DEP Agreement No.: G0024

Grantee Name: University of Florida, Department of Agricultural and Biological Engineering
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Grantee's Grant Manager: Wendy Graham
Quarterly Reporting Period: April 1, 2007- June 30, 2007

Project Title: Demonstration of Water Quality Best Management Practices for Beef Cattle Ranching in the Lake Okeechobee Basin

Summary of Project Accomplishments

1) Task 1: The Project work plan is complete.

2) Task 2: Identification of cooperators is complete.

3) Task 3: Nutrient Management Assessments have been obtained from NRCS and DACS.

4) Task 4: Selecting specific sites for BMP demonstration is complete.

5) Task 5: Monitoring for the December 2004- November 2005 pre-BMP period is complete.

6) Task 6: The Amendments Evaluation Task is complete.

7) Task 7: BMP implementation is complete.

8) Task 9: Hydrologic Monitoring of BMP effectiveness (Sanjay Shukla):

Surface flow, ground water table depth, and surface and ground water quality monitoring continued during April through June 2007. The monitoring locations and watershed boundaries are shown in Figs. 1 and 2. Table 1 shows the description of monitoring locations and associated BMPs.

The second year of the post-BMP data is being collected at the fencing site. At the two wetland sites, this is the first year of the post-BMP data collection. As previously reported, at the time of installation of the riser board structures at the two wetland sites, the bases of the structures at sites 1 and 4 were not constructed as per the design specification and therefore, the flashboard risers did not function as expected. Due to the excessive vegetation around the riser board structures, this error was not identified by NRCS inspectors, the ranch owner or UF personnel. During the 2007 drought the error was discovered. The base of the structures were filled with cement in February and April 2007 to make them operate as per the design (See Figure 3).

15 additional groundwater wells were installed at wetland site 1 in July 2007. If possible, additional wells will also be installed at site 4. These wells will help quantify the fate of additional water retained in the wetland due to the BMP implementation. It has been suggested that water retained in the wetland could move through subsurface pathways and join the ditch located down gradient of the structure. However, it can also be argued that water retained in the wetland will result in a temporary increase in the surface water area as well as increased wetness in the upland areas which can result in increased evaporation losses. These new wells will give more insight into the hydrology of the site, more specifically the groundwater flow.

A topographic survey was conducted within the ranch to collect the elevation data for at the flume and groundwater well locations. The elevation data was related to the nearest NGS (National Geodetic Survey) bench mark. New bench marks for all the five sites within the ranch were established.

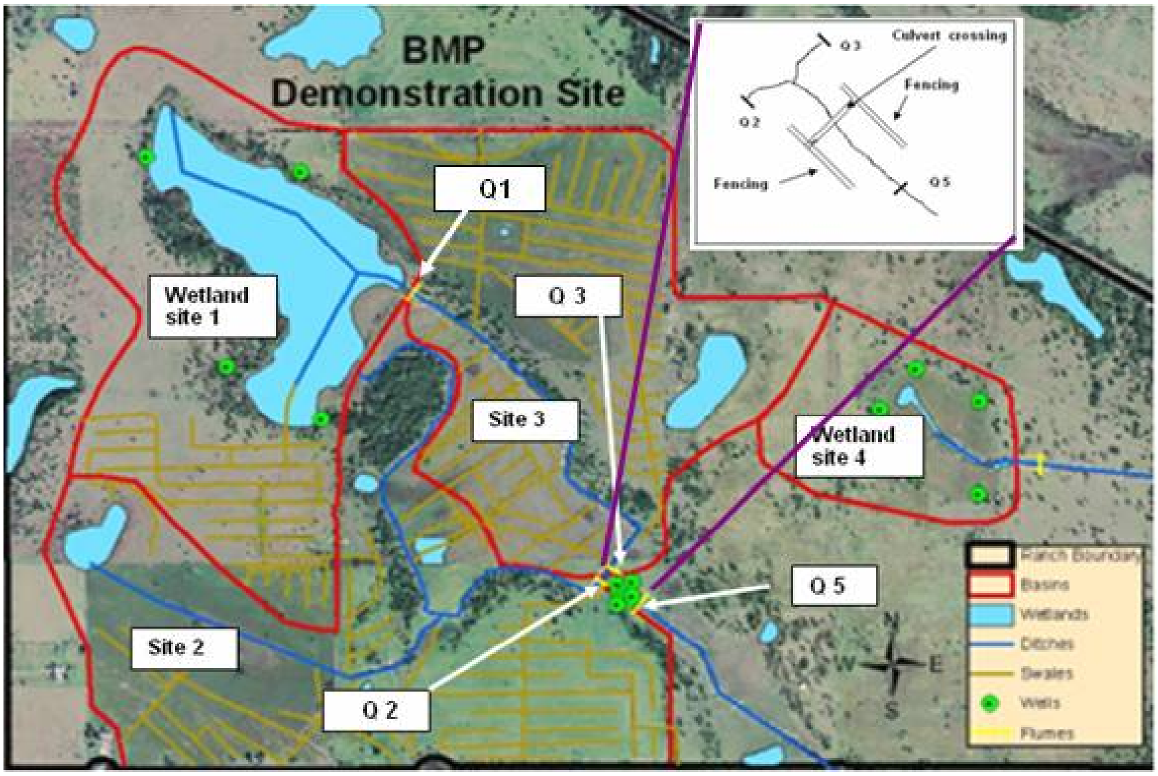

Figure 1. Locations of surface water monitoring stations.

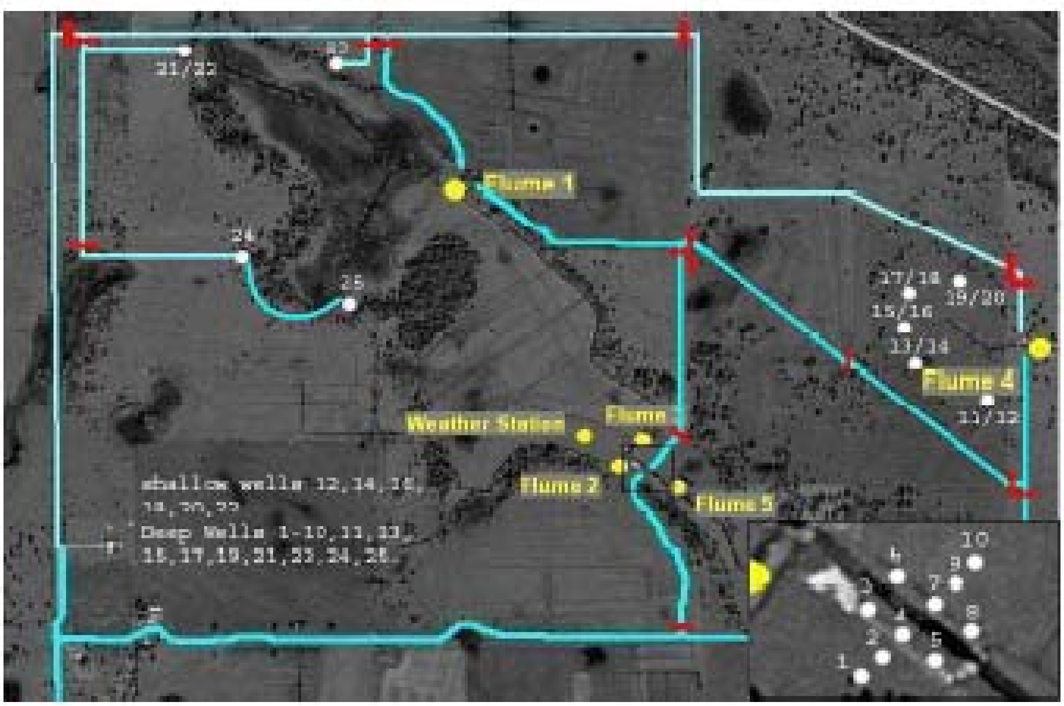

Figure 2. Locations of groundwater monitoring wells.

Figure 3. Filling of the culvert base at wetland sites 1 and 4.

Table 1. Description of the surface water monitoring stations and associated BMPs.

Flume	Description	BMP
1	Trapezoidal flume to measure the flow from the wetland site	Wetland Water Retention
2	Trapezoidal flume to measure the flow to the stream fencing site	Ditch Fencing and Culvert Crossing
3	Trapezoidal flume to measure the flow to the stream fencing site	Ditch Fencing and Culvert Crossing
4	Trapezoidal flume to measure the flow from a wetland	Wetland Water Retention
5	Trapezoidal flume to measure the flow downstream of the fencing site	Ditch Fencing and Culvert Crossing

Monitoring Data

The flow rates and cumulative flow volume data for January through May 2007 for the five sites are presented in Figures 4 and 5. The total flow volume at flume 1 was higher that that at flume 3, which might indicate that the flow that passes flume 1 may subsequently enter the groundwater and thus not reach flume 3.

The January-May 2007 period received much less rainfall than the average. The average rainfall for Okeechobee County during this period is 17 in. At the Pelaez ranch, the rainfall was only 8 in during this period (< 50% of the average) making it a unusually dry period (Figure 6). Due to dry conditions, few flow events occurred during this period.

Water table depths for the wells at the three sites (fencing site and wetland sites 1 and 4) are shown in Figs. 7-9. Wells 1, 2, 4, 7, 9, and 10 are located at the cattle crossing site on a transect crossing the ditch upstream of flume 5 and downstream of the junction of flumes 2 and 3. Wells 11, 15 and 19 measure the water table elevations at wetland site 4. Wells 21, 23, and 24 measure the water table dynamics at wetland site 1. The data from the topographic survey conducted during the February–June 2007 period were used in conjunction with the water depth data from the pressure transducers to obtain the water table elevation in reference to the sea level.

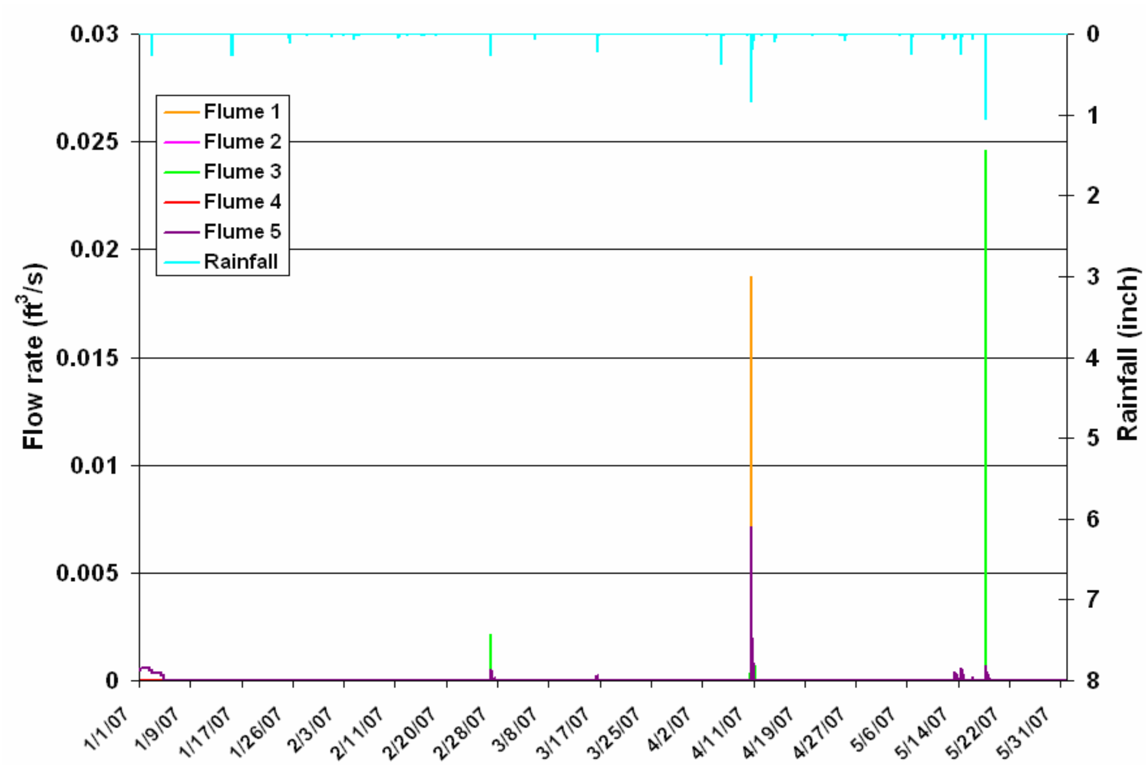

Figure 4. Flow rates at the flumes 1-5 for Jan-May'07.

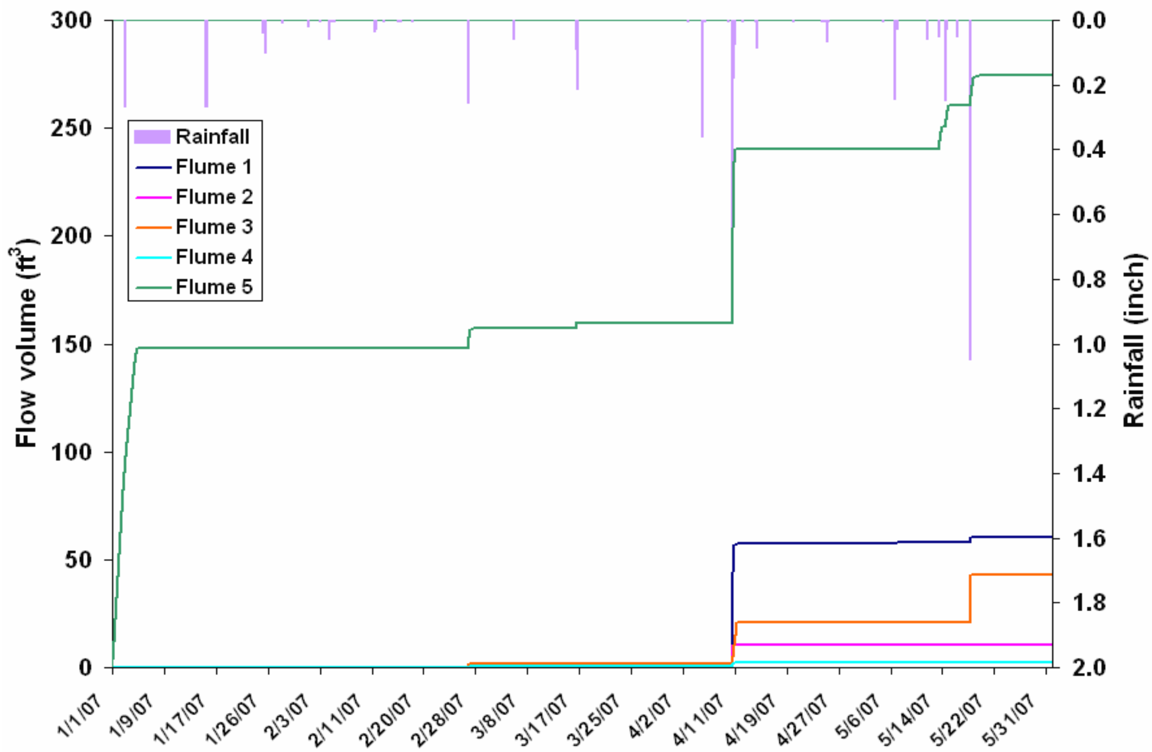

Figure 5. Cumulative flow volume (ft^3) for the flumes 1-5 for Jan-May'07.

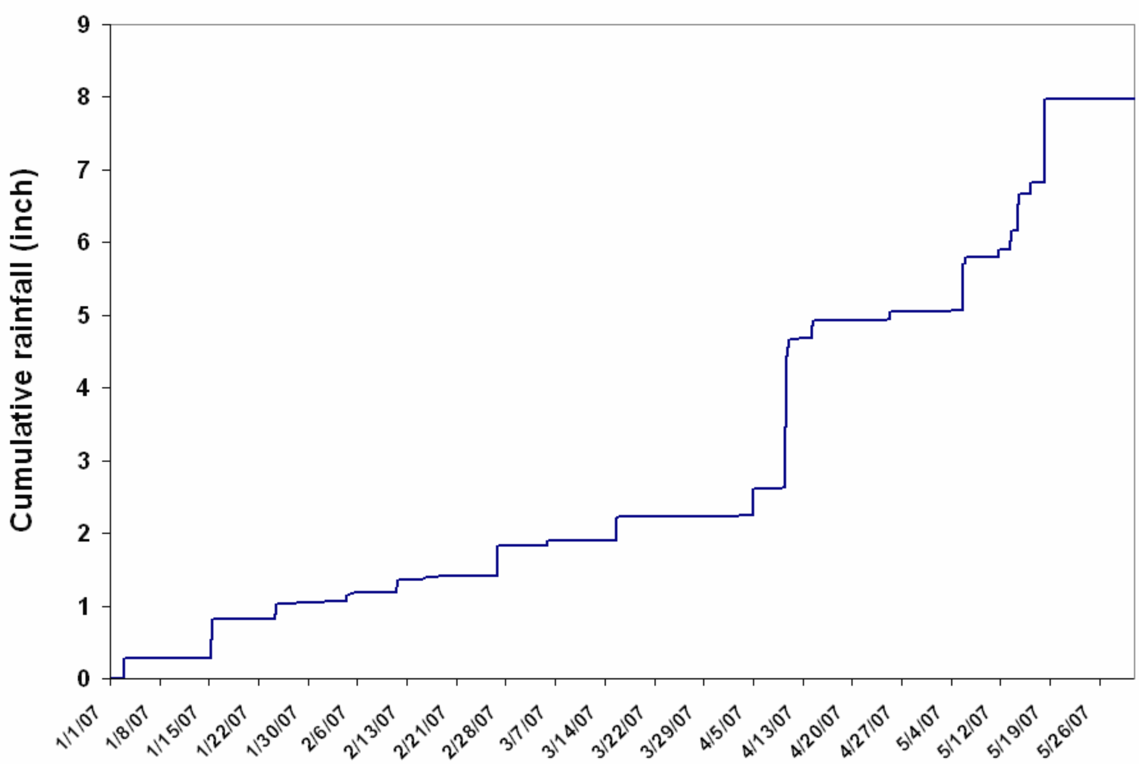

Figure 6. Cumulative rainfall for Jan-May'07.

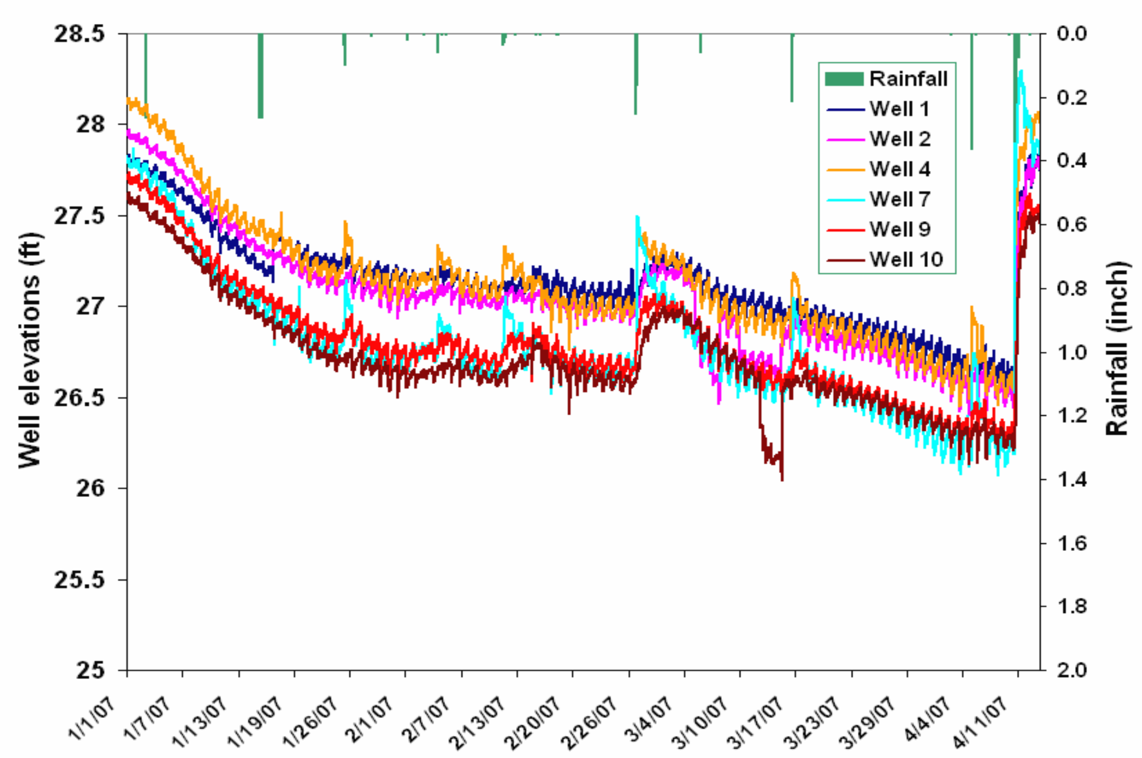

Figure 7. Water table depth (ft above sea level) at the fencing site for Jan-May'07.

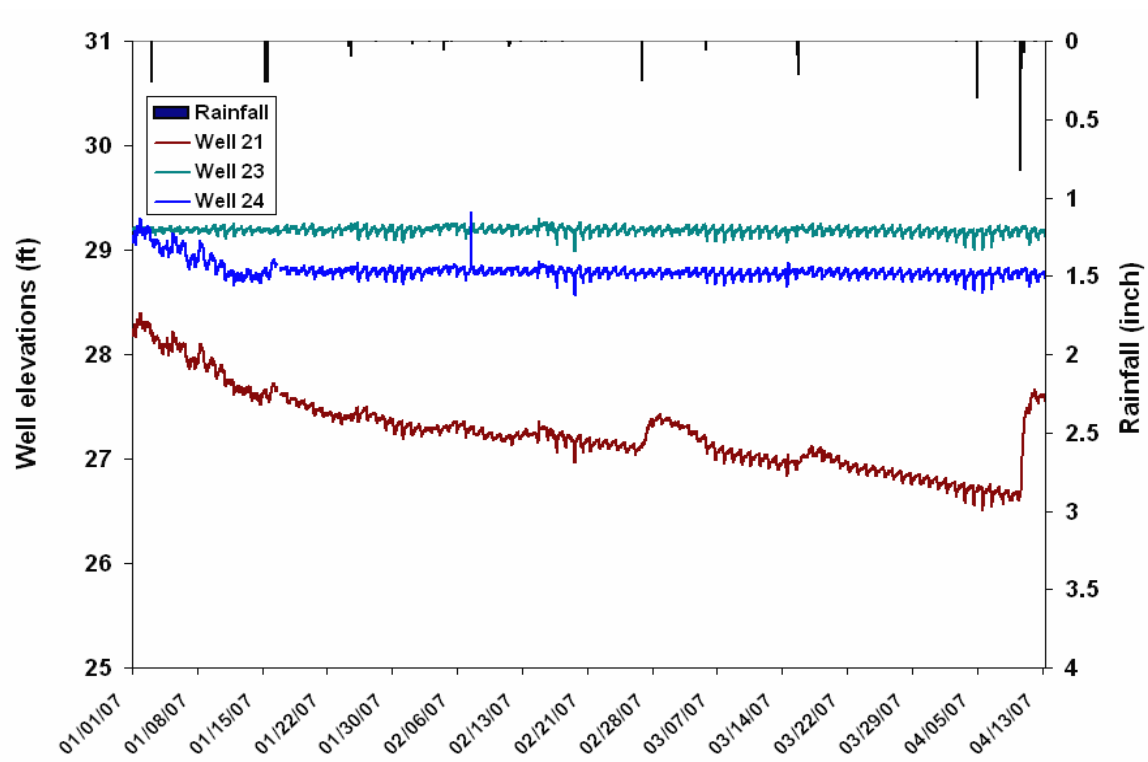

Figure 8. Water table depth (ft above sea level) at the wetland site 1 for Jan-May'07.

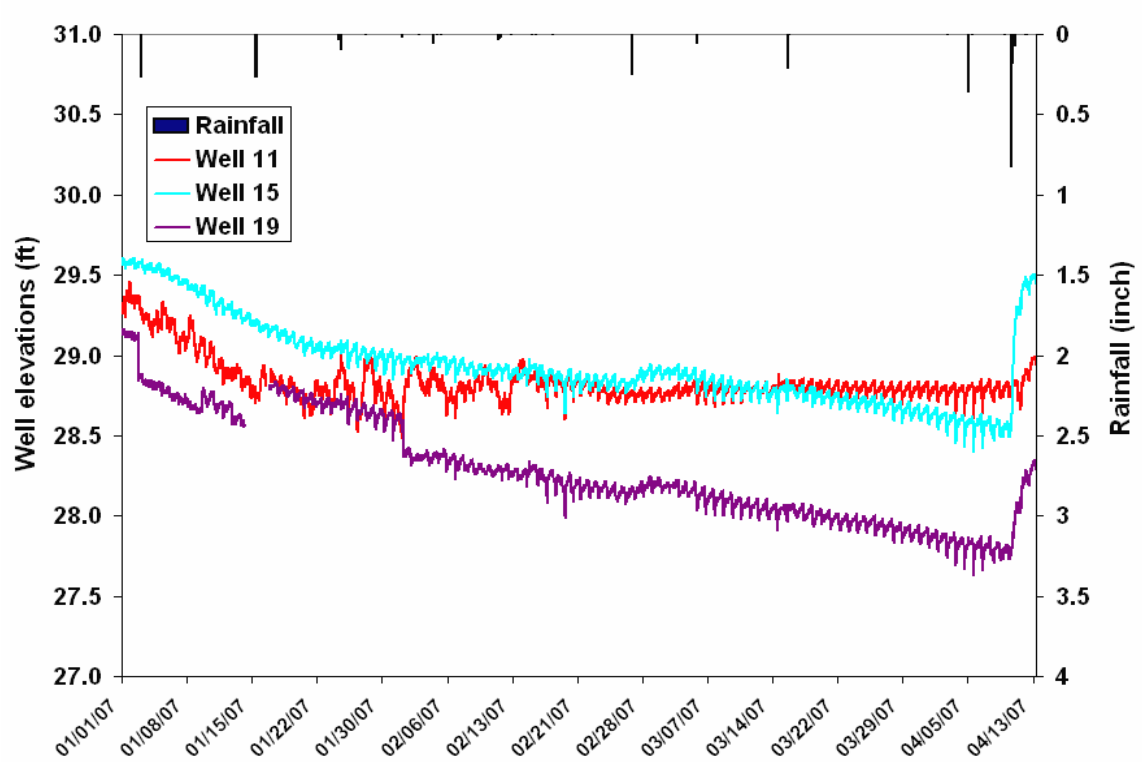

Figure 9. Water table depth (ft above sea level) at the wetland site 4 for Jan-May'07.

Water quality (surface and groundwater) samples were colleted during April through June 2007 and sent to the Analytical Research Laboratory (ARL), Gainesville, FL. The concentrations of the N (NH3, NO3, and TKN) and P (TP) species in the monthly ground water samples are presented in Tables 2 through 5. The analyses results for the surface water samples taken during the flow periods (May 2007) are not yet available and will be presented in the next quarterly report.

Table 2. NH_3-N concentrations (mg/l) in the monthly groundwater samples (Jan-April '07).

Wells	Nutrient: NH_3-N (mg/L)			
	1/17/2007	**2/15/2007**	**3/16/2007**	**4/13/2007**
Well 1	1.86	1.30	0.13	1.94
Well 2	1.80	1.65	0.91	1.22
Well 3	1.13	0.97	0.13	0.84
Well 4	2.49	1.12	1.48	1.00
Well 5	1.00	0.74	1.02	0.65
Well 6	0.98	0.70	0.13	1.23
Well 7	1.03	0.92	0.13	0.79
Well 8	0.64	0.42	0.82	0.88
Well 9	1.00	0.98	0.13	1.11
Well 10	1.10	0.84	0.93	1.28
Well 11	0.91	0.75		
Well 13	0.73	0.63	0.51	
Well 15	1.31	0.69		
Well 17	1.00	1.04	0.77	
Well 19	0.55	1.13	0.13	0.75
Well 21	0.23	0.14	0.13	

Table 3. NO_x-N concentrations (mg/l) in the monthly groundwater samples (Jan-April '07).

Wells	Nutrient: NO_x-N (mg/L)			
	1/17/2007	**2/15/2007**	**3/16/2007**	**4/13/2007**
Well 1	0.32	0.03	0.19	0.11
Well 2	0.08	0.07	0.02	0.01
Well 3	0.15	-0.02	0.10	-0.03
Well 4	0.20	-0.02	0.02	0.05
Well 5	0.06	-0.02	0.03	0.02
Well 6	0.06	-0.03	0.02	0.19
Well 7	0.04	-0.04	0.02	0.79
Well 8	0.06	-0.03	0.06	0.01
Well 9	0.07	-0.04	0.02	-0.05
Well 10	0.06	-0.02	0.03	0.11
Well 11	0.06	-0.03		
Well 13	0.07	0.02	0.21	
Well 15	0.07	-0.03		
Well 17	0.10	-0.03	0.03	
Well 19	0.21	0.09	0.05	-0.02
Well 21	0.19	0.11	0.20	

Note negative concentrations indicate that values were below the detection limit

Table 4. TKN concentrations (mg/l) in the monthly groundwater samples (Jan-April '07).

Wells	**Nutrient: TKN (mg/L)**			
	1/17/2007	**2/15/2007**	**3/16/2007**	**4/13/2007**
Well 1	1.90	2.24	2.00	2.87
Well 2	2.15	2.93	2.28	2.13
Well 3	3.04	2.12	2.11	2.37
Well 4	2.67	4.22	2.15	1.70
Well 5	2.94	3.09	1.75	2.22
Well 6	1.19	1.15	3.70	2.36
Well 7	2.64	1.58	2.09	5.43
Well 8	1.84	1.69	1.91	1.40
Well 9	1.93	1.65	4.38	1.82
Well 10	2.78	0.83	2.87	2.26
Well 11	0.99	3.37		
Well 13	1.12	1.03	1.34	
Well 15	3.77	0.86		
Well 17	3.07	1.61	1.46	
Well 19	5.87	4.90	6.61	3.14
Well 21	2.35	2.98	0.94	

Table 5. Total P (TP) concentrations (μg/l) in the monthly groundwater samples (Jan-April '07).

Wells	**Nutrient: TP (μg/L)**			
	1/17/2007	**2/15/2007**	**3/16/2007**	**4/13/2007**
Well 1	8.25	36.53	5.50	9.87
Well 2	41.28	28.38	21.59	39.49
Well 3	23.27	108.7	16.33	7.50
Well 4	8.37	23.88	19.33	11.25
Well 5	728.8	83.34	90.35	75.31
Well 6	19.12	10.62	6.56	5.55
Well 7	28.88	28.94	15.26	54.50
Well 8	157.4	7.54	9.85	6.60
Well 9	14.45	11.75	9.42	9.15
Well 10	10.60	9.36	6.06	11.66
Well 11	5.87	5.93		
Well 13	3.16	5.15	15.17	
Well 15	3.13	9.64		
Well 17	4.95	6.66	13.59	
Well 19	32.15	489.6	33.48	15.34
Well 21	4.94	176.0	2.63	

Passive Flux Meter Deployments at Pelaez Ranch (Michael Annable)

The following data on groundwater and phosphorous flux is based on deployment of 18 Passive Nutrient Flux Meters (PNFM) at the Pelaez Ranch, four around each wetland and ten at the cross section of a ditch. See Figure 10 for well locations. Water table levels were recorded for ten of the wells. The PNFM's at the Pelaez Ranch were deployed for a period of 33 days.

The water flux profiles based on the PNFM deployments for each of the wetlands at the Pelaez Ranch are provided in Figure 11. Darcy velocities range from 0 to 7 cm/day with an average of 3.5 cm/day. Pelaez wells PTFM1-10 provide phosphate flux along a transects near the ditch which drains the wetland and surrounding areas. The water flux along well transects perpendicular to the ditch is shown in Figure 12. The Darcy velocities are more uniform with an average of 6.5 cm/day. The phosphate flux in wells around wetlands 1 and 4 are provided in Figure 13 & 14 Mass flux rates average 1.5 mg/m2/day. Figure 15 indicates there that there are higher phosphate fluxes on the east side of the ditch than the west side and on average the phosphate flux is higher along the ditch then in the wetlands. The left side of the transect shows a trend of similar to Pelaez wetland 4 where the phosphate flux increase with depth. This variation in phosphate flux maybe due to land practices or different water flux between the sides of the ditch.

Table 6 summarizes the average mass flux of phosphate at each of the wells during the 33 day monitoring period.

Basin Wide Loads Based on Local Flux Measurements

The field data collected from six wetlands (two at Pelaez Ranch, two at Larson Dairy and two at Beaty Ranch) were used to calculate a basin-wide estimate of the total amount of phosphorus exchange between groundwater and isolated wetlands. The amount of phosphorus that could be reduced to Lake Okeechobee by detaining more water in the wetlands and surrounding groundwater for a longer period of time was estimated to be similar to the measured fluxes. To estimate the mass of phosphate that could potentially be reduced from the load reaching Lake Okeechobee the phosphate flux values measured at the six wetlands were applied to the priority basins of the Lake Okeechobee watershed.

The priority basins, S-65E, S-65D, S-154 and S-191 have consistently produced the highest levels of phosphorus concentrations of all the tributary basins to Lake Okeechobee (SFWMD and USEPA, 1999). The priority basins have abundant cow calf operations. The priority basins account for 12% of the land area in the Lake Okeechobee watershed (Figure 17), and 35% of the phosphorus entering the lake (Dunne, et al., 2006). The Lake Okeechobee Action Plan of 1999 states that if the priority basins met their target loads the phosphorus loading into Lake Okeechobee could be reduced by over 100 tons per year (SFWMD and USEPA, 1999).

Basin Wide Phosphorus Calculations for Isolated Wetlands

By using the characteristics of the six wetlands studied, an estimate of the amount of phosphorus loads from all the wetlands located within the priority basins was calculated. Seven percent of the land surface in the priority basins is reported as isolated wetlands (Dunne, et al., 2006). The priority basin's total area is 974 square miles (SFWMD and USEPA, 1999). Therefore there is an estimated 68 square miles of isolated wetlands within the priority basins. The average area of the study wetlands was determined by area measurements collected at each site. The average area of the six wetlands was 7,900 square meters. This average site wetland would indicate approximately 22,400 individual isolated wetlands in the priority basins.

By taking the average and range of phosphate mass flux shown in Tables 7 and 8 and using the duration of gradients surrounding the wetlands the average exchange between the wetlands and groundwater can be calculated (Table 9). Multiplying by the number of individual isolated wetlands estimated for the basin, the estimated mass load average and range is calculated (Table 10). The phosphate mass load estimated represents the priority basin's total phosphate mass load between isolated wetlands and groundwater.

This calculation produces phosphorus mass load range for the priority basins of 2.6 to 14 metric tons per year with an average of 4.69 metric tons per year

Based on other studies, if the detention of water in the isolated wetlands is capable of decreasing the mass load approximately 4 to 20 percent then between 0.10 to 2.77 metric tons per year will not reach Lake Okeechobee (Zhang, et al., 2006). South Florida Water Management District studies indicate that small on-site wetlands can potentially remove between 25 to 80% of the phosphorus they receive which would increase the anticipated phosphorus removal (SFWMD and USEPA, 1999). The Lake Okeechobee Annual Report for 2005 indicated that retaining water on a 410 acre wetland reduces phosphorus by 1.2 metric tons per year, a 71% reduction (Grey, et al., 2005).

Literature estimates for phosphate reduction from water detention in isolated wetlands range from 4 to 80% of the wetlands phosphorus stored in the wetland. With such a broad range it is obvious that more studies are needed to confirm the effectiveness of water detention in isolated wetlands to reduce phosphate loads. However, the reduction of 100 metric tons per year of phosphate that the Lake Okeechobee Action Plan of 1999 discusses is out of the range of the above estimates (SFWMD and USEPA, 1999). SFWMD and USEPA may also have taken into consideration other phosphate BMPs.

Basin Wide Phosphorus Calculations for Drainage Ditches

Similar to isolated wetlands, drainage ditches can serve as a source for phosphorus exchange with groundwater. The phosphate flux measurements obtained from the ditch transect at Pelaez Ranch were used as a representative measurement of phosphate flux along drainage ditches in the Lake Okeechobee priority basins. By using an estimate of the length of ditches in the priority basins and multiplying by the phosphate discharge flux the mass load of phosphate from drainage ditches in the priority basins was estimated. The greatest ditching density estimated for unimproved pastures, improved pasture, intensively managed pastures and citrus and row crops was 18 km/km^2 (Haan, 1995). To determine the maximum amount of phosphorus from the drainage ditches it was assumed that all of the area in the priority basins has the greatest ditching density for land uses. By multiplying the ditching density by the area of the priority basins a drainage ditch length of 45,000 km was determined. Steinman and Rosen describe the total linear meters of canals in the watershed north of Lake Okeechobee to be 4,000 km (Steinman and Rosen, 2000). Thus calculating the mass loads with these two estimates of ditch length results in very different numbers. Both estimates of drainage ditch length were used in order to create a range of possible phosphate mass loads from drainage ditches into Lake Okeechobee.

To obtain a mass load, the discharge area the drainage ditches was required. The discharge area was found by using the one meter depth that the PNFM measured and multiplying it by two to represent each side of the drainage ditch. This provides a phosphate mass load of 4 and 31 metric tons per year with an average of 18 metric tons per year, Table 11.

From the estimates of phosphate loads from drainage ditches in Lake Okeechobee is shown that there was a greater opportunity in reducing the phosphate from drainage ditches than from isolated wetlands.

Conclusions from Passive Flux Meter Observations and Analyses

Using the phosphate flux from the six isolated wetlands studied basin wide estimates for phosphate mass loads from wetlands and drainage ditches were estimated. Using literature as a guide the reduction of phosphate mass loads to Lake Okeechobee from isolated wetlands was calculated. From these calculations it was shown that the drainage ditches and isolated wetlands may contribute the same range of phosphate mass loads to Lake Okeechobee. However depending on the drainage ditch length used the drainage ditches may play a substantially larger part in phosphate mass loads than previously thought. The phosphate mass load from isolated wetlands was calculated to range from 2.6 to 14 metric tons per year while the drainage ditches contributed 4 to 32 metric tons per year. To help reduce the range of phosphate mass load for drainage ditch and provide a more accurate estimate a more accurate total drainage ditch length in the priority basins should be established. It should also be noted that seasonal inundation of of isolated wetlands and ditches may decrease the phosphate mass load from both the isolated wetlands and drainage ditches.

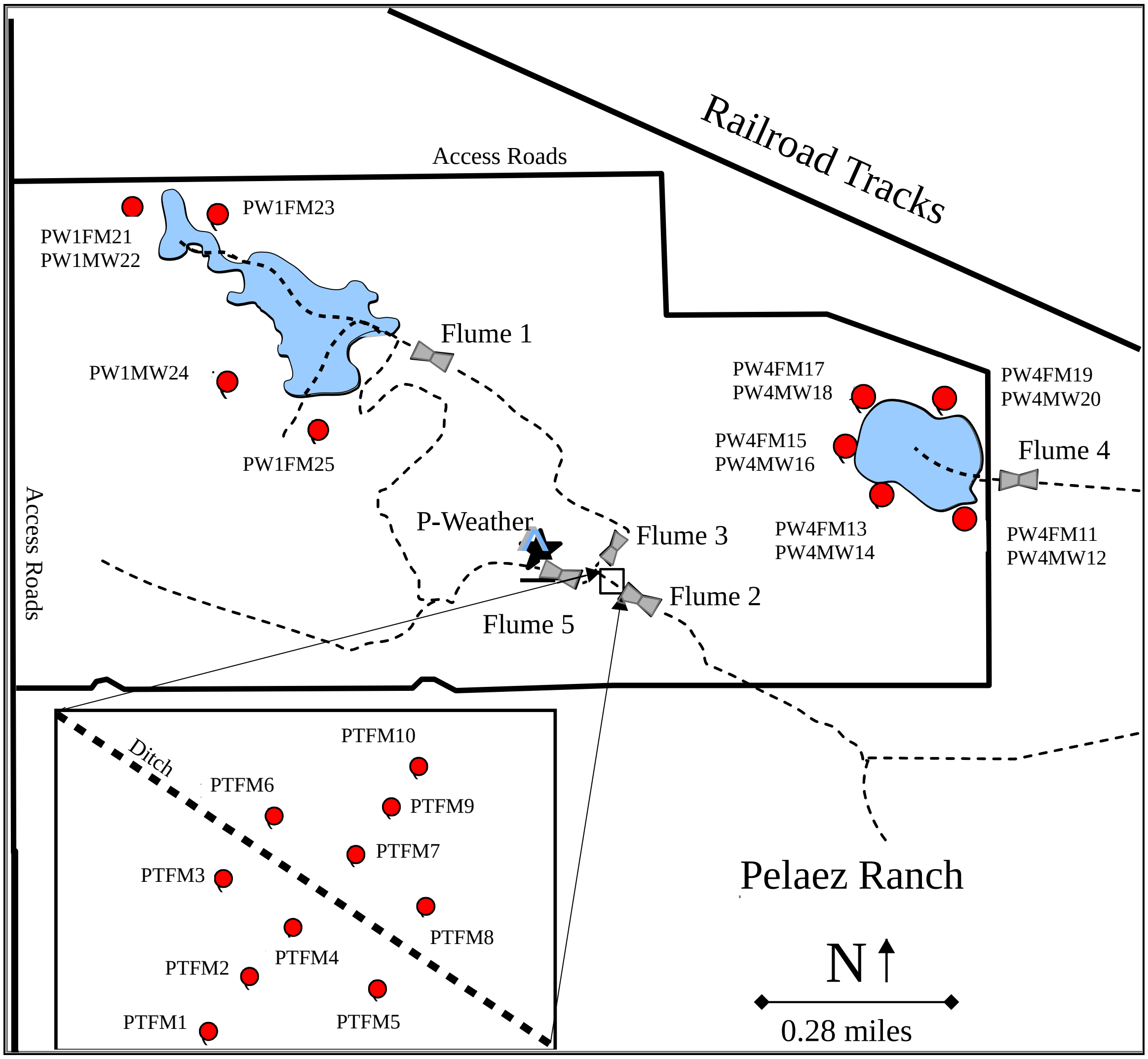

Figure 10: Pelaez Ranch - All the flux meter (FM) well contained PNFM and only wetland 4 contained a transducer in the wetland.

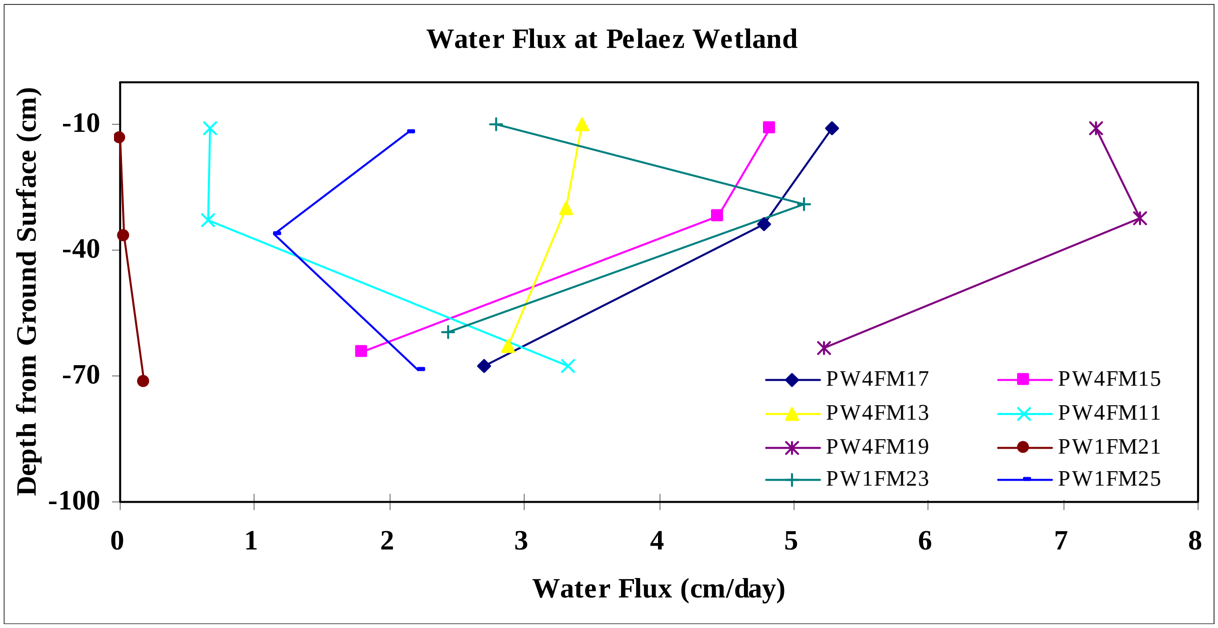

Figure 11: Water flux versus depth at Pelaez wetland for each well location.

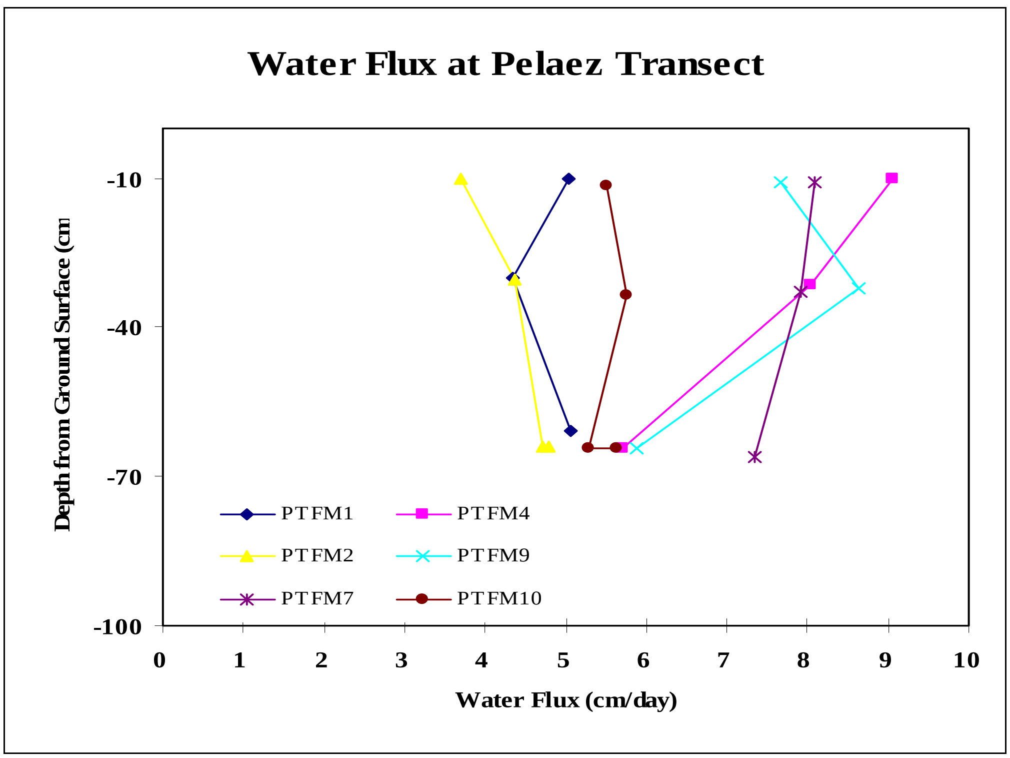

Figure 12: Water flux versus depth at Pelaez transects along the ditch.

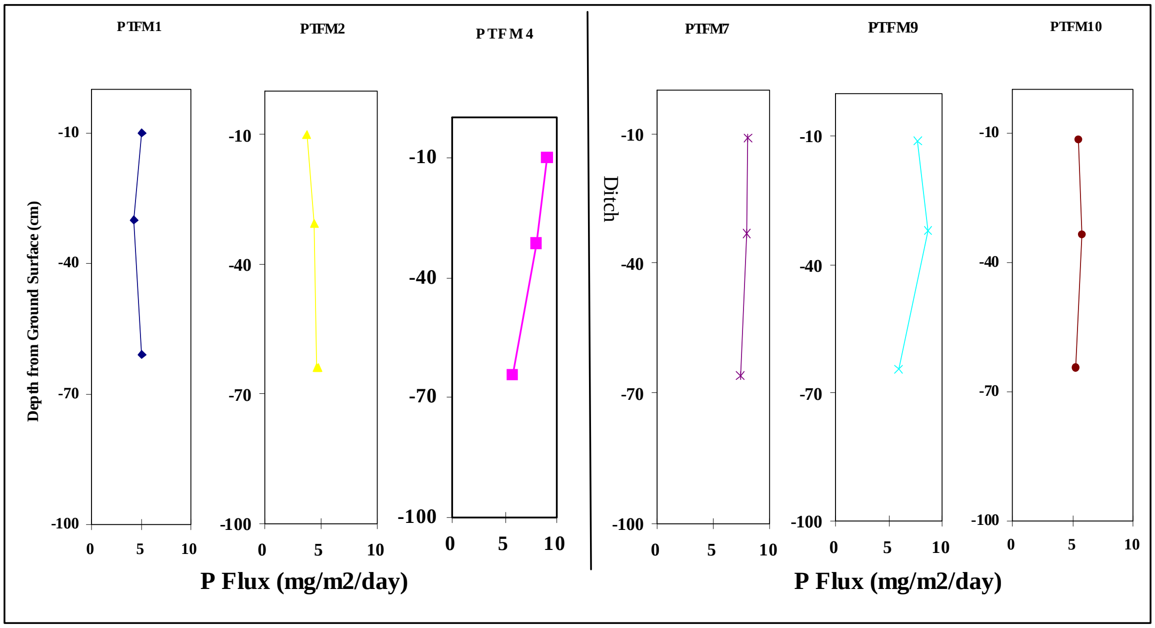

Figure 13: Phosphorus flux versus depth at Pelaez transect crossing the ditch.

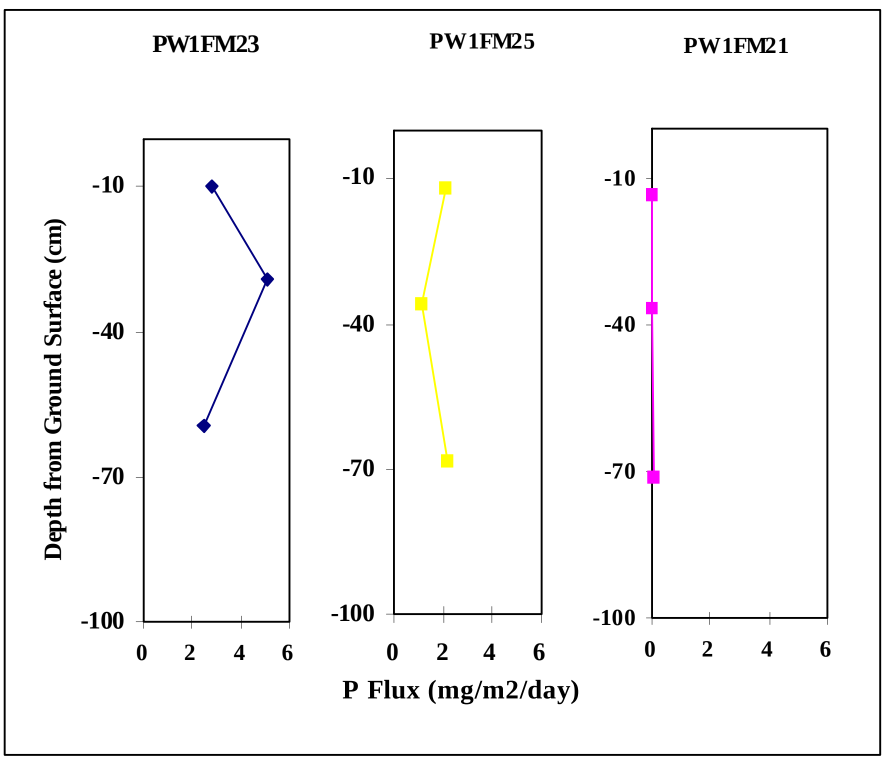

Figure 14: Pelaez wetland 1 phosphate flux versus depth at each well location.

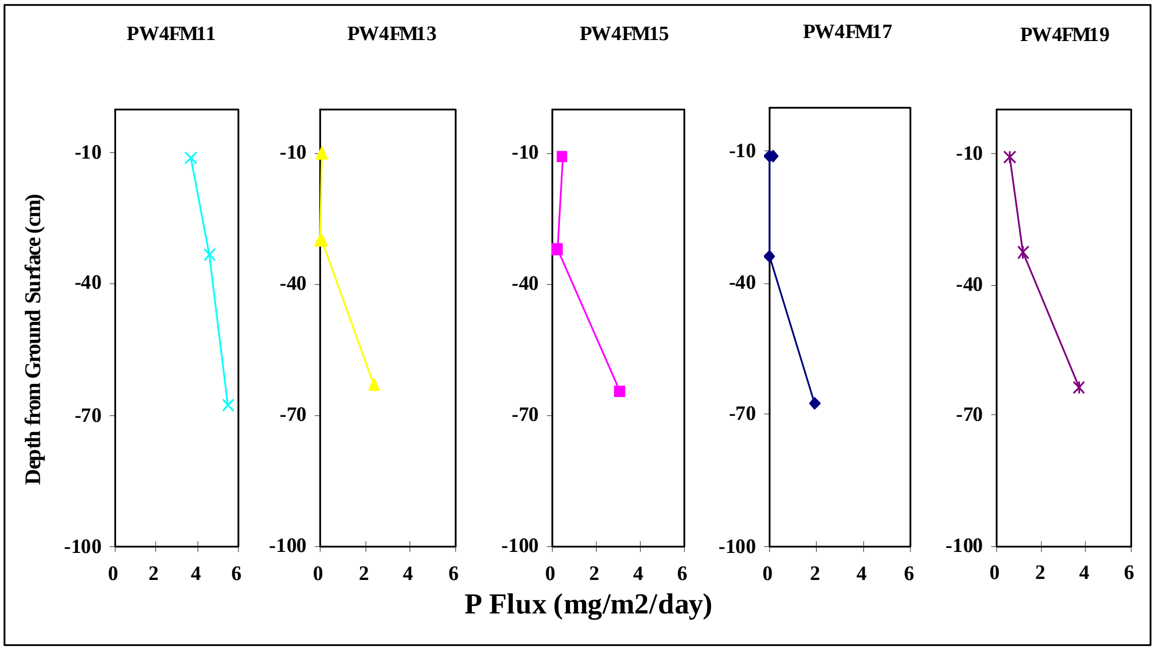

Figure 15: Pelaez wetland 4 phosphate flux versus depth at each well location.

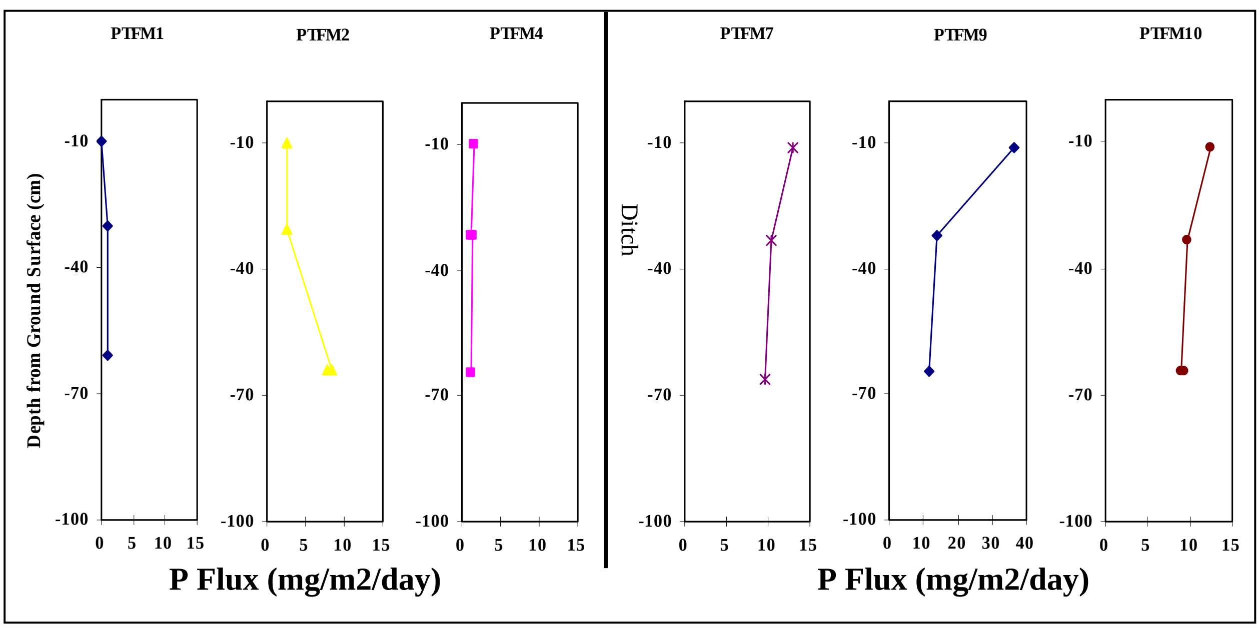

Figure 16: Pelaez transect phosphate flux versus depth at each well location. Note: The axis for phosphate flux on well PTFM9.

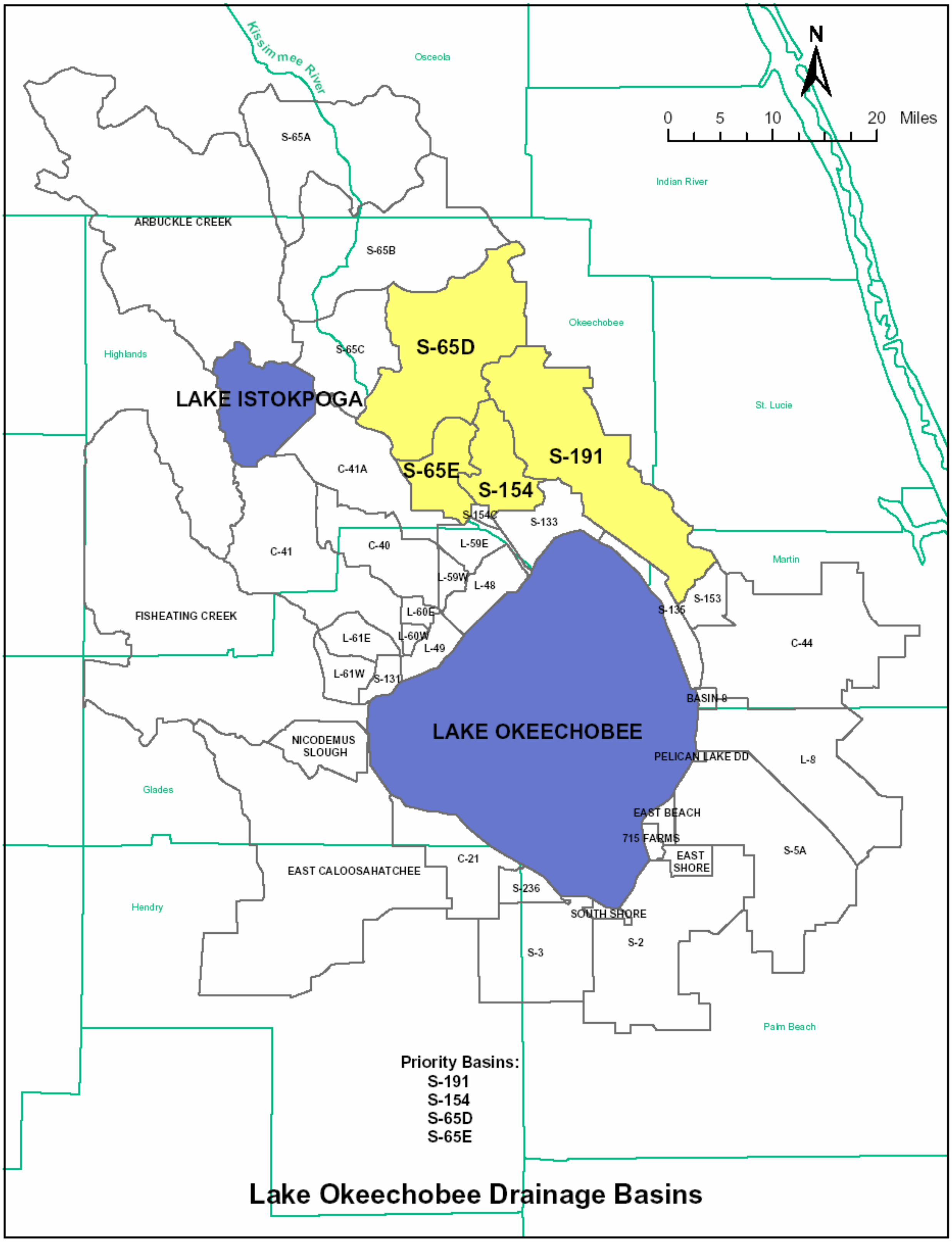

Figure 17: Lake Okeechobee drainage basins. The yellow basins are priority basins (SFWMD, 2007).

Wetland ID	J_{c*} mg/m^2/day	Mass Load mg/day	Mass Load Average of Well mg/day	Mass Load Average of Wetland mg/day
PW1FM25	2.1	3921.9		
	1.1	2100.3		
	2.2	4041.6		
	1.8	3247.3		
	1.7	3129.7	3288.2	
PW1FM23	2.8	5112.5		
	5.1	9296.0		
	2.4	4439.8		
	3.4	6282.8	6282.8	
PW1FM21	0.0	0.0		
	0.0	0.0		
	0.0	66.6		
	0.2	323.6		**PW1**
	0.1	130.1	104.1	3225.0
PW4FM19	0.6	593.3		
	1.2	1148.7		
	3.7	3565.6		
	1.8	1769.2	1769.2	
PW4FM17	0.2	172.2		
	0.0	0.0		
	0.0	0.0		
	1.9	1897.0		
	0.6	632.3	540.3	
PW4FM15	0.5	466.3		
	0.2	193.7		
	3.1	2976.2		
	1.2	1212.0	1212.0	
PW4FM13	0.0	38.1		
	0.0	35.1		
	0.1	73.4		
	2.4	2319.3		
	0.8	809.3	655.0	
PW4FM11	3.7	3644.9		
	4.6	4472.2		
	5.5	5410.2		**PW4**
	4.6	4509.1	4509.1	1447.6

Table 6: Mass flux for each section in each PNFM and mass load estimates using the areas of the wetland.

Wetland	Average Phosphate Mass Load g/day
LW1	2.74
LW2	1.24
BW1	1.26
BW2	0.82
PW1	3.23
PW4	1.45

Table 8: Summary table of the average phosphate mass load per wetland (LW – Larson wetland; BW – Beaty wetland)..

Wetlands	PNFM Measurement Mass Flux mg/m2/day	Mass Flux found from Darcy Velocity and TP Concentration mg/m2/day
LW1	7.46	64.06
LW2	2.09	8.02
BW1	2.83	14.82
BW2	1.83	7.22
PW1	1.75	--
PW4	1.74	0.12
Average	2.71	5.898

Table 9: Mass flux measurements estimated from the PNFM and gradient calculations.

Wetland	Gradient In days	Gradient Out days	Phosphate In grams	Phosphate Out grams	Cumulative Phosphate grams
LW1	4.0	30.0	11.0	82.2	93.1
LW2	1.5	32.5	1.9	40.2	42.1
BW1	4.0	30.0	5.1	37.9	43.0
BW2	1.0	33.0	0.8	27.0	27.8
PW4	0.0	33.0	0.0	47.8	47.8

Table 10: Number of days water gradient was into and out of the wetlands and grams of phosphate measured throughout deployment period.

Phosphate Mass Flux Range	Phosphate Mass Load Range
mg/m2/day	(metric tons/year)
1.50	2.59
2.71	4.69
8.00	13.84

Table 11: Basin wide estimates of phosphate mass loading and reduction from isolated wetlands.

Phosphate Mass Flux Range	Phosphate Mass Load Range (Using two 1 meter cross sections)
mg/m2/day	(metric tons/year)
1.36	3.97
6.32	18.46
10.93	31.91

Table 12: Basin wide estimates of phosphate mass loading from drainage ditches using a conservative drainage ditch length.

8) Task 10: Hydrologic Model Evaluation (Sanjay Shukla):

Efforts are underway to simulate the hydrology and nutrient dynamics in the watershed using the ACRU 2000 and WAM models. The two models have been calibrated using the pre-BMP data from the five sites. BMPs are currently being incorporated in the models along with the post-BMP data to evaluate the performance of ACRU and WAM for simulating BMP effectiveness.

10) Task 8: Economic Analyses (Alan Hodges):

Methods

Best management practices (BMP) studied as a part of this project were evaluated for costs of implementation. BMPs evaluated included structural improvements such as fencing and water tanks to exclude cattle from waterways, culverts/risers to retain surface water in isolated wetlands, as well as herd and pasture management by rotational grazing, altered feeding and fertilization regimes. Wetland water retention and stream fencing BMPs were each evaluated at 2 flow and water quality monitoring stations. Costs considered for implementation of BMPs included materials, labor, contract services, and management for operations and maintenance, and interest and depreciation on capital investments for equipment and property improvements amortized over the useful life of the investment. Costs were estimated based upon actual expenses incurred by researchers and ranch cooperators, together with farm enterprise budgets. Records provided by the cooperating rancher (Pelaez Ranch) included animal stocking rates for rotational grazing, forage fertilization rates, and supplemental feeding for each management unit (pasture). Management activities were tracked on 17 management units (pastures) across the period 2003 through 2006. These pastures represented a total of 546 hectares, and ranged in size from 3.9 to 56 ha. Forages managed included Floralta, stargrass and bahiagrass. The management information was aggregated to reflect the experimental watersheds monitored by the hydrologists on the project. The BMPs were assessed regarding their economic effectiveness for phosphorus removal, and impact on overall ranch income, expenses and profitability. Unit costs for BMPs were expressed on a per acre basis and per animal unit. Potential impacts of BMP's on cow herd health and performance and other non-market values were also assessed through interviews with ranch personnel.

Preliminary Results

Animal stocking on the experimental ranch totaled 13,711 animal unit months (AUM) over the four year period, or an average of 0.52 animals per hectare. Stocking rates increased nearly fourfold during the period, from 1,507 AUM in 2003 to 6,286 AUM in 2006 due to retention of heifers for permanent breeding stock (Table 13). About 15 percent of the cow herd is replaced each year by heifers. As such, this represented an increasing nutrient load on the system.

Forage improvement activities included application of ammonium sulfate, mixed fertilizers and dolomite lime, along with clearing, controlled burning and planting (Table 14). Fertilizers and amendments were applied on most of the pastures, while the other activities occurred on only one unit (RRW). Expenses for forage improvement totaled $203,716, of which $170,240 were for fertilization. Forage improvement expenses averaged $373 per hectare and $14.9 per AUM.

During the winter season, supplemental hay and soy protein pellets were fed to the experimental herd, with over 2 million pounds (916 Mg) of feed were provided (Table 15). The quantity of feed provided increased dramatically in 2004 and 2005, then decreased slightly in 2006, although higher prices in the latter year resulted in higher total costs. Expenses for supplemental feeds totaled $106,819, averaging $196 per ha or $7.8 per AUM.

A number of structural improvements were made at the experimental ranch study in support of the BMP's. Cattle were excluded from natural water bodies by providing water tanks served by underground water lines from a small well, and fences and gates and culvert crossings were installed. A second BMP was to retain stormwater in wetlands by installing water control structures with risers. Total capital costs for these structural improvements amounted to $39,157, with expenses to exclude cattle from water bodies, including water tanks, well, fencing, well and water lines, amounting to $33,271, while expenses for water control structures/risers totaled $5,886, as detailed in Table 16. Structural improvement costs averaged $80 per hectare or $40.01 per animal unit-year (AUY). Expenses for the water retention and stream exclusion BMPs were comparable at $86 and $77 per ha, respectively.

The annual depreciation expense on structural improvements, assuming a straight-line depreciation method and a useful life of 20 years, would be $1,958 in current dollars, or $3.59 per ha, or $1.77 per AUY. Average annual operating expenses for Pelaez Ranch were reported to be about $380 dollars per cow, which is significantly higher than the average for the southeast US region ($282/cow) according to Cattle Fax market news service (Table 18). The annual cost of implementing the structural improvements for BMPs in this study, would represent an increase of less than 1 percent in total operating costs, based on regional averages.

Ranch management indicated that the BMPs resulted in no changes in ranch operations, management or overhead expenses, or general herd health. It was felt that excluding cattle from natural streams and providing water supply in above-ground tanks improved the quality of drinking water, although a definite value could not be placed on this benefit.

Preliminary results for surface water runoff nutrient load reduction by the BMP for exclusion from waterways by fencing and culvert crossings were reported by Shukla (Table 19). During the pretreatment period (2004-05) the total phosphorous load flowing out of the site was 1.89 kg/ha, while during the one-year post-treatment period (2005-06), the TP load dripped to 0.15 kg/ha, representing a load reduction of 1.74 kg/ha or 92 percent. For nitrates (NH4), the load reduction was 1.20 kg/ha (95%) and for total nitrogen the load reduction was 5.03 kg/ha (93%). However, a large part of these differences was likely to do with differences in weather patterns, since total rainfall and flows off the ranch were significantly lower in the BMP period. A more narrow measure of the treatment effect can be measured by comparing loads between inflows and outflows from the treatment area during the post-BMP period. For total phosphorous the load was reduced by 0.07 kg/ha (32%), while total nitrogen load was reduced by 0.04 kg/ha (10%). Further post-treatment monitoring will be conducted to confirm these results.

Using these preliminary results for total nutrient runoff reduction, together with the amortized annual capital cost (depreciation) of the waterway exclusion BMP, its cost-effectiveness can be evaluated in a preliminary manner. The annual capital cost for the waterway exclusion BMP was $3.85 per ha (Table 20). For the lower-bound estimated phosphorous removal rate of 0.07 kg/ha annually, the average cost for TP removal would be $55 per kg, and for total nitrogen, the cost of removal is estimated at $96 per kg. This cost for phosphorous removal compares favorably with the technology of stormwater treatment areas in the Central Florida area ($442 to $1109 per kg), and is similar to costs for reservoir-assisted stormwater treatment areas ($77/kg) and the patented Managed Aquatic Plant System ($24/kg), as reported by Sano et al (2005).

Additional economic analyses will be completed after the second year of post-BMP data has been obtained for the fencing BMP, and the first year of post-BMP data has been obtained for the wetland retention BMP.

Table 13. Summary of pasture management units, best management practices evaluated, and animal stocking (2003-06).

Pasture	Area (Ha)	Forage Type	BMP Evaluated	Basin	Area within basin (ha)	Animal Stocking (AUM*)				
						2003	2004	2005	2006	Total
41	16.6	Floralta	None	0		60	120	138	356	674
42	32.8	Stargrass	None	0		106	212	212	475	1,004
43E	31.3	Floralta	Stream fencing	3	11.1	99	207	213	453	972
43W	27.6	Floralta	Stream fencing	4	17.8	96	204	204	328	832
44	19.4	Bahia	Water retention	4	1.1	41	81	95	207	423
45	37.6	Stargrass	None	0		90	180	177	345	792
46	30.8	Bahia	Water retention	4	1.1	64	129	121	197	511
51	30.8	Floralta	Stream fencing	1	3.1	119	239	241	589	1,187
51SW	4.0	Stargrass	None	0		48	48	48	98	242
51NW	3.9	Stargrass	Stream fencing	2	0.9	90	90	90	108	378
52	42.7	Stargrass	Stream fencing	2	39.7	90	180	213	666	1,149
53	44.8	Bahia	Stream fencing	1	28.9	90	180	162	325	757
54	41.5	Bahia	Stream fencing	2	14.0	90	180	195	386	851
55	49.3	Bahia	Water retention	1	37.8	75	165	168	250	658
56	41.8	Floralta	Stream fencing	1	1.4	169	338	338	654	1,498
RRE	34.8	Stargrass	None	0		90	183	195	461	929
RRW	56.0	Stargrass	Water retention	1	5.1	90	186	189	390	855
Total	546					1,507	2,921	2,998	6,286	13,711

* Animal unit months: Adult cows= 1.00, Bulls = 1.35, Yearling heifers = 0.70.

Table 14. Summary of forage improvement expenses by management unit.

Pasture	Ammonium sulfate 2003	Ammonium sulfate 2004	Fertilizer 2003	Fertilizer 2004	Fertilizer 2005	Fertilizer 2006	Dolomite (2004)	Cleared, Burned (2004)	Plant Stargrass (2004)	Total Expense
41	840		1,000	2,792	2,880	3,140	1,272			11,924
42	1,680		1,610	5,152	4,900	5,424				18,766
43E	1,260		1,500	4,188	4,320	4,710	1,908			17,886
43W	1,491		1,775	4,956	2,485	5,501	2,258			18,466
44										0
45			2,250	3,312	6,480	7,065	2,862			21,969
46										0
51		1,470	1,750	4,886	4,690	8,635	2,226			23,657
51SW						775				775
51NW	265	420		598	1,400	775				3,458
52		1,680			5,600	6,198	2,544			16,022
53										0
54										0
55										0
56	2,138		2,375	6,631	6,840	7,458	3,021			28,462
RRE		1,260			4,200	4,649	1,908			12,017
RRW		315	1,495	2,392	5,600	5,036	477	11,250	3,750	30,315
Total	7,674	5,145	13,755	34,907	49,395	59,365	18,476	11,250	3,750	203,716

Table 15. Summary of feed quantities and expenses, by management unit (pasture).

Pasture	Quantity Soy Pellets and Hay (lbs)					Expense ($)				
	2003	2004	2005	2006	Total Four Years	2003	2004	2005	2006	Total Four Years
41	6,240	13,320	16,648	289,562	325,770	265	566	957	21,717	23,506
42	34,592	68,432	55,460		158,484	1,470	2,908	3,189		7,567
43E	20,280	48,096	17,044		85,420	862	2,044	980		3,886
43W				12,132	12,132				910	910
44			4,392	17,480	21,872			253	916	1,169
45	9,180	19,800	10,620		39,600	390	842	611		1,842
46	5,880	42,690	36,810	18,400	103,780	250	1,556	1,549	965	4,319
51	39,008	77,168	59,404	46,096	221,676	1,658	3,280	3,416	3,457	11,810
51SW	5,520	10,920	23,340		39,780	235	464	1,342		2,041
51NW	6,900	13,650	13,725		34,275	293	580	789		1,663
52	9,180	19,800	25,708	15,839	70,527	390	842	1,478	1,188	3,898
53	14,280	128,740	134,652	25,360	303,032	607	4,808	6,282	1,445	13,142
54	5,040	44,100	47,600	29,320	126,060	214	1,653	2,250	1,555	5,673
55				21,760	21,760				1,154	1,154

56	55,200	103,920	103,920	63,296	326,336	2,346	4,417	5,975	4,747	17,485
RRE	9,180	20,106	19,270	14,154	62,710	390	855	1,108	1,062	3,414
RRW	9,180	20,412	36,208		65,800	390	868	2,082		3,340
Total	229,660	631,154	604,801	553,399	2,019,014	9,761	25,681	32,261	39,116	106,819

Table 16. Summary of structural improvement costs by management unit (pasture).

Pasture	Water Tank, Rock Foundation	Well, Pump, Tank	Culvert	Fence, Gate	PVC Pipe, Trench/Fill	Riser	Water Control Structure	Total Capital Cost	Annual Depreciation Expense (20 yrs)
41	756							756	38
42	756							756	38
43E	756			559	255			1,570	78
43W	756			559	255			1,570	78
44	756				1,055	1,058	1,013	3,882	194
45	756				1,028			1,784	89
46	756				1,055			1,811	91
51	756							756	38
51SW	496							496	25
51NW	496							496	25
52	756		3,950	3,057	1,028			8,791	440
53	756				1,028			1,784	89
54	756				1,028			1,784	89
55	756				1,028	1,488	2,327	5,599	280
56	756	1,710			1,028			3,494	175
RRE	756				1,028			1,784	89
RRW	1,016				1,028			2,044	102
Total	12,592	1,710	3,950	4,175	10,844	2,546	3,340	39,157	1,958

Table 17. Summary of animal stocking rates and expenses per unit, by experimental unit BMP.

Experimental Unit BMP	Area (Ha)	Animal Stocking (AUM)		Forage Improvement Expense			Feed Expense			Capital Cost		
		Total 4 years	Per Ha Per Mo	$	$ per ha	$ per AUM	$	$ per ha	$ per AUM	$	$ per ha	$ per AUM
None	125.9	3,641	0.60	65,450	520	18.0	38,370	305	10.5	5,577	44	1.5
Stream fencing	264.3	7,624	0.60	107,951	408	14.2	58,466	221	7.7	20,245	77	2.7
Water retention	155.5	2,446	0.33	30,315	195	12.4	9,982	64	4.1	13,336	86	5.5
Total	545.7	13,711	0.52	203,716	373	14.9	106,819	196	7.8	39,157	72	2.9
Water retention and stream fencing	419.9	10,071	0.50	138,266	329	13.7	68,449	163	6.8	33,581	80	3.3

Table 18. Average cow-calf costs in the southeast U.S.

Region	Pasture	Other feed	Total Feed	Labor	Vet, Supplies	Interest	Total Operating	Fuel, Utilities,	Total Cash

								etc.	Expense
				($/head)					
Southeast	75	83	165	45	21	26	125	25	282
United States	98	90	194	48	20	24	119	30	315

Source: Cattle-Fax Survey, 2006

Table 19. Mass balance of nutrients (kg/ha) for fencing/cattle crossing site.

	Pre-BMP	Post-BMP	Pre-BMP	Post-BMP	Pre-BMP	Post-BMP
	NH_4 (kg/ha)		TN (NO_3-N+TKN) (kg/ha)		TP (kg/ha)	
Flow into BMP site (Q2 plus Q3)	1.90	0.08	5.93	0.41	1.40	0.22
Flow out of BMP site (Q5)	1.27	0.07	5.40	0.37	1.89	0.15

Source: Shukla

Table 20. Average cost of nutrient removal from surface water runoff by waterway exclusion BMP.

Nutrient	Removal Rate (kg/ha)	Average Cost ($/kg)
Nitrate (NH_4)	0.01	385
Total Nitrogen (NO_3-N+TKN)	0.04	55
Total Phosphorous	0.07	96

Reflects average annual amortized capital cost for BMP of $3.85/ha

11) Task 11: BMP Education:

No BMP education activities were conducted during April – June 2007.

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