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CHAPTER 2

PARTICULATE PHOSPHORUS DEMONSTRATION FARM

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INTRODUCTION

Phosphorus (P) load reduction BMPs continue to effectively lower P loads from the Everglades Agricultural Area (EAA) farms (SFWMD, 2003). The majority of EAA farm P load reductions realized to date are due to drainage pumping reductions - the volume factor in the load equation (Izuno and Rice, 1999). The reduction in pumped volume has been achieved primarily by on-farm retention of rainfall. However, researchers have shown that there are still several drainage events during the year that contribute a substantial percentage (10 to 50%) to a farm's total P load (Stuck et al, 2001). These high P loading drainage events are due to increased particulate P concentrations and were associated with lower canal levels, high flow velocities, and/or long duration quiescent periods prior to the drainage event. After scrutinizing the results accumulated from eight years of BMP implementation, it was evident that research efforts should focus on those specific drainage events that occur less frequently, but contribute heavily to the total P load leaving a farm.

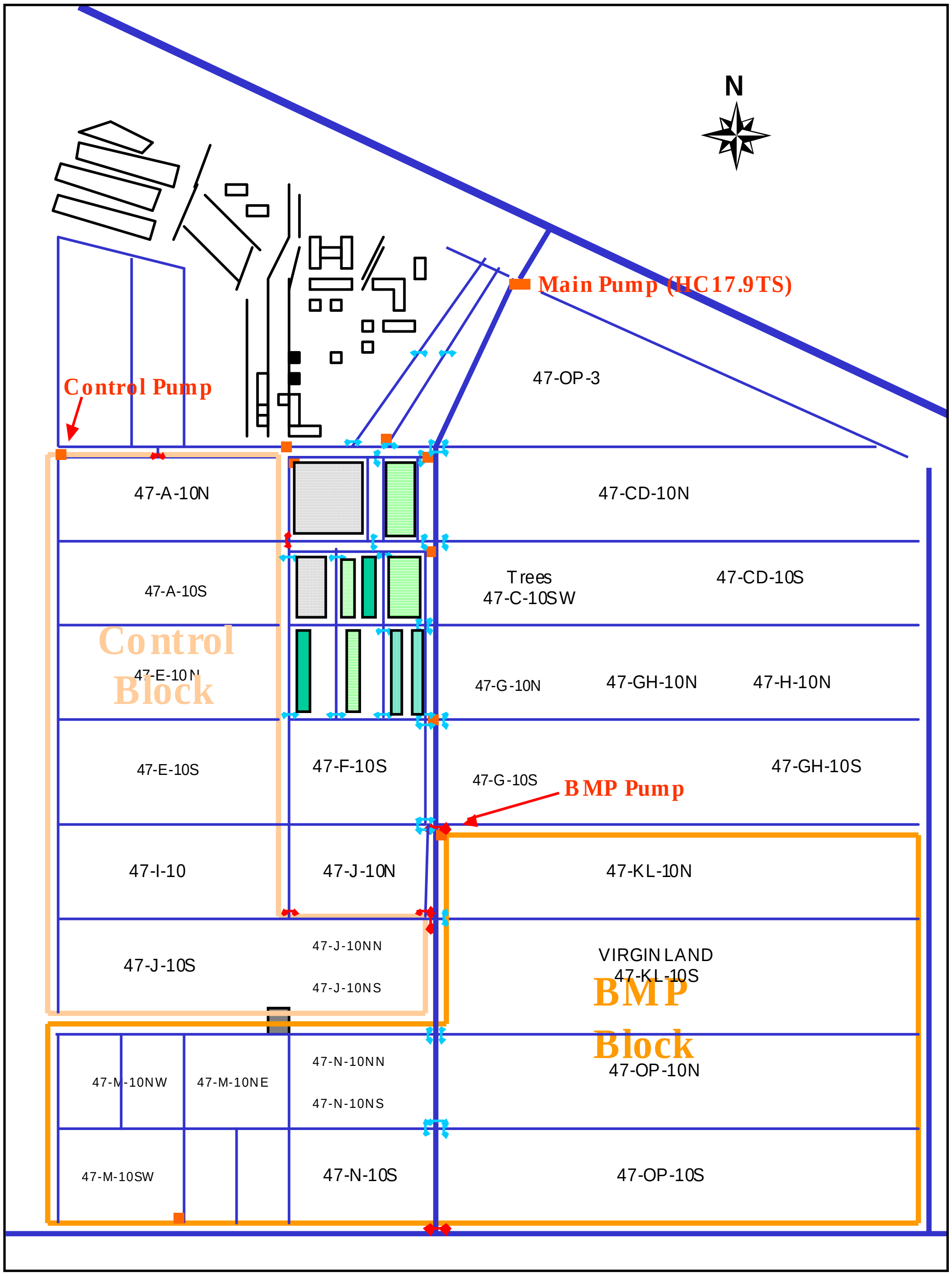
A three-year study conducted on three EAA farms investigated conditions on-farm that result in large P load events (Daroub et al., 2003). The study revealed that approximately one-half of a farm's particulate P load was comprised of recently deposited, less dense, organic matter of aquatic plant origin and one-half consisted of denser, higher mineral content, canal sediments. Aquatic plants and plant detritus are key components in the development of an EAA farm's P load. They serve as sinks for soluble reactive P (SRP), as sources for P-laden detritus in the drainage stream, as well as sources of soluble P (SRP and dissolved organic P) returning to the water column during decay. A two-year study by Daroub et al. (2003) of EAA farm canal floating aquatic weed inventories found that P stored in main canal floating aquatic weeds ranged from 10 to 45 kg at any given point in time. In addition over 85% of the biomass of the collected samples consisted of water lettuce. Limiting the growth of the three predominant floating macrophytes found in EAA farm canals should result in a reduction in easily transportable particulate P floc and subsequent particulate P loads.

In light of these recent findings on particulate P sources and transport on EAA farms, the University of Florida's Everglades Research and Education Center created a BMP demonstration sugarcane farm at the research center (Figure 2.1). Two hydraulically isolated sugarcane blocks of 125 and 200 acres each were created and equipped with identical drainage pumps and monitoring instrumentation to record rainfall, flow, canal levels and to collect discrete hourly drainage water samples. Instrumentation to monitor sugarcane field water tables is proposed for installation in the near future. The study was established to demonstrate to growers the operational differences between an **optimized BMP** (referred to as BMP in illustrations) sugarcane farm and a **conventional BMP** (referred to as CONTROL) sugarcane farm. Demonstration farm data: sugarcane yield, drainage volumes, P species concentrations, total suspended solids (TSS), canal levels, flow velocities, and rainfall will be analyzed to assess the effectiveness of optimized BMPs. 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 farm loads.

The application of critical canal level and flow velocity controls to current sediment control BMPs should effectively eliminate the sediment fraction of the particulate P loads emanating from EAA farms. The light flocculent particulate matter that comprises the remaining 50% of an EAA farm's particulate P load will be addressed by eliminating emergent floating aquatic vegetation in farm canals.

In the main canals of EAA farms the predominant floating aquatic plant species are water lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), and water pennywort (*Hydrocotyle verticillata*). Economical practices that prohibit the growth of these floating aquatic weeds, yet do not inhibit the growth of submerged aquatic plants need to be assessed. Eliminating emergent floating macrophyte growth in farm canals should optimize P co-precipitation with calcium carbonate during conditions of active photosynthesis by submerged aquatic plants (DeBusk and Dierberg, 2003). This photosynthesis-induced precipitate contains P and is of low bio-availability and relatively low transportability. Optimizing P co-precipitation in main farm canals will lead to sequestering of P in less mobile canal sediments and allow for eventual recycling of canal sediments onto farm fields.

Figure 2.1. Layout of BMP Demonstration Farm at the EREC.



OBJECTIVES

In this study the effects of applying critical velocity controls on the reduction of particulate P load will be assessed and demonstrated. Effective and economical floating aquatic weed control practices will be investigated and assessed. Results of control practices for critical flow velocity and floating aquatic weeds will then be demonstrated during farmer field days and BMP workshops.

The specific objectives of this project are to:

1. Conduct additional BMP research at the sugarcane demonstration farm at the EREC and provide a hands-on, educational venue for EAA growers that directly shows the effective implementation of particulate P BMPs. The BMP demonstration farm will serve to assess and demonstrate promising and potential alternative practices that may further reduce P loads.

2. Enhance the performance of sediment control BMPs that are currently employed in the EAA by growers through research, education, and demonstration programs that emphasize the importance of limiting farm canal drainage velocities through pump speed (flow) and canal level management.

3. Assess and demonstrate economical and effective control practices for the predominant floating aquatic weeds found in main farm canals throughout the EAA (*Pistia stratiotes, Eichhornia crassipes,* and *Hydrocotyle verticillata*).

MATERIALS AND METHODS

Two similar blocks of sugarcane fields at the Everglades Research and Education Center were identified and hydraulically segregated via canal and culvert installations (Figure 2.1). The first research block of 125 acres was designated a **Control block** and employs the array of BMP practices that are found on the EREC's BMP permit for the South Florida Water Management District (SFWMD). These practices include nutrient application control, nutrient spill prevention, soil testing, one-inch rainfall retention, and four sediment controls - level fields, field ditch sumps, discharge barrier, and slow field ditch drainage.

The second research block of 200 acres was designated the optimized **BMP block**. This block employs the same set of BMPs as the Control block plus two additional practices of critical velocity control and floating aquatic weed control. In addition all field ditches and canals were cleaned of bottom sediments with a backhoe prior to the initiation of the study. Maximum velocity of the BMP block's main drainage canal during pumping does not exceed 0.12 m/s. This critical velocity value is an approximate critical flow velocity derived from recent on-farm particulate phosphorus load studies (Daroub et al, 2003) . Velocity in this block's main canal is controlled via pump drainage flow rate (engine RPM adjustment) and canal level monitoring.

Each research block has its own discharge pump and is drained at a rate proportional to the area of the block. Both blocks are monitored for discharge flow, canal water level, and discrete hourly sampling of discharge water over the duration of the study. Water samples are analyzed for Total Suspended Solids (TSS), Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), and Particulate Phosphorus (PP). Automatic water samplers are fitted with carousels containing 24-1 L sample collection bottles. Water samples are iced and retrieved daily during pumping events. Consistent with published protocols, retrieved water samples were filtered and then pH adjusted to < 2 with H_2SO_4 prior to storage at 4 ^oC and then analyzed for P. Samples were analyzed within 28 days of collection. Particulate P is calculated as the difference between TP and TDP. Water samples for TDP analysis are immediately filtered though a 0.45 µm filter-membrane, samples for TP analysis are not filtered. Analysis for TP and TDP are performed using the mercury oxide digestion method (Method 365.4, EPA 1993). Total suspended solids analysis is done following SOP No 13 from the EREC (EREC-SOP, 2002) and Method 160.2 (EPA, 1993).

The pump stations of each block were electronically instrumented to monitor discharge flows and collect water samples during farm drainage events. An electric relay was mounted on the pumps which triggers Dataloggers (Campbell Scientific Inc., model CR10X) to instruct autosamplers (ISCO, model 3700) to collect water samples from the drainage stream. Dataloggers also record rainfall measured with a tipping bucket rain gage (Campbell Scientific, Inc model TE525), canal water levels measured with submersible pressure transducers (WICA Instrument Corp.), and temperature (Campbell Scientific, Inc., model 107). The system is powered by solar-charged (SOLAREX) 12 V batteries. Dataloggers record data at 5 and 60-minute intervals and data are downloaded twice daily via radio telemetry.

Each block has an identical drainage pump that is a trailer mounted, 14” Standard Axial Flow belt driven pump powered by a 60 HP diesel engine. The pumps have a drainage capacity range of 200 to 5000 gal min^{-1}. Flow is measured by an inline DeltaForce Magnetic Flowmeter mounted into the discharge pipes. The DeltaForce flow units consist of a DeltaMag Flowtube and a DeltaPulse monitor. This technology includes self-contained sensors that mount flush with flowtube internals from side standpipes. Each compact sensor contains a coil that generates a strong magnetic field inside the flowtube. The sensors also contain the electrodes and circuitry needed to measure the resulting flow voltage signal. The use of multiple sensors produces a flowtube that is highly insensitive to piping effects, and an inherent redundancy that permits the measurement to continue should a single sensor fail (Calibration Sheets: Appendix 2C).

Farming practices at the two sugarcane blocks are typical of adjacent sugarcane farms. Sugarcane is the main crop with some acreage planted in rotation to sweet corn or beans. Since 1996 a standard sugarcane fertilization program based on IFAS soil test laboratory results has been followed and is being applied to both blocks. Discharge TP concentrations from the EREC whole farm have averaged 0.216 mg/L since 1994; the average unit area P load for the EREC whole farm has averaged 0.76 kg P Acre/yr. These unit area loads reflect the history of the farm which originally was a mixed commodity research farm that conducted vegetable, dairy, cattle, and sugarcane research. Since 1997 approximately 85% of the total cultivated acreage has been planted to sugarcane and the remaining cultivated acreage has been planted to vegetable research field trials.

Floating weed retention booms were installed in May 2003 across the surface of the main canals of both blocks. The weed retention boom at the optimized BMP site is located at 400 ft from the pump intake. The purpose of this device is to trap floating aquatic plants, sequestering them downstream from the scouring zone of the pump structure. The weed retention boom at the Control block is located 30 ft from the pump intake. Since this canal does not receive any herbicide treatment, the main reason for the installation of the weed boom in this canal was to prevent clogging at the drainage pump intake.

Growth of floating aquatic weeds was uninhibited in the main canal of the Control block. Floating aquatic weeds in the main canal of the BMP block were manually removed from the retention boom at project startup. Thereafter floating aquatic weeds were controlled bi-weekly as needed via manually spot spraying with glyphosate. Field ditches of both blocks are sprayed annually with glyphosate after cane harvest and before onset of the rainy season.

Main canal sediment depth measurements and samples were taken after canals in the BMP block had been cleaned but prior to the study’s first drainage event. Four evenly spaced transect locations were measured upstream of the pump station at each block. Canal sediment surface elevation and depth were determined at each location using a neutrally buoyant disc pad on the end of a calibrated pole. Sediment depth was determined using a calibrated penetrometer probe that was driven through the sediment to the canal bottom. Both depths were referenced to the then-current canal water surface elevation. At the same time, core samples of the sediment were taken at each transect. These core samples were then sectioned and analyzed for key physical and chemical parameters, including bulk density, solids content, specific gravity, volatile organic matter content, and P content. The canal sediments are scheduled to be measured and sampled yearly and the results from the two blocks compared over time.

This program is proposed to run through at least one annual cycle, and ideally would span three or more wet seasons to try to include the effects of droughts, El Nino, La Nina, tropical depressions, hurricanes, etc. Current funding will support the program through December 2004, which covers slightly more than one annual cycle. Extension of the program to two or more annual cycles will require funding beyond what is currently committed.

RESULTS

Drainage data from the two blocks were collected from five drainage events that occurred between July 28 through December 17, 2003. A summary of the hydraulic data for each of the events for each block is presented in Table 2.1. Approximately 80% of the total monitored flow was sampled at the Control block and 95% of the flow at the BMP block.

Table 2.1. Hydraulic Drainage Event Statistics for Particulate P Demonstration Farm.

Start Date	Event Number	Interevent Time (days)	Start Decimal Date	Finish Decimal Date	Duration (hrs)	Volume Pumped (m^3)	Cumulative Volume (m^3)	Volume Sampled (m^3)
				Control Farm				
07/28/2003	CON-030728		07/28/2003 13:00	07/31/2003 22:00	81	4,048	4,048	3,839
08/04/2003	CON-030804	3	08/04/2003 09:00	08/07/2003 08:00	71	8,238	12,286	5,648
08/11/2003	CON-030811	4	08/11/2003 14:00	08/13/2003 08:00	42	8,267	20,553	5,104
08/25/2003	CON-030825	12	08/25/2003 08:00	08/26/2003 08:00	24	6,454	27,007	6,454
12/16/2003	CON-031216	112	12/16/2003 11:00	12/17/2003 18:00	31	3,222	30,230	3,222
							Total or Avg.	24,268
								80.3%
				BMP Managed Farm				
07/28/2003	BMP-030728		07/28/2003 14:00	07/31/2003 22:00	80	5,230	5,230	5,230
08/04/2003	BMP-030804	4	08/04/2003 10:00	08/06/2003 21:00	59	11,894	17,124	8,860
08/11/2003	BMP-030811	5	08/11/2003 10:00	08/14/2003 14:00	76	15,691	32,815	15,691
08/25/2003	BMP-030825	11	08/25/2003 08:00	08/28/2003 08:00	72	17,691	50,506	17,691
12/16/2003	BMP-031216	110	12/16/2003 11:00	12/17/2003 18:00	31	4,960	55,467	4,960
							Total or Avg.	52,433
								94.5%

Physical and chemical data of drainage waters from each event is presented in Table 2.2. The data presented includes equivalent P concentrations and content for each event. The equivalent concentrations are calculated numbers and represent the total sampled mass of the entity of interest, e.g. total suspended solids, divided by the total pumping volume (during sampling) of the event or year. They represent a characteristic or mass average concentration of the sampled portions of the event or year. Similarly, the P content is calculated as the total sampled mass of particulate P divided by the total sampled mass of suspended solids, and represents the mass average P content for the sampled portion of each event. The characteristic concentrations may be used to estimate the total loads, compensating for un-sampled periods. The P content of TSS for the Control and BMP blocks were 1531 and 6108 mg kg^{-1} ,respectively, indicating that the solids exported from the Control block had lower P content than the BMP block TSS.

Table 2.2. Drainage Physical-Chemical Statistics for Particulate P Demonstration Farm.

Start Date	Event Number	TSS Load Sampled (kg)	TP Load Sampled (kg)	TDP Load Sampled (kg)	PP Load Sampled (kg)	TSS Equiv Conc (ppm)	TP Equiv Conc (ppb)	TDP Equiv Conc (ppb)	PP Equiv Conc (ppb)	% PP	P Content of TSS (mg/kg)
					Control Farm						
07/28/2003	CON-030728	30.5	0.291	0.178	0.113	7.9	76	46	29	39%	3692
08/04/2003	CON-030804	752.3	1.236	0.210	1.026	133.2	219	37	182	83%	1364
08/11/2003	CON-030811	237.5	0.580	0.273	0.307	46.5	114	53	60	53%	1293
08/25/2003	CON-030825	156.5	0.558	0.297	0.261	24.2	86	46	40	47%	1671
12/16/2003	CON-031216	18.5	0.320	0.197	0.123	5.7	99	61	38	38%	6653
	Total or Avg.	1,195.3	2.985	1.155	1.830	49.3	123	48	75	61%	1531
					BMP Managed Farm						
07/28/2003	BMP-030728	54.4	0.212	0.065	0.148	10.4	41	12	28	70%	2716
08/04/2003	BMP-030804	66.1	0.504	0.166	0.338	7.5	57	19	38	67%	5112
08/11/2003	BMP-030811	76.1	1.253	0.508	0.746	4.9	80	32	48	59%	9798
08/25/2003	BMP-030825	108.3	1.271	0.608	0.663	6.1	72	34	37	52%	6121
12/16/2003	BMP-031216	21.3	0.215	0.117	0.098	4.3	43	24	20	45%	4599
	Total or Avg.	326.1	3.5	1.5	2.0	6.2	66	28	38	58%	6108

A summary of the drainage event data from the two blocks is presented in Table 2.3. The Control block average TSS concentration of 49.3 mg L^{-1} was eight times greater than the TSS concentration of the BMP block (6.2 mg L^{-1}). Phosphorus concentrations of drainage waters differed greatly for the two blocks. Drainage water concentrations of TP, TDP, and PP for the BMP block were 54, 58 and 51 % lower than Control block concentrations. It is interesting that the greatest percent reduction was observed in the TDP concentration of drainage waters. Both blocks were drained similarly on a volume per acre basis and in ratios consistent with rainfall amounts received (Table 2.4). The pumping to rainfall ratio for the Control block was 0.12; the ratio for the BMP block was calculated to be 0.14. 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.

Table 2.3. Summary of Drainage Event Constituent Data.

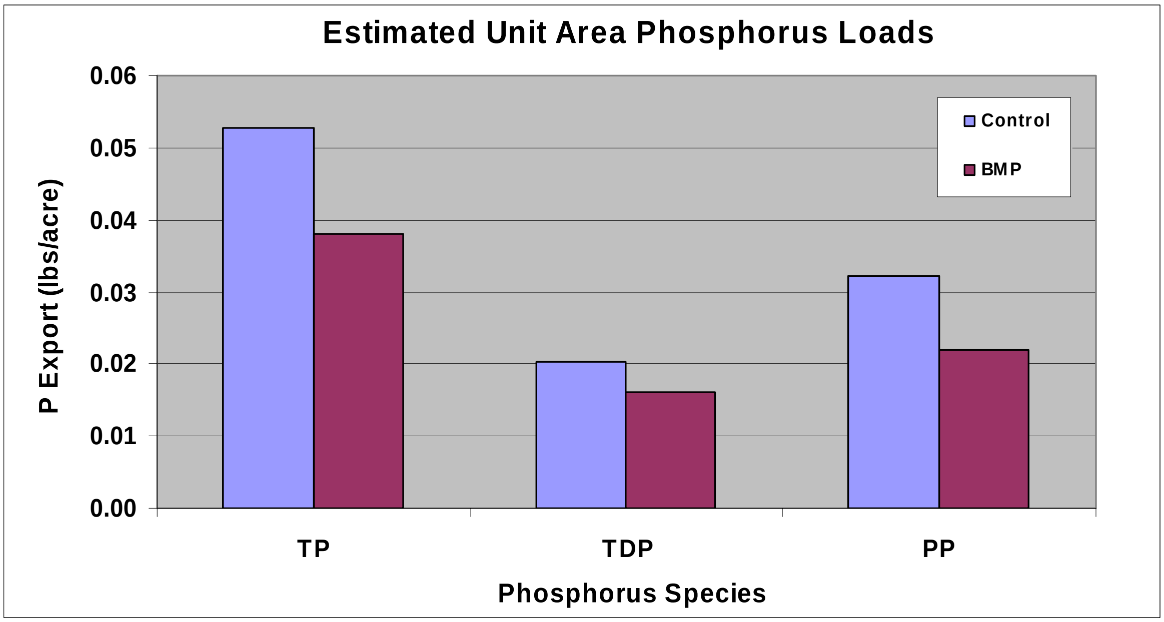
Farm	Total Drainage (m^3)	TSS Equiv Conc (mg/l)	TP Equiv Conc (ppb)	TDP Equiv Conc (ppb)	PP Equiv Conc (ppb)	Estimated TSS Load (kg)	Estimated TP Load (kg)	Estimated TDP Load (kg)	Estimated PP Load (kg)	TSS P Content (mg/kg)
Control (125 acres)	30,230	49.3	123	48	75	1488.9	3.72	1.44	2.28	1531
BMP (200 acres)	55,467	6.2	66	28	38	345.0	3.66	1.55	2.11	6108

Table 2.4. Summary of Rainfall and Pumping Data.

Farm	Year	Total Drainage (m^3)	Total Drainage (in/acre)	Rainfall (in)	Pump:Rain Ratio (in/in)	Average Velocity (m/s)
Control	2003	30,230	2.4	20.0	0.12	0.111
BMP	2003	55,467	2.6	19.2	0.14	0.039

Graphical representation of the P loads exported on a unit area basis from the two blocks is presented in Figure 2.2. BMP block unit area loads for TP, TDP, and PP were 28, 21, and 32 % lower than corresponding loads from the Control block.

Figure 2.2. Unit Area Total, Particulate, and Dissolved P Loads.

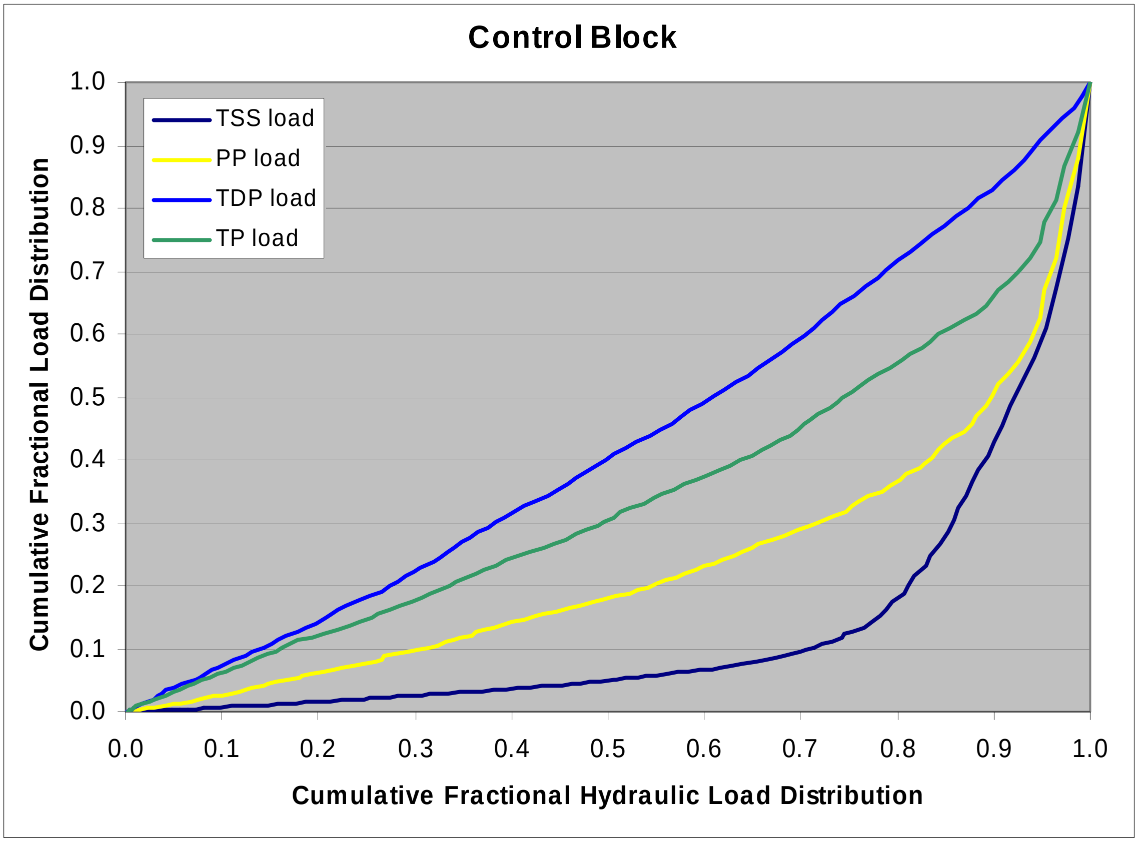


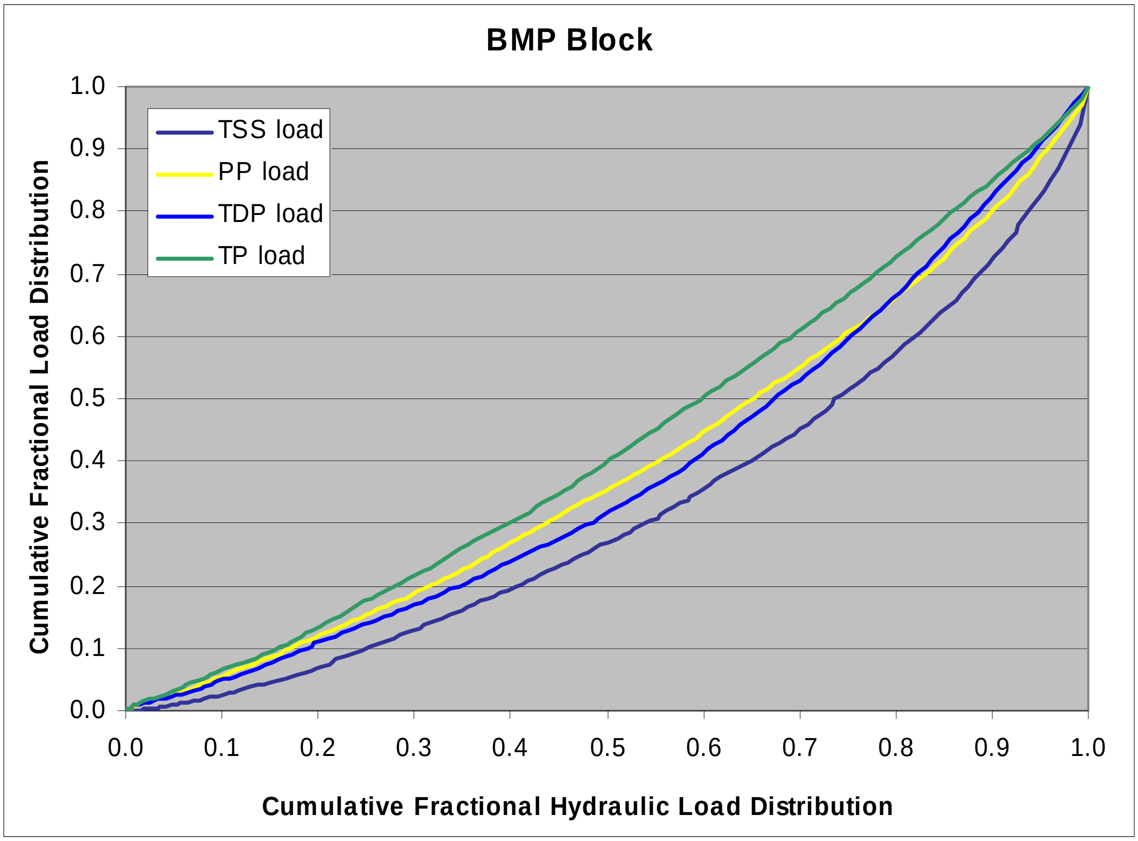
Load Distribution Analysis

Every drainage water sample collected and analyzed has an associated set of supporting data, which includes sample time, sample duration, instantaneous flows, instantaneous levels, cumulative time since event start, and cumulative flow since event start. This data was used to calculate derived parameters such as loads, load rates, and velocities near the pump station. This was done for all samples presented in this study. For the purpose of analysis, the parameter P load rate is defined as the kg of P exported per hour. The use of load rate causes normalization among samples that might have had different sampling time durations. The load rate of a sub-event (or packet of water) defines its level of importance in contributing to the overall annual P load. The higher the load rate, the greater the contribution of that particular sub-event or packet of water to the annual load. The data in each block's data set were ranked by P load rate, from lowest to highest. Once this was done, the cumulative hydraulic and phosphorus (TP, TDP, and PP) loads of the data points as ranked, were determined. Figure 2.3 shows the results of this analysis, with the cumulative loads expressed as a fraction of the total load.

For the Control block, the shape of the curve for TSS and PP cumulative load rate vs. cumulative hydraulic load rate is skewed. For the Control block approximately 80% of the TSS was exported in only 20% of the hydraulic load and approximately 65% of the PP load was exported in only 20% of the hydraulic load. The relationship for cumulative TDP load to cumulative hydraulic load was more consistent and uniform indicating relatively uniform export of TDP load across and within drainage events. All cumulative load curves from the BMP block show similar consistent relationships (trends) with respect to cumulative hydraulic load. This indicates that for the BMP block there was much less variation of P loads among sub-events when compared to the Control block, i.e. loads were exported evenly across hydraulic loads. The skewed distribution of the cumulative load rate to hydraulic load rate from the Control block indicates that efforts should be directed towards investigating the Control block drainage event sub-events (hourly loads) that contributed the most to Control block TSS and PP loads.

Figure 2.3. Cumulative Hydraulic and Particulate P Load Distributions.



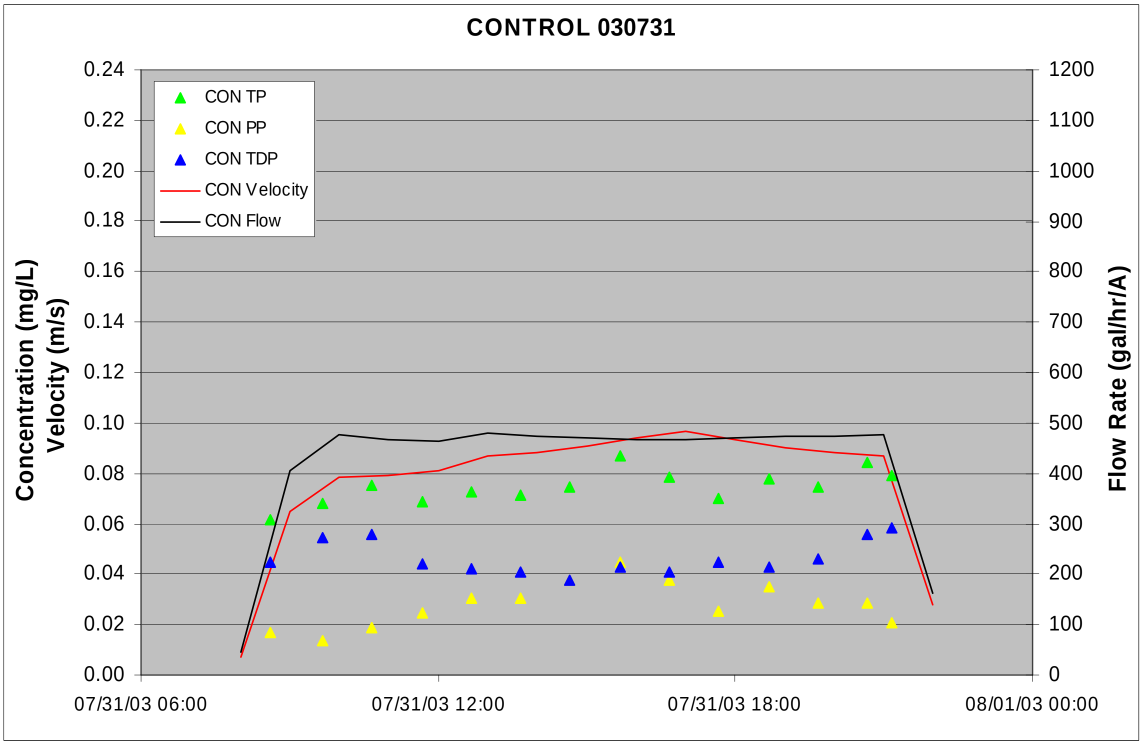


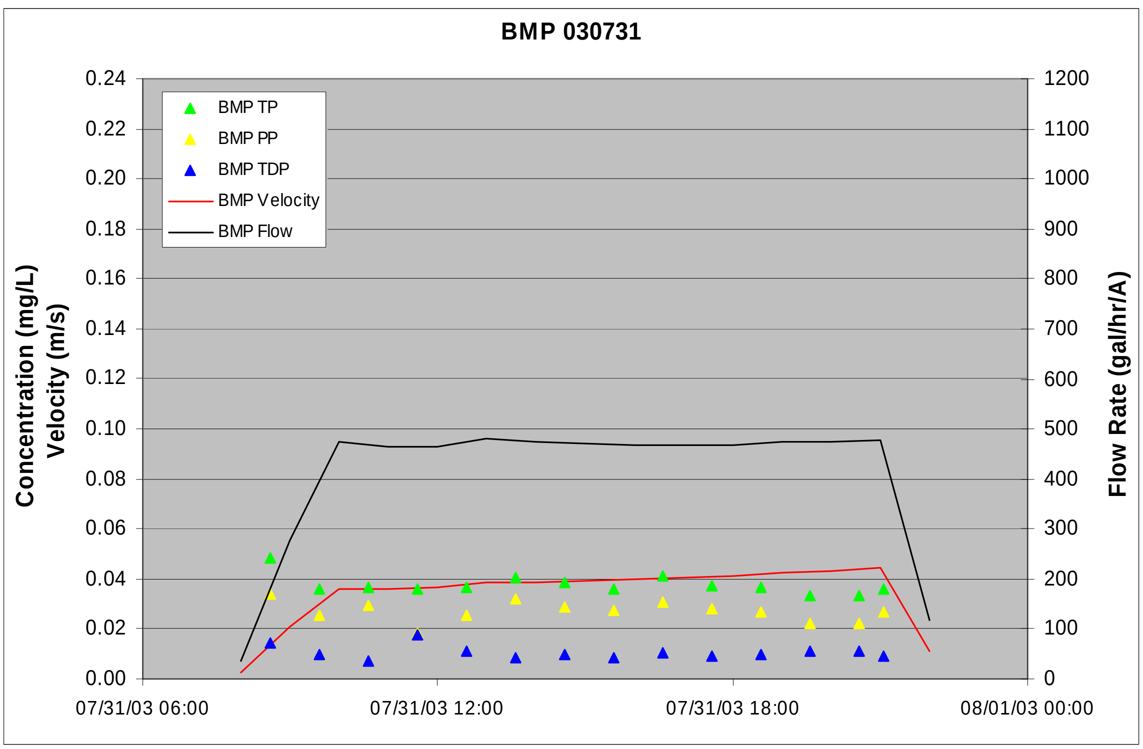
Event Analysis

As an aid in determining and assessing the factors affecting P loads of sub-events at the Control block, the five drainage events that were sampled between July 28 and December 17, 2003 are represented in a series of graphs (Figures 2.4 thru 2.8). Each figure is comprised of two graphs, one graph each for the Control and BMP blocks. The figures provide a direct comparison of the drainage details from each block during the each event's time frame. Each graph shows the relationship between TP, TDP, and PP concentrations and flow velocity and flow rate over time for a specific block (Control or BMP).

Drainage Event 030731 (July 31, 2003; Figure 2.4) is the first event sampled upon completion of installation of drainage pumps and flow monitoring equipment. Drainage flow rates between 400 and 500 gal hr^{-1} $acre^{-1}$ were imposed upon both blocks for the duration of the event. During the event canal velocities averaged 0.03 and 0.08 m sec^{-1} for the BMP and Control blocks; maximum hourly average canal velocities at the BMP and Control sites were 0.04 and 0.10 m sec^{-1}. Concentrations of TP, TDP, and PP for the BMP block were 46, 74, and 3% less than the respective Control block P concentrations. The higher TDP concentrations of the Control block relative to PP concentrations from the Control block and relative to TDP concentrations from the BMP block are interesting to note and will be addressed in the discussion section. Also, it is interesting to note that even though the average velocity of the Control block was more than twice that of the BMP block, no increase in PP concentration was observed. This would indicate that canal velocities for this event were below the velocities required for substantial sediment and recently settled solids transport.

Figure 2.4. Profiles for Event 030731.





Drainage Event 030804 (August 4, 2003; Figure 2.5) occurred over the course of three days starting on August 4, 2003. The last day of drainage pumping is not shown due to operator error of auto-samplers at both sites. Drainage flow rates were set at 600 gal hr^{-1} $acre^{-1}$ at the initiation of drainage and as the event progressed drainage rates fell slightly over the duration of the event. During the event canal velocities averaged 0.04 and 0.15 m sec^{-1} for the BMP and Control blocks, respectively. The maximum hourly average canal velocities at the BMP and Control sites were 0.06 and 0.46 m sec^{-1}. Concentrations of TP, TDP, and PP in drainage water from the BMP block were 74, 49 and 79 % less than the respective Control block P concentrations. The effect of velocity on PP concentration can be clearly observed in the graph labeled Control 030804 in Figure 2.5. On August 4 and 5, 2003 as the velocity in the main canal at the Control block increased an immediate response is observed in the PP concentration in drainage waters.

Drainage Event 030811 (August 8, 2003; Figure 2.6) event occurred as one 43-hour continuous pumping event at the Control block. At the BMP block the event was partitioned into three pumping periods of 30, 14, and 5 hours each. A drainage flow rate of 500 gal hr^{-1} $acre^{-1}$ was applied to each block at the initiation of the event. Event averaged canal velocities for the BMP and Control blocks were 0.03 and 0.11 m sec^{-1}; maximum hourly average canal velocities for the BMP and Control blocks were 0.04 and 0.21 m sec^{-1}. From the Control block the effects of increased velocity on drainage water PP concentration is clearly evident on August 13, 2003; with the rapid increase in canal velocity a sharp increase in PP concentration is observed. The drainage water average TP, TDP, and PP concentrations from the BMP block were 30,40, and 20 % less than P concentrations from the Control block.

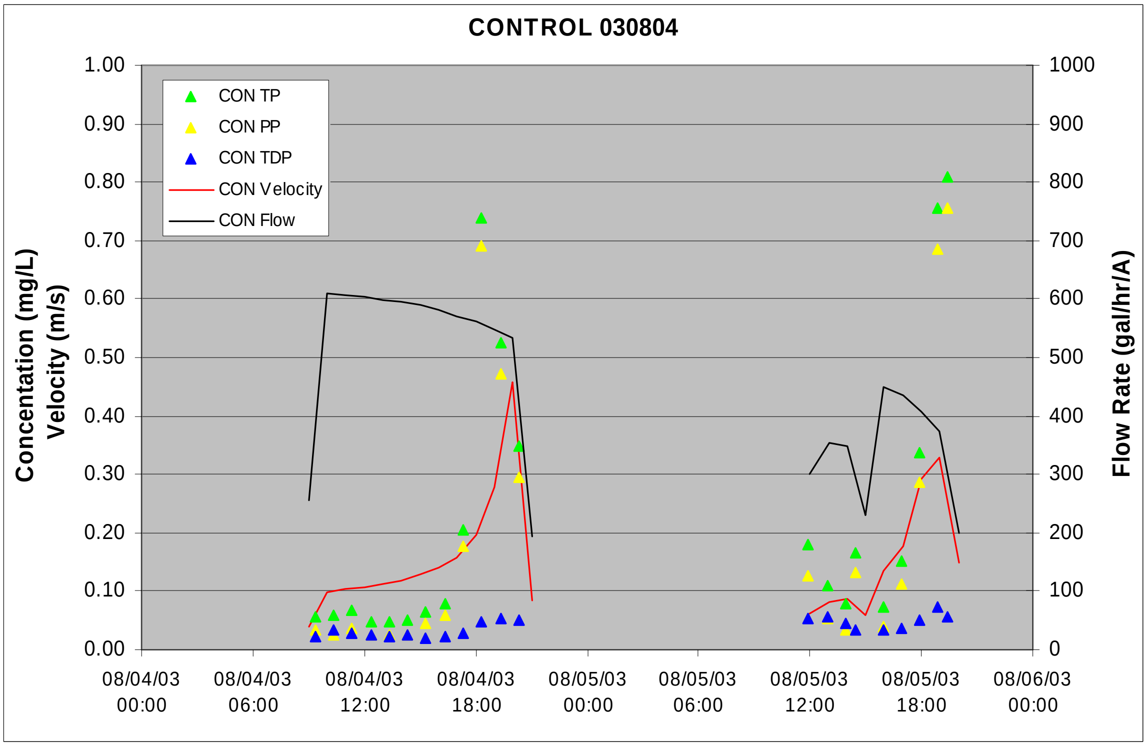
Drainage Event 030825 (August 25, 2003) is presented in Figure 2.7. The Control block event was one continuous 25-hr pumping period. The BMP block partitioned the event into two long duration cycles of 33 and 19 hours each. The second cycle of pumping at this block was added to address research farm manager concerns of high water levels in cane fields in the BMP block as well as water levels in research fields adjoining the BMP block. The south border of the BMP block is adjacent to a large farm canal and at times the high water level in the canal causes seepage into the south areas of the BMP block.

Event average canal velocities for the BMP and Control blocks were 0.04 and 0.10 m sec^{-1}; maximum hourly average canal velocities for the BMP and Control blocks were calculated to be 0.06 and 0.19 m sec^{-1}. The effects of increased velocity on PP concentration of drainage water is evident during this event at the Control site. There also appears to be spikes in PP concentrations at the BMP site that are unrelated to canal velocity. These spikes most likely are the result of particulates entering the drainage stream through random dislodgement. The short period pumping cycle at the control block appeared to reduce PP export concentrations from those one would expect from the velocity observed. The drainage water average TP, TDP, and PP concentrations from the BMP block were 16, 26, and 8 % less than P concentrations from the Control block.

The last event of 2003, Drainage Event 031216 (December 16, 2003), is presented in Figure 2.8. For both blocks the event was comprised of two cycles of approximately 8 hrs each that occurred on December 16 and 17, 2003. The first and second cycle drainage rates for both blocks were targeted at 400 and 550 gal hr^{-1} $acre^{-1}$, respectively. Event average canal velocities for the BMP and Control block were 0.03 and 0.07 m sec^{-1}; maximum average hourly canal velocities for the BMP and Control blocks were calculated to be 0.04 and 0.11 m sec^{-1}. The drainage water average TP, TDP, and PP concentrations from the BMP block were 57, 61, and 47 % less than P concentrations from the Control block. The largest difference in drainage water P concentration was for TDP concentrations. The difference in TDP concentrations may be the result of the complete coverage of the canals surface by water lettuce, which leads to anaerobic conditions and likely increased TDP concentrations through increased flux from sediments and plant detritus.

The first cycle of canal sediment inventory was completed in June of 2003. A summary of the sediment data is presented in Table 2.5. The sediments from the Control block contained higher P concentrations than the BMP block sediments. At both sites, the highest TP concentrations were at the 0-2.5-cm depth. In general, there were no major differences in bulk density or organic matter content.

Figure 2.5. Profiles for Event 030804.



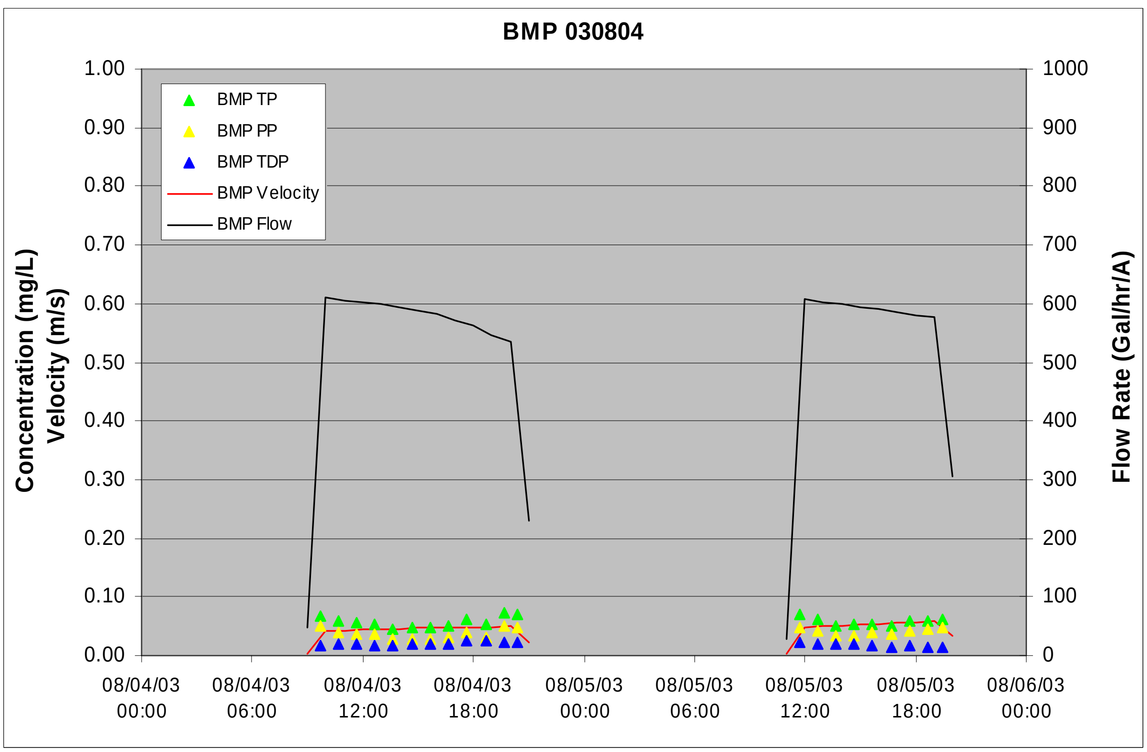
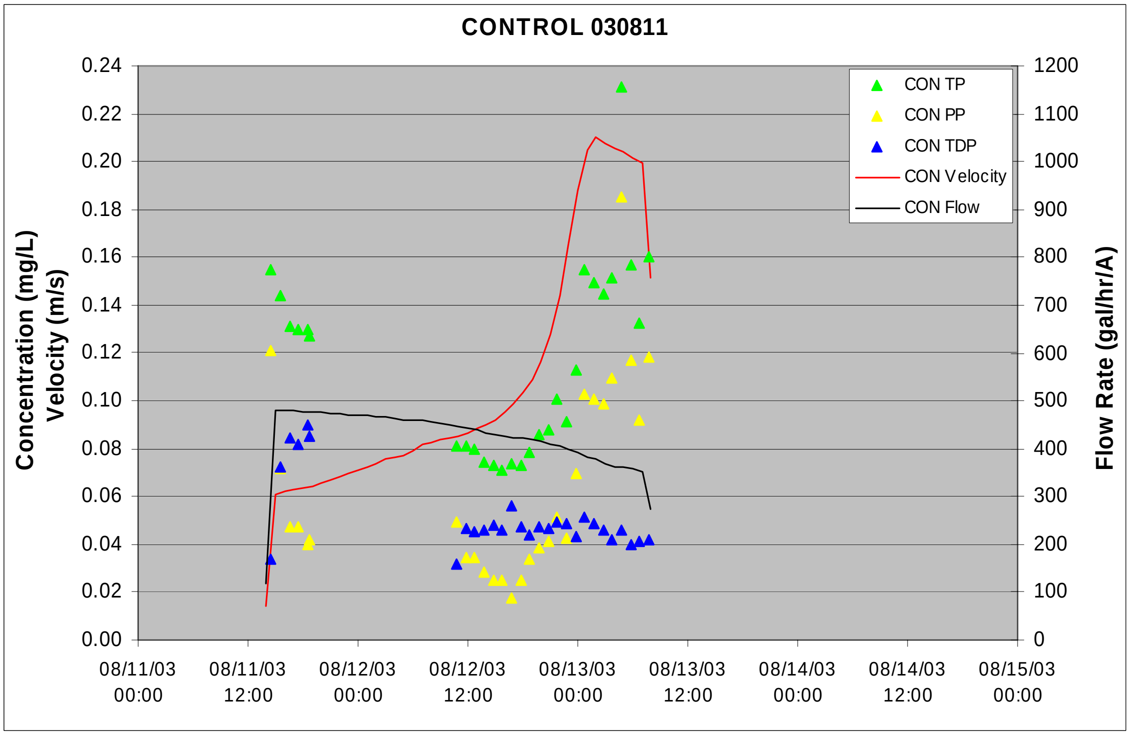


Figure 2.6. Profiles for Event 030811.



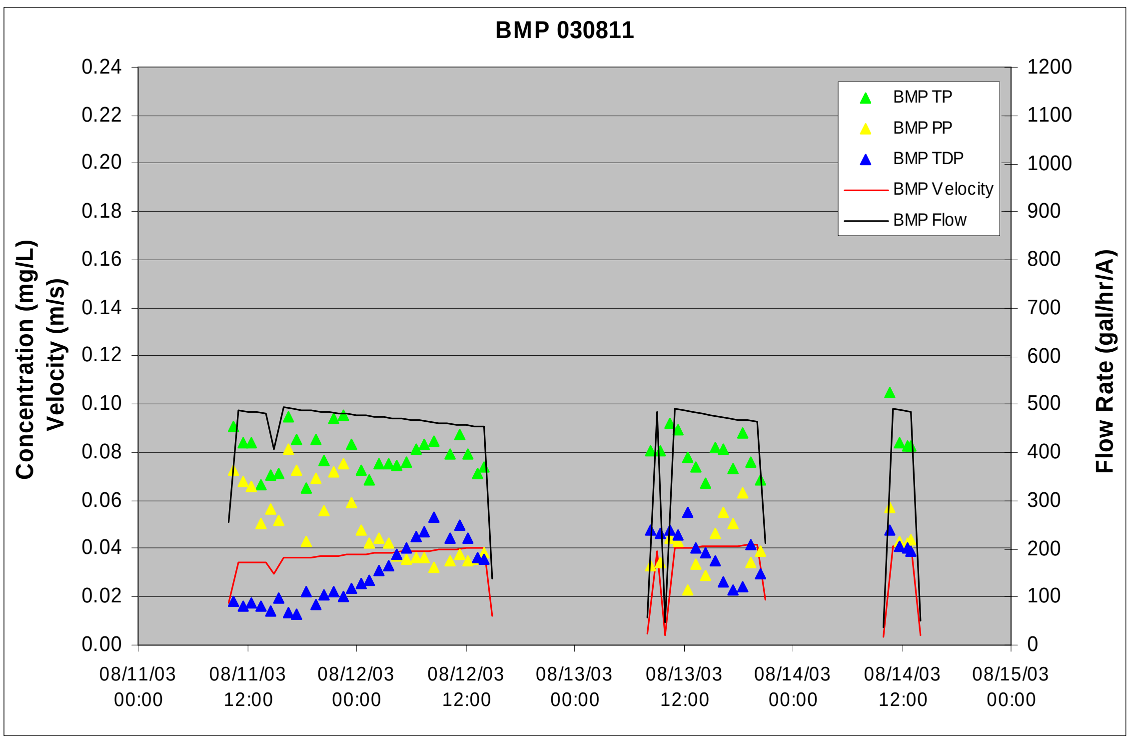
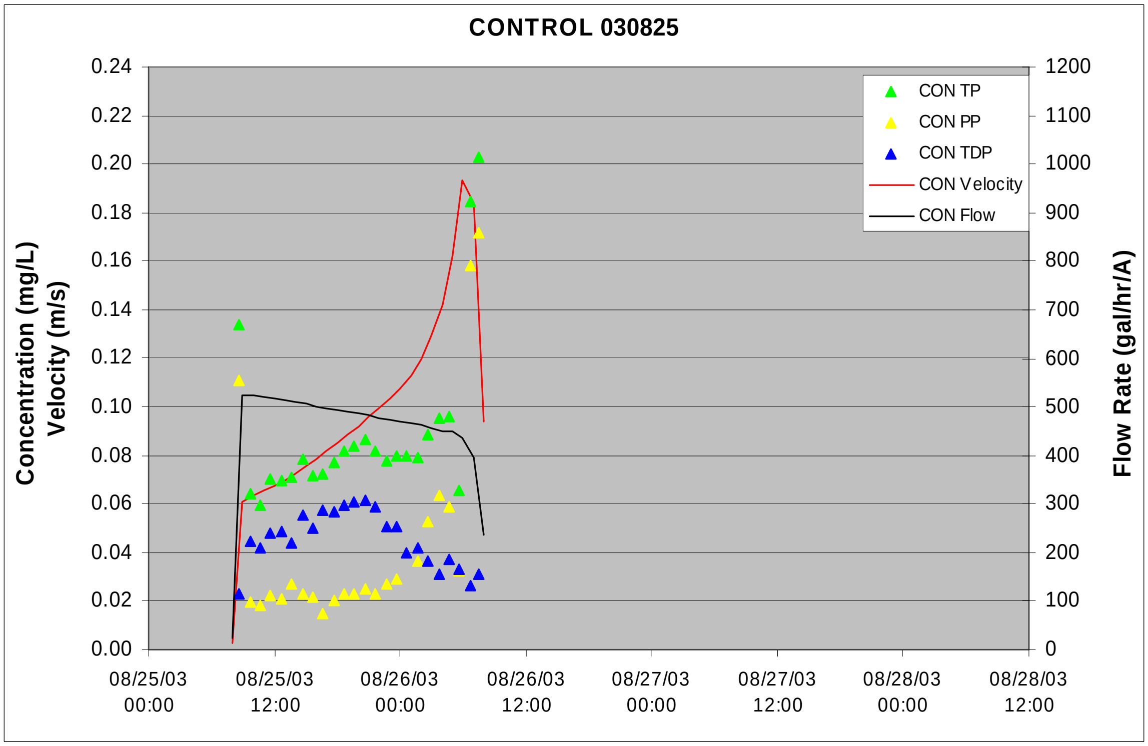


Figure 2.7. Profiles for Event 030825.



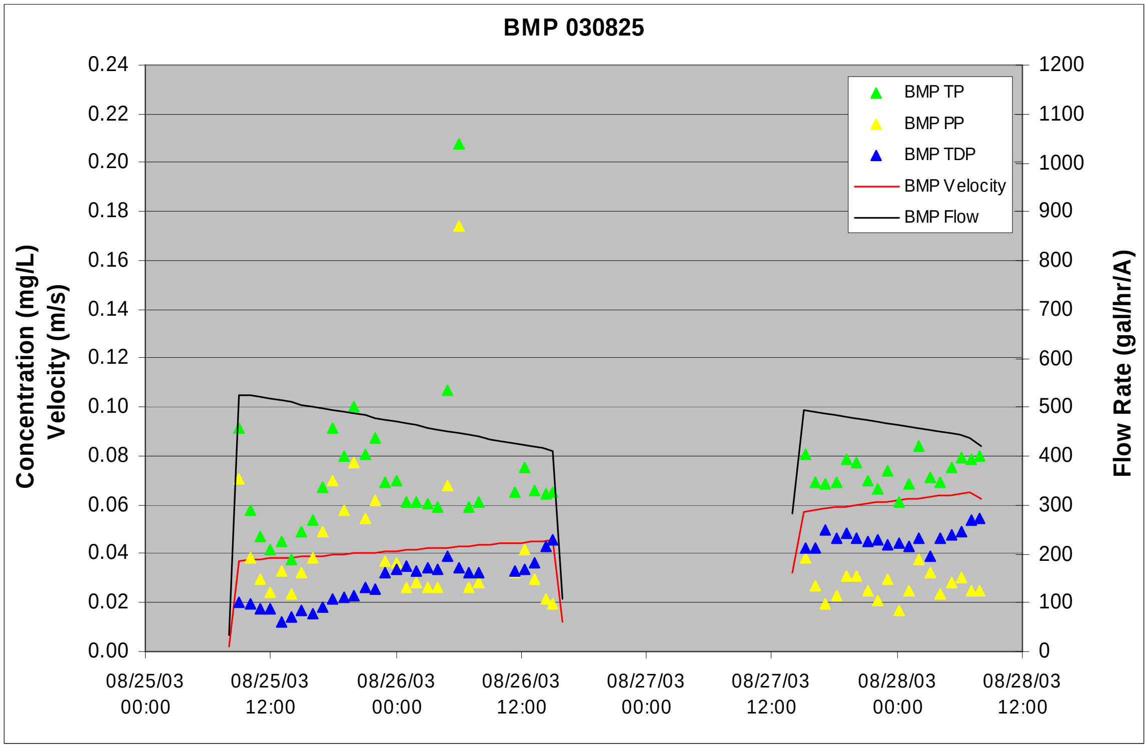


Figure 2.8. Profiles for Event 031216.

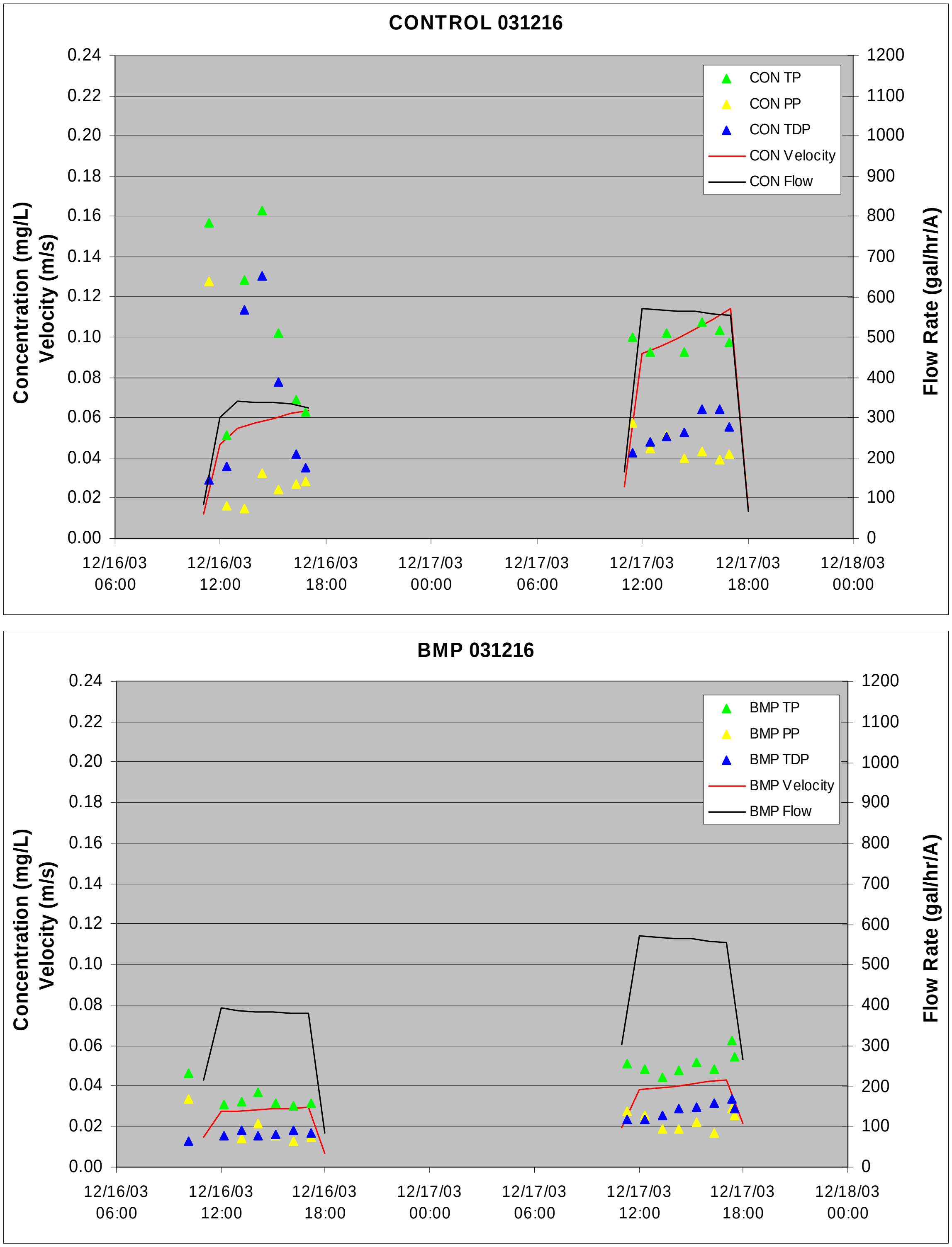


Table 2.5. Canal Sediment Physical and Chemical Characteristics.

Site	Section (cm)	Bulk Densty (g cm^{-3})	Ash Content (%)	O.M. (%)	TP Content (mg kg^{-1})	Sample Size (n)
Control Block	0.0 - 2.5	1.04	55	45	956	4
	2.5 - 5.0	1.06	54	46	813	4
	5.0 -7.5	1.10	59	41	829	4
BMP Block	0.0 - 2.5 cm	1.09	58	42	790	4
	2.5 - 5.0 cm	1.11	60	40	560	4
	5.0 -7.5 cm	1.14	51	49	596	4

DISCUSSION

The 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 application of critical velocity limits will lead to measurable P load reductions (Figure 2.2). 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). Under the study's present arrangement it is difficult to determine what fraction of the P load reduction is due to source control and what fraction is due to critical velocity control. The efficacy of each practice may be determined separately after the current study is completed. At that time both blocks could be operated with identical velocity controls and differing levels of aquatic weed control. Contributions to P Load from controlled aquatic weed growth vs. uncontrolled weed growth could then be compared. Conversely, both blocks could be operated with identical levels of control of floating aquatic weeds and different drainage velocities to compare the effect of velocity on P load. Depending on the results of the current study, if warranted, these direct comparisons could be conducted at the conclusion of the present study.

The critical velocity (0.12 m s^{-1}) imposed on the BMP block was obtained from recent on-farm P load research results (Daroub et al, 2003). A more precise value for critical velocity for the block will be identified by analyzing P concentrations and loads over time and over a range of canal velocities. Currently the study determines and records flow velocity and canal level as hourly averages. To improve the assessment and determination of critical velocity effects, flow and canal levels for both blocks in the second year of the study will be measured and averaged over a five minute as well as hourly intervals.

From the initial season's data set, P loads resulting from TDP and PP concentration differences can be reviewed and examined. Although the study was established to measure particulate P load reductions and the largest contributor to the difference in P load between the control block and the BMP block was PP concentration (Table 2.3), there was an unexpected increase in the TDP concentrations and loads from the Control block relative to the BMP block. The fact that TDP concentrations were appreciably higher in the Control block drainage waters than the BMP drainage waters underscores the need to continue the program for a minimum duration of two years. This will allow researchers to sample canal waters and monitor canal conditions between drainage events, and to further differentiate P species observed in the drainage waters. Two of the many questions that need to be answered include, "Are there differences in P species (SRP or DOP) that contribute to the TDP concentration differences?", and "What conditions in the canals are causing the differences in TDP concentrations between the Control block and BMP block drainage waters?". 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. In addition, 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 in determining the effects of the exported solids on P cycling in downstream receiving waters.

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