.

In addition to the above, it was determined that sugarcane land yielded P concentrations and loads that were equal to, or lower than, fallow land that was allowed to flood and drain. Also, in spite of the effects of the higher fertilization rates, and the more demanding water management requirements of vegetable crops, vegetables could be grown in the EAA without greatly affecting P concentrations and loads. To accomplish this, the growers were advised to block farms into hydraulically isolated units and to rotate crops accordingly. By doing so, vegetable field drainage water would not directly enter the farm drainage stream, but rather would be diverted to sugarcane blocks for retention or detention. Additionally, it was determined that growing rice in rotation with vegetables, which requires no additional P fertilizer, yielded a major export of P from the EAA in grain and held nutrients in plant matter, which could then be reincorporated into the soil. It was cautioned, however, that drain down of the rice floodwater be accomplished in a manner such that it did not directly enter the drainage stream. Allowing the floodwater to subside naturally leaves residual nutrients in the field for use by the succeeding crops. Additional drainage required to lower water table levels should be discharged to sugarcane field blocks, keeping the nutrient enriched water from directly entering the farm drainage stream. This practice was extrapolated to pertain to all floodwaters, regardless of whether they originated from rain, or purposeful flooding of fallow fields.

The initial study lead to the development of BMPs for reducing P concentrations and loads in the EAA. Using the results of the study, and best professional judgment, expected reductions in P loading were attached to each BMP. It was hypothesized that P load reductions ranging from 20 to 60% could be realized for farms in the EAA and for the basin as a whole. The BMPs suggested by the UF/IFAS research, the industry and the SFWMD, were selected by the SFWMD for inclusion in the table of BMP options used in compliance of Rule 40E-63 (Table E1). Mandatory BMP implementation started in January 1995.

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 has undertaken a project to implement and assess the efficacy of the suggested BMPs at the farm level. In addition, funding was provided to assess the contribution and transport of particulate P from the EAA canals, monitor non-P species mainly specific conductivity in EAA canals, and assess the potential impact of P flux and transport forms in Water Conservation Area canals.

Ten farms, representative of EAA soils, geography, crop systems, and water management practices, were chosen. Due to Stormwater Treatment Area development and a change in project goals, two farms were removed from the monitoring program. In January 2002, three farms were kept in the project. The three are 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 were 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.

Current Emphases

In 2003, research was conducted on three farms to assess conditions that lead to increased particulate P transport and subsequent P load spikes. In addition a demonstration farm was established at the Everglades Research and Education Center (EREC) to compare the effectiveness of optimized particulate P BMPs to conventional BMPs in reducing particulate P load. Initial results are promising and show appreciable reductions in total P export through implementation of critical canal velocity control and floating aquatic weed management. The next step of this research is to characterize the bioavailability of sediment P transported off the farm.

This annual report includes three chapters as follows.

1- Chapter I: Summarizes particulate P research and findings from 2000 to 2003 with special emphasis on findings in 2003. This research was conducted on three farms in the EAA.
2- Chapter II: Provides preliminary results from the particulate P BMP demonstration farm at the EREC.
3- Chapter III: Contains data update on specific conductance in the EAA farm canals for 2003.

CHAPTER I: On-farm Particulate P Measurement and Control

Phosphorus transport in runoff can occur in soluble and particulate forms. Particulate P consists of all solid phase forms including P sorbed by sediment particles and organic material transported during runoff. The primary objective for researching particulate P transport in the EAA is to optimize management practices that can reduce the overall P export at the farm level. Particulate P accounts for 20% to 70% of the total P exported from EAA farms, and is also frequently the cause of spikes in farms total P loads. The mass fraction of P exported in suspended solids is frequently higher than that of organic soil or field organic matter of the area and the chemical composition of the suspended solids resemble more the composition of canal aquatic vegetation than those observed in typical organic soils of the EAA. The conclusion of our earlier studies suggests that a significant fraction of the particulate P in the EAA originates from in-stream biological growth rather than from field soil erosion.

Recently deposited biological sediment material such as settled plankton, filamentous algae, and macrophyte detritus is the fraction that contributes the most to particulate P export. Exported solids may also be contributed directly from loosely bound material detached by turbulent shear forces of floating aquatic vegetation. Other contributions to particulate P loads come from submerged aquatic vegetation and planktonic growth.

Table E1. Best Management Practices summary and "BMP equivalent points"

BMP	PTS	DESCRIPTION
WATER MANAGEMENT PRACTICES		MINIMIZES THE VOLUME OF OFF-SITE DISCHARGES
½ Inch Water Detention 1 Inch Water Detention	5 10	Delay pumping based on rain gage measurements. Detention (in farm canals and soil profile) measured on a per event basis – rainfall vs. runoff.
Improved Infrastructure	5	Water table management plan; controlling levels in canals and field ditches using internal water control structures, fallow fields, aquatic cover crop fields, prolonged crop flood; effective irrigation and discharge plans.
Other	tbd	Properly constructed and maintained storage system; greater detention with water management plan having target water table levels and structure operating procedures; monitored water table.
NUTRIENT CONTROL PRACTICES		MINIMIZES THE MOVEMENT OF NUTRIENTS OFF-SITE * Limited Applicability
Fertilizer Application Control	2 ½	Uniform and controlled boundary fertilizer application (e.g. banding at the root zone; pneumatic controlled-edge application such as AIRMAX); calibrated application equipment; setbacks from canals.
Fertilizer Spill Prevention	2 ½	Formal spill prevention protocols (handling, transfer, education).
Soil Testing	5	Avoid excess application by determining P requirements of soil.
Plant Tissue Analysis	2 ½	Avoid excess application by determining P requirements of plant.
Split P Application*	5	Applying P proportionately at various times during the growing season. Total application not exceeding recommendation.
Slow Release P Fertilizer*	5	Applying specially treated fertilizer that breaks down slowly thus releasing P to the plant over time.
PARTICULATE MATTER AND SEDIMENT CONTROLS		**MINIMIZES THE MOVEMENT OF PARTICULATE MATTER AND SEDIMENTS OFF-SITE** (Each consistently implemented across the entire basin acreage.)
Any 2 Any 4 Any 6	2 ½ 5 10	• leveling fields • ditch bank berm • sediment sumps in canals • sediment sumps in field ditches • canal/ditch cleaning program • slow drainage velocity near pumps • sediment sump upstream of drainage structure • cover crops • raised culvert bottoms • stabilized ditch banks • aquatic plant management • debris barriers at outfall
PASTURE MANAGEMENT		PLAN FOR ON-FARM OPERATION AND MANAGEMENT PRACTICES
Pasture Management	5	• **reduce cattle waste nutrients in discharges by "hot spot" management, i.e. plans for placement of drinking water, feed and supplements, cowpens and shade.** • low cattle density
OTHER BMPs		OTHER PRACTICES PROPOSED
Urban Xeriscape	5	Use of plants that require less water and fertilizer.
Det. Pond Littoral Zone	5	Vegetative filtering area for on-site stormwater runoff.
Other BMP Proposed	tbd	BMP proposed by permittee and accepted by SFWMD.

One of the primary goals of this study was to identify conditions that cause high particulate P load rates, and analyze those conditions to determine operating procedures that might reduce particulate P export. Load rate is the product of flow and concentration over a given unit time period. High particulate P loads may occur from transport of moderate amounts of high P content material. This condition is more likely to occur whenever there is a large supply of readily transportable biological material close to the pump station. This light material can be transported at moderate flow rates, for example at pump start-up after long inter-event time periods. High particulate P load rates may also occur from transport of large amounts of lower P content sediment material over a short period of time. This type of high particulate P load rate could occur during high pumping rate events, that causes canal level to drop close to the bottom, increasing flow velocity, and resulting in the dislodging and transport of base sediment material in the canal. There are obviously intermediate conditions when the combination of flow and concentration can cause high particulate P load rates.

The on-farm particulate P measurement and control study is conducted on three farms in the EAA: a sugarcane farm in the northern EAA (UF9200A), a mixed-crop operation in the eastern EAA (UF9206A&B), and sugarcane farm in the western EAA (UF9209A). Each pump station is fully instrumented, and data is continually recorded for key parameters such as rainfall, pump flow rates, and inlet and outlet water levels. All pump stations are equipped with 3700 portable ISCO® automatic samplers that collect water samples every 15 or 30 minutes and composite into one- or two-hour discrete samples for analysis. All collected samples are analyzed for total suspended solids (TSS), total P (TP), and total dissolved P (TDP). Particulate P is calculated as the difference between TP and TDP.

<u>Event Analysis</u> was conducted on all three farms (4 pump stations). The annual contributions from the particulate P loads to the total P loads have decreased in two of the three farms in 2003 (Table 1.5 in Chapter I). Particulate P at UF9200A decreased from an average of 50% over the last three years (2000-2002) to 28% in 2003. The particulate P load contributions of UF9206A increased from 26% in year 2000 to 36% in years 2001 and 2002, and decreased to 27% in 2003. Particulate load contributions from farm UF9206B decreased from 40% in 2000 to an average contribution of 36% during the last three years. At UF9209A the contribution from particulate P to the total P load was almost constant, around 67% in 2001 and 2002. In 2003, UF9209A pumped its canals lower and longer than previous years, causing more sediments to be dislodged from bottom of the canal and

transported out of the farm, and resulting in a particulate P contribution of 80% to the total P load.

The normalized or unit area loads (UAL) for particulate P and dissolved P are presented in mass per unit farm area (kg P/acre; Figure E1). Particulate P loads from farm UF9200A have been fairly constant over the four-year period, averaging about 0.15 kg particulate P/acre (0.33 lb P/acre). Particulate P loads from UF9206A /B have been steadily decreasing during the first three years of the study, but increased to about 0.24 kg/acre (0.53 lb/acre) in 2003. The loads for UF9209A were substantially lower than the other two farms, averaging 0.05 kg particulate P/acre (0.11 lb/acre) during the last three years.

Equivalent concentrations for both TSS and particulate P showed a decline from 2000 to 2001 at UF9200A and at UF9206A/B and then remained relatively constant or showed a slight increase from 2001 to 2002. In 2003, average TSS concentrations from these three farms remained constant. Equivalent concentrations for TSS and particulate P at UF9209A showed a steady increase from 2001 to 2002, but TSS values for 2003 increased from 22 mg/L to 110 mg/L.

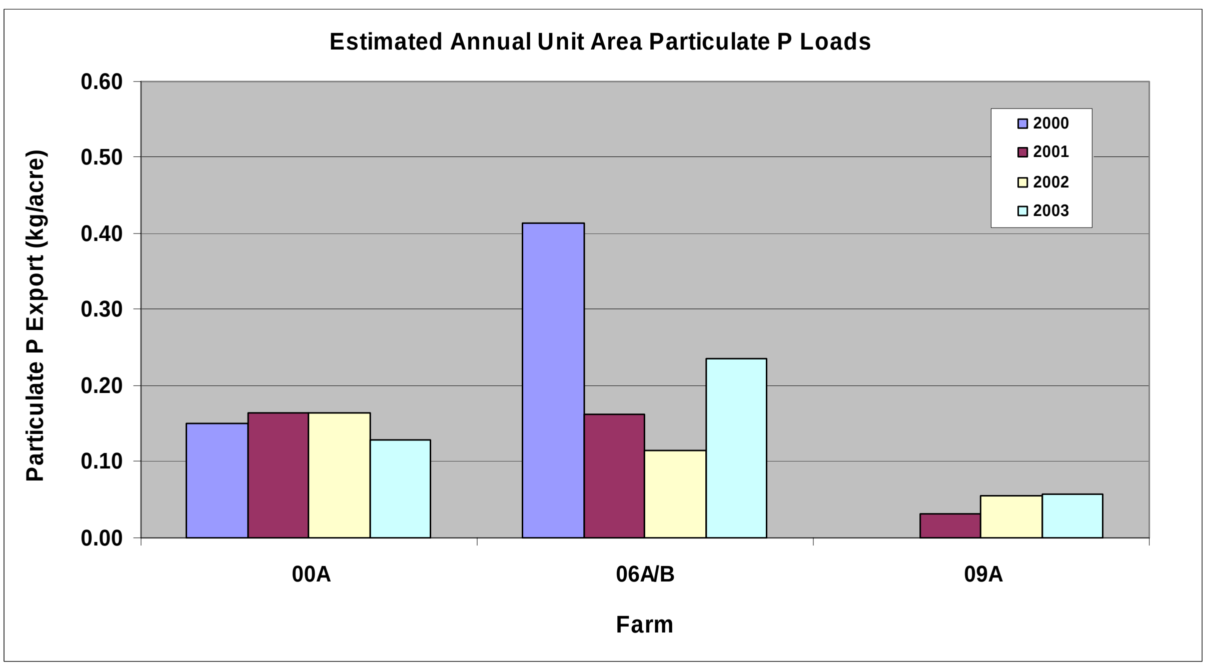

Figure E1. Annual Unit Area Particulate P loads Over the Four Year Study Period.

Equivalent particulate P concentrations at UF9200A and UF9206A/B significantly declined from 2000 to 2001, and then remained almost constant for all three farms from 2001 to 2002 (Figure E2). In 2003, average particulate P concentrations at UF9200A decreased from 79 ppb to 64 ppb, however, farm UF9206A and B showed a notable increase, with the highest value observed at UF9206B. Average particulate P concentrations from farm UF9209A have been steadily increasing during the last three years, but they are still lower than the other three farms.

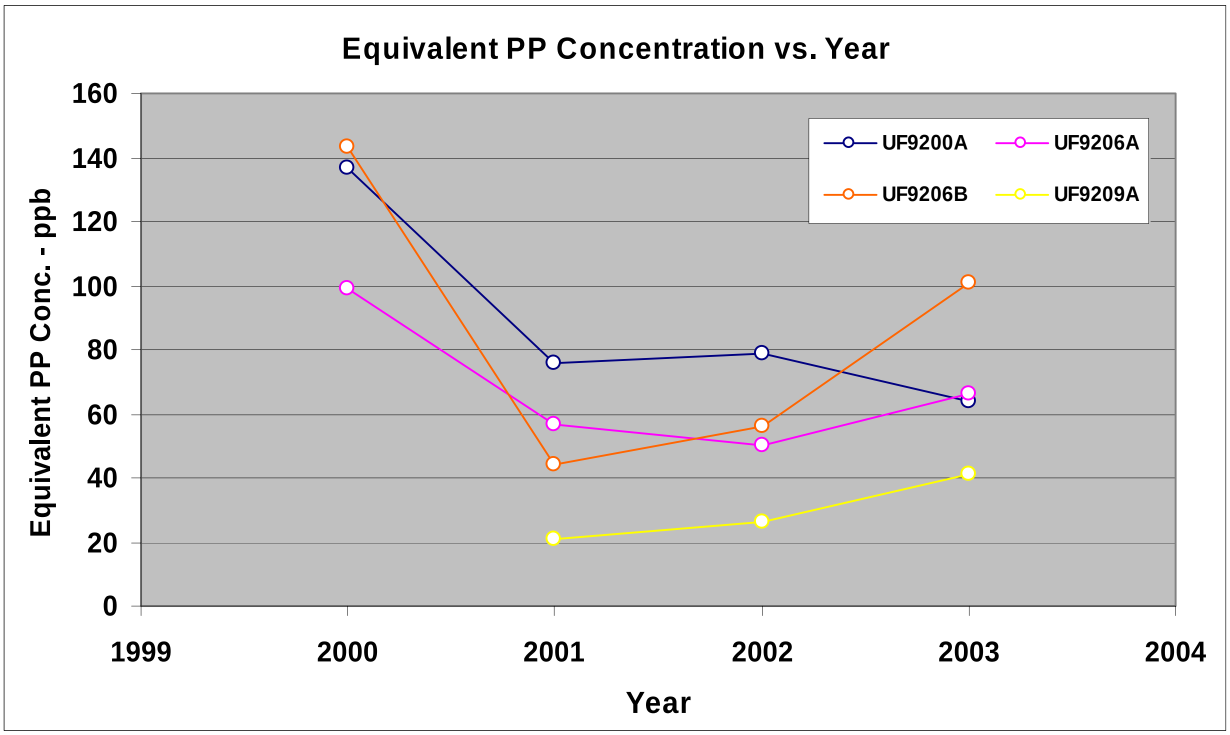

Figure E2. Equivalent Particulate Phosphorus Concentration from 2000 through 2003.

Load Distribution Analysis of the cumulative hydraulic and particulate P loads generated for each farm and year, showed that 50% of the annual particulate P load was contributed by less than 25% of the hydraulic load. For farm UF9200A, 18-22% of the annual hydraulic load during the last four year of the study, contributed to 50% of the annual particulate P load. For farm UF9206A, 16-26% of the annual hydraulic load contributed to 50% of the annual particulate P load. For farm UF9206B, 13-19% of the annual hydraulic load contributed to 50% of the annual particulate P load, and for farm UF9209A, only 8-14% of the annual hydraulic load contributed to 50% of the annual particulate P load.

Process Distribution Analysis was conducted to determine the most probable mechanism for particulate P transport in the sub-events that contribute most to annual loads, i.e. those in the top 50% of the load distribution. The objective of this analysis is to identify conditions that give rise to the higher particulate P transport events. The most distinctive pattern observed from this analysis is the number of farm-years that were dominated by few events. Data over the four-year study shows that six of the 15 farm-years sampled had a single event that contributed 30% or more to the top 50% particulate P load. Three farm-years had two events that contributed a total of 30% or more. Three farm-years had three events that contributed a total of 30% or more. Only two of the 15 farm-years had their load rates distributed such that it took more than three events to contribute a total of 30% or more to the top 50%. The timing of these clusters is also interesting. In 2000, all three stations under study at the time (UF9209A did not start sampling until 2001) were dominated by one event. In 2001, two stations out of four were dominated by one event. In 2002, one out of four stations was dominated by one event, and in 2003, three out of four stations were dominated by one event.

Operational Summary of Study Farms

The diversity of the farms has allowed a number of observations to be made regarding the importance of various operating parameters affecting particulate P loads. Dominant events started when pumping operations deviated from typical practices, but these deviations were specific to each particular farm.

Farm UF9200A

This farm represents a medium size (1280 acres) sugarcane monoculture located in the northern portion of the EAA. The grower has two high capacity (9000-28,000 gpm range) and one low capacity (5000-9000 gpm) single-speed electrical pumps, which can be operated with automatic on-off level control. Water discharge rate is controlled by selection of either high or low capacity pump, depending on the needs of the farmer. Canal water level control is practiced by automatic shut down and start-up of the chosen pump at canal level set points. This practice leads a minimum allowable level in the canal, but also causes short periods (usually less than one hour) of pump cycling. The imposition of automatic water level control insures that velocities will not exceed a certain maximum.

Normalized annual average particulate P loads exported from UF9200A have been fairly constant, averaging about 0.15 kg/acre (0.33 lb P/acre). Annual Average TSS and particulate P concentrations rapidly decreased from 2000 to 2001, then remained constant after that. Dominant events have resulted from high pumping velocity after long inter-event times. Following is a summary of the various operating procedures on this farm that affected particulate P loads.

- This farm showed the less aggressive aquatic weed control program and some the highest velocities of the three farms. This combination generally increases start-up particulate P loads after long inter-event times. This farm had two dominant events during the four year study that were characterized for their long duration and high velocities. Responses of the same magnitude were not seen at the other two farms.
- Short-period pump cycling continues to contribute far more than its hydraulic share to high particulate load rates, but their contributions were reduced in 2003 due to predominant use of the low capacity pump. Short-period pump cycling of large capacity pumps leads to high particulate P loads and it is discouraged.
- Canal level control, when practiced without pump cycling, interrupted continued high velocity and reduced P load rates.
- Higher velocities and shallower canals give this farm a shorter response time than farm UF9209A. However, this farm was able to reduce average canal velocities in its main farm canal through increased use of its low capacity pump for the year 2003.

Farm UF9206A/B

This farm represents a medium-size (1750 acres) mixed crop operation located on the eastern side of the EAA. The grower generally rotates various fields with cane, vegetables, rice, and sod. The canal grid of this farm has been extensively modified over the years to allow the storage and movement of large volumes of water within the farm. Aquatic weed management is aggressive, with main canal upstream of drainage pumps relatively free of aquatic vegetation. There are two separate discharge pump stations on this farm, each of which has two variable-speed diesel pumps (3000-23,000 gpm range) that are operated manually. Water discharge is controlled by the number and speed of pumps running at a particular station. There is no automatic water level control at this farm, thus on occasions canals are drained close to the canal floor. Constant rotation of crops such as vegetables requires the grower a closely manage field water tables, resulting in more frequent and often prolonged pumping events.

Particulate P loads from farm UF9206A/B have shown a notable decrease during the first-three years of the study, declining from an average value of 0.41 kg P/acre (0.90 lb/acre) in 2000 to 0.12 kg P/ acre (0.26 lb/acre) in 2002. However, in 2003 the average particulate P load values increased slightly to 0.24 kg P/acre (0.53 lb/acre). This increase in particulate P load may be related to an increase in total drainage volume (45% increase) and the number of drainage events observed at both stations (UF9206A and B) in 2003. Annual average TSS and particulate P concentrations decreased from 2000 to 2001 and increased slightly in 2002. In 2003, average TSS concentrations remained constant. At UF9206B, dominant events resulted from canal levels that were very low at the beginning of the event, or were drained so low that extreme velocities were encountered. At Farm UF92006B a steady increase was observed in average velocity and particulate P concentration from 2001 to 2003. Following is a summary of the various operating procedures that affected particulate P loads on this farm.

- This farm practiced aggressive aquatic weed control and a complex water management regime. Results from this farm suggest that the supply-exhaust mode is a very frequent occurrence during the year. Part of this is due to the fact that it has a higher rainfall-to-pumping ratio than the other two farms, but part is probably due to the fact that this farm has achieved a true reduction of its highly transportable particulate P inventory. Particulate P contribution at this farm ranges between 25 to 40% of the total P load.

- This farm does not practice canal level control, and average water velocities have been steadily increasing during the four years of the study. These high velocities have resulted in the mobilization of large quantities of low P content sediments, resulting in an increase in the overall particulate P load in 2003.

- Additional particulate P load reductions may be realized if canal velocities are limited by modulating drainage flow (engine RPM) with canal level. This farm showed the lowest annual average canal depth during pumping (UF9206B, 0.77 m or 2.5 ft) of all three farms. Keeping canals above a critical level during pumping, coupled with continued aggressive weed and water management practices, would optimize this farm for particulate P load reduction.

Farm UF9209A

This farm represents a medium-size (3072 acres) sugarcane monoculture located in the western side of the EAA. This farm has three diesel-powered pumps (6000-35,000 gpm range), which are operated manually. Historically, the particulate P fraction of the total P load from this farm has accounted for about 70% on a time-weighted basis. However, this farm has shown the lowest discharge total P concentration compared to the other two farms during the last three years of the study. Farm UF9209A operates at the lowest average canal velocities of the three study farms. It has a medium aggressive canal maintenance program. Main canals are kept clean, but some laterals and field ditches have extensive weed coverage. Discharge is controlled by selection of pump capacity. Canal water level is controlled manually, with pumps being shutdown when a predetermined water level is reached.

Normalized annual average particulate P loads exported from this farm have been fairly constant, averaging about 0.05 kg/acre (0.11 lb/acre). Average TSS concentration at this farm increased from 12 mg/L in 2001 to 22 mg/L in 2002, but in 2003 the concentration significantly increased to 110 mg/L. Annual particulate P concentrations also showed a steady increase during the last three, but the change was not as drastic as that observed in the TSS concentration. Increases in TSS and particulate P concentrations at this farm during the last three-years, are mainly the result of changes in operations that started in the last quarter of 2002. Pumping records shows that during the last 15 months, canal levels have been pumped to lower depths and the average duration of each event increased from 41 hours in 2002 to 61 hours in 2003. These longer drainage events combined with low canal levels in 2003, resulted in the transport of large quantities of low P content canal sediments. This farm showed the lowest average velocity and particulate P concentrations compared to the other two farms. Lower velocities and greater canal depths at this farm result in longer response times than the other two farms before the effects of continued high velocities can be observed. Following is a summary of the various operating procedures that affected particulate P loads on this farm.

- This farm has the advantage of few floating aquatic weeds in the main canals and wide and deep canals, resulting in the lowest velocities observed of the three farms. Its relative particulate P contribution is high (65-80% of total P), but its absolute contribution is the lowest of the three farms.

- The practice of long-period pump cycling appears to be beneficial at this farm because of the farm's long response times.

- Because of its low velocities, the farm has theoretically a reservoir of readily transportable material stored along the main canal. This has been observed during the last 15 months of the study. The farm has deviated from its normal operations, increasing the pump run time and lowering minimum canal levels, causing an increase in the amount of low P content sediment material to be exported out of the farm in 2003. This farm appears to be more sensitive to moderate changes in operating conditions than the other two farms.

General Recommendations

Velocity – Velocity is a key control parameter for reducing particulate P export. Recommended velocities are relative, in that they must be within the operating framework of the configuration of the farm. Velocities should be as low as possible, and velocity excursions should be avoided, regardless of the average or typical velocity of the canal system. Velocities greater than 0.4 m/s (1.3 ft/sec) have been associated with greater transport rates at the study farms. Given the parabolic relationship between velocity and erosion, "slow and long periods" is preferred than "fast and short periods" for pumping a given volume of water.

Pump Cycling and Reduced Run Times – Long-run period cycling of about 8-16 hours, which reduces continuous pumping duration, has been shown to be beneficial in interrupting continued high velocity transport. This was evidenced on farms where the response time of the farm hydraulic system (i.e., the time required from pump start-up to the time when the equivalent of one volume of farm canal water is exported) is greater than the pump cycling period. Short period cycling of one hour or less is detrimental and should be avoided.

Level Control – Control of canal water levels is critical in avoiding major velocity excursions, and also to stay away from large deviations of the normal farm canal velocities. Lack of level control or major changes in minimum canal levels have resulted in dominant events at the two farms that did not practice strict canal water level control. Canal levels should be controlled to give minimum canal depths that do not exceed the maximum velocity recommendation.

Aquatic Weed Control and Retention – Aggressive weed control programs in the main canals is one of the most productive techniques in reducing the supply of high P content biomass. However, the physical removal along the entire length of the main canals is expensive to implement. For that reason, the installation of weed-retention booms is recommended to be located at a distance >300 m (984 ft) upstream the main pump station.

CHAPTER 2: Particulate Phosphorus Demonstration Farm

The primary motivation for studying particulate phosphorus (P) is the potential for developing or modifying management practices that reduce P export from EAA farms. Previous studies have shown that particulate P accounted for 20% to 70% of the total phosphorus (TP) exported from EAA farms, and that particulate P export was frequently the cause of spikes in TP loads. Previous research has also shown that a significant fraction of particulate P in the EAA originates from in-stream biological growth rather than from soil erosion.

With the knowledge that the key role particulate P plays in the development of EAA farm P loads, a comparative field study was established at the EREC in Belle Glade, Florida. Two hydraulically isolated sugarcane blocks of 125 and 200 acres each were segregated and equipped with identical drainage pumps and monitoring instrumentation to record rainfall, flow, canal levels and velocity, and to collect discrete hourly drainage water samples. A primary goal of the study was to demonstrate to growers the operational differences between a particulate P **optimized BMP** sugarcane farm (BMP) and a **conventional BMP** (Control) sugarcane farm. The first two years of the study will compare the effects of velocity control and floating aquatic weed management on particulate, dissolved, and total P loads. The application of velocity controls to current sediment control BMPs should effectively eliminate the sediment fraction of the particulate P loads that emanate from EAA farms. The light flocculent particulate matter that comprises the remaining 50% of an EAA farm's particulate P load will be reduced by eliminating floating aquatic weeds in farm main canals.

Drainage data from the two study blocks were collected from five drainage events that occurred between July 28 through December 17, 2003. Drainage water concentrations of particulate, dissolved, and total P for the BMP block were 54, 58 and 51 % lower than Control block concentrations. It is interesting to note that the greatest percent reduction was observed in total dissolved P concentration of drainage waters. Both blocks were drained similarly on a volume per acre basis and in ratios consistent with rainfall amounts received. Average canal velocities during drainage events for the Control and BMP block were calculated to be 0.12 and 0.04 m s^{-1}, respectively. BMP block unit area loads for particulate, dissolved, and total P were 28, 21, and 32% lower than corresponding loads from the Control block.

Load distribution analyses were conducted on each block's data set of hourly drainage loads. For the Control block approximately 80% of the TSS was exported in 20% of the hydraulic load and approximately 65% of the particulate P load was exported in 20% of the hydraulic load. All cumulative load curves from the BMP block show similar and uniform trends with respect to cumulative hydraulic load. This indicates that for the BMP block there was little variation of P loads among hourly sub-events when compared to the Control block, i.e. the BMP block P loads were exported evenly across hydraulic loads.

As an aid in determining and assessing the factors affecting P loads from the Control block, the five drainage events that were sampled between July 28 and December 17, 2003 are presented graphically in Chapter 2. The graphs provide a direct comparison of the drainage constituent details from each block during the each event's time frame. Each graph shows the relationship between particulate, dissolved, and total P concentrations and flow velocity and flow rate over time for a specific block (Control or BMP). It is evident from the Event graphs that velocity plays a direct role in the export of particulate P loads. The critical maximum velocity imposed on the BMP block was 0.12 m sec^{-1}; there was no velocity control placed on the Control block and canal velocities during one event approached 0.45 m sec^{-1}.

The main goal of this study is to measure the combined effects of drainage flow velocity and floating aquatic weeds on the P loads exported in the drainage waters from sugarcane fields. From one partial season of drainage data, initial results appear to confirm the hypothesis that particulate P source control (removal of floating aquatic weeds) and particulate P transport control (limiting canal velocity) will lead to measurable P load reductions. At this early point in the study the observed P load reduction in the BMP block most likely is a result of decreases in easily transportable particulate P as well as the absence of conditions that allow export of less transportable P sources (canal sediments).

In the future, by assessing conditions and P species concentrations in the Control block and BMP canals between drainage events, a clearer picture of P cycling within farm canals may be drawn. By studying the exported solids for physical and chemical composition differences and conducting P-flux studies on the solids, we will better understand the dynamics of particulate P generation in farm canals with and without floating aquatic weeds. The results from these investigations will assist researchers, managers, and planners in determining the effects of the exported solids on P cycling in downstream receiving waters.

CHAPTER 3: Specific Conductance in the EAA

The Everglades Forever Act of 1994 mandated a research and monitoring program on the evaluation of water quality standards in the Everglade Agricultural Area (EAA) (Chapter 40E-63). The goal of this research was to evaluate the constituents that have been previously identified as elements of water quality concern that will likely not be significantly improved by the Storm Treatment Areas, and current Best Management Practices (BMPs) being widely implemented throughout the EAA; and to identify strategies needed to address such parameters, including specific conductance. The objectives of this work as stated by Chapter 40E-63, Part III: “the farm-scale research shall be expanded to include monitoring for specific conductance at all points where total P is currently being monitored. The expanded research program shall include the development, testing, and implementation of BMPs to address reduction of specific conductance”. Chapter III of this report provides an update on the UF/IFAS specific conductance research in 2003. A comprehensive report on the subject was issued in March 2004 that included data collected from 1997 through December 2002.

Specific conductance was continuously monitored through 2003 at three representative farms (four discharge sites: 84 total months of data at UF9200A and UF9206A&B, 73 total months of data at UF9209A) in the EAA. All data were collected using Hydrolab DataSonde® (series 3, 4, 4a) multi-parameter water quality data loggers.

Results of the specific conductance data in 2003 confirm that specific conductance is not an issue in the majority of the EAA farm canals monitored. Out of the three farms monitored, only one had average specific conductance higher than 1.275 mS/cm. As addressed in our March 2004 report, the farm with high specific conductance level, UF9206A&B, is in an area of shallow wells that have high salt concentrations. The irrigation water flowing into this farm was also characterized by higher specific conductance.

Drainage pumping had no significant effect on specific conductance, while irrigation water reduced specific conductance at three (UF9206A&B and UF9209A) of the four pumping structures. Sites that received irrigation water directly from low specific conductance district canals (Miami, and West Palm Beach canals) had lower mean specific conductance values. Sites that received irrigation water from district canals with relatively higher specific conductance (Ocean and Hillsboro canals) had relatively higher mean specific conductance values.

There was a monthly (from January to November) upward trend in specific conductance at two (UF9200A, and UF9206A) of the four pump structures in 2003. However, there was also no obvious upward or downward trend in specific conductance over the entire monitoring period (1997-2003). This implies that the implementation of farm level P load reduction BMPs in the EAA since 1995 have had no impact on specific conductance in canal water at these three farms.

It was the conclusion of this study that no further BMPs can be identified by additional research that would provide abatement of specific conductance for farm discharge waters of the EAA. The currently employed P load reduction BMPs had no obvious impact on specific conductance at the three farms, so we conclude that further BMPs that target specific conductance will not be effective or practical. Specific conductance in the EAA is primarily affected by geological influences and additional farm management practices will have minimal effect on specific conductance.