

August 8, 2006

Ms. Joyce Zhang  
South Florida Water Management District  
3301 Gun Club Road  
West Palm Beach, Florida 33406

**SUBJECT:** Letter Report Entitled: Phosphorus Reduction Performance and Implementation Costs under BMPs and Technologies in the Lake Okeechobee Protection Plan Area

Dear Joyce:

I have completed my re-evaluation of the phosphorus (P) reduction performance and implementation costs that Dr. Harper and I previously submitted to Ms. Benita Whalen as a letter report on October 20, 2003. The primary purpose of this re-evaluation was to update the values in the previous report and include one additional agricultural land use category (ornamentals) and separate range/woodland pastures from unimproved pastures. The urban land use category was also broken out into more detail.

To complete these tasks, a workshop was organized and held with leading agricultural experts with specific knowledge of BMP implementation practices and effectiveness. The workshop was held in Gainesville, FL on May 23, 2006 with the following attendees: Joyce Zhang (SFWMD), Drs. Don Graetz and Tom Obreza (Soil Science, UF), Drs. Roger Nordstedt, Ken Campbell and Sanjay Shukla (ABE, UF), Dr. Ed Hanlon (Director, SWFREC, UF), and Dr. Patrick Bohlen, Director of Research, MacArthur Agro-ecology Research Center. Dr. Ike Ezenwa (Agronomy, UF) was later contacted with regards to sand-land sugarcane production practices. The workshop was invaluable to determining the latest research and crop management practices for the primary crops grown in the Lake Okeechobee basins. The appropriate values for existing and BMPs practices for each agricultural land use were discussed in detail with updated values being developed by group consensus. The following are the primary changes developed by the group:

1. Table 1 from the previous report was reorganized to eliminate confusion for the listed primary land uses. Also, one of the land uses (ornamental), which was previously under other land uses, was considered significant enough to be analyzed separately during this assessment.
2. The stormwater retention and wetland restoration BMPs were separated with significantly less emphasis being placed on wetland restoration P reductions due to recent field data that show these restoration projects are less effective than originally thought. It is also important to note that it is assumed that stormwater retention systems will not impact in-field water tables because if they did, then they could adversely affect P loads. Also, it is assumed that the retention ponds are not constructed on fields with historic high P levels, or if they are the land is treated with alum prior to flooding.
3. Existing unit loads and BMP reductions from unimproved pastures were redone so that there would be a difference between unimproved pasture and range/woodland

pastures. The workshop group agreed that the typical definition of unimproved pasture has animal densities and grass and fertility practices somewhere in between the improved and range/woodland pastures categories. Table values were adjusted accordingly.

4. The land use category of ornamentals was added and assumed to be an intensive ornamental nursery operation, but it is recognized that ornamental field crops, such as caladiums, may also be mapped under this category. However, ornamental field crops would be more similar to row crops than nurseries, and therefore it is suggested that for now the row crops table be used for ornamental field crops.
5. An assessment table for the land use category of field crops was added and assumed to be a hay field that is fertilized with P. The workshop group helped develop estimates for existing and BMP P reduction and cost estimates.
6. The workshop group found the previous P fertilizer rates for citrus to be high because P fertilization on citrus typically only occurs over the first few years after planting. This change significantly reduced the potential P reductions for the fertility BMP.
7. There were a few other minor changes made to P reduction ranges and typical values and the estimated costs of implementation as suggested by the workshop group. Most of these changes were associated with stormwater retention and the fertility BMP.
8. An assessment table was also developed for the urban land use category because of this land use's importance in any watershed BMP implementation programs.

The overall findings from this assessment are provided in Table 1 while the detailed updated assessments for the primary agricultural and urban land uses are provided in Attachment 1. As before, it is anticipated that the implementation of owner and typical cost share BMPs in the urban and agricultural sectors will still provide approximately a twenty five (25) percent reduction in phosphorus loads into the tributary streams within the Okeechobee basin. Additional reductions could be achieved by a more aggressive BMP implementation program within the basin. The reductions shown are for what are called a "typical" BMP implementation level under a moderately aggressive program that assumes a limited amount of cost share support will be available for farmers and urban landowners.

Table 2 provides estimates of the tons of P reduction that might be expected across the Okeechobee basin, excluding the Upper Kissimmee Chain of Lakes basins, based on BMP efficiencies presented in Attachment 1 and the most recent (2006) land use data provided by the District. This table uses the same unit loading estimates as presented in Table 1.

It is recommended that the values in this report be updated periodically as additional research and field data come available.

Sincerely,



Del Bottcher, Ph.D., P.E.

Enclosures: Table 1, Table 2, and Attachment 1

**Table 1: Land Use Categories, Unit Load Factors, and P Reduction Factors for 2002 Land Use**

Landuse Category	FLUCCS	FLUCCS Description	Unit Load (lbs/acre/ yr)	Owner Implemented BMPs (1)	Typical Cost Share BMPs	Alternative Practices
Urban	1009	Mobile Home Units	0.66	3%	0%	0%
	1100	Residential Low Density				
	1200	Residential Medium Density				
	1300	Residential High Density				
	1400	Commercial and Services				
	1500	Industrial				
	1600	Extractive				
	1700	Institutional				
	1800	Recreational				
Improved Pastures	2110	Improved Pastures	0.72	11%	19%	49%
Unimproved Pastures	2120	Unimproved Pastures	0.49	7%	13%	44%
Woodland Pastures/Rangeland	2130/3000	Woodland Pastures/Rangeland	0.27	4%	6%	35%
Row Crops	2140	Row Crops	6.30	30%	30%	50%
Sugarcane	2156	Field Crops - Sugarcane	0.63	10%	23%	52%
Citrus	2210	Citrus	1.62	12%	20%	42%
Sod / Turf	2420	Sod Farms	2.52	20%	27%	50%
Ornamentals	2430	Ornamentals	4.10	32%	35%	50%
Dairies	2520	Dairies	3.38	9%	28%	48%
Pine Plantations	4400	Tree Plantations/Pine	0.18	1%	10%	50%
Dairies in non-priority basins		Dairies in Istokpoga and Caloosahatchee	0.17	2%	30%	48%
Natural Areas	4000	Upland Forests (not including 4400's)	0.20	0%	0%	0%
	5000	Water				
	6000	Wetlands				
	7000	Barren Land				
	1900	Open Land				
	8000	Transportation, Communication, and Utilities				
Other Areas	9000	Special Classifications	0.70	10%	0%	0%
	2150	Field Crops				
	2230	Other Groves				
	2220	Fruit Orchards				
	2320	Poultry Feeding Operations				
	2410	Tree Nurseries				
	2450	Floriculture				
	2510	Horse Farms				
2540	Aquaculture					
	2610	Fallow Crop Land				

**Table 2: Land Use Categories, Unit Load Factors, and Estimated P Reduction Factors Using 2006 Land Use for Lake Okeechobee Protection Plan Area, Excluding the Upper Kissimmee Basin**

Land Use Category	Acres	Amount of Total Area	Existing Unit Load (lbs-P/ac/yr)	Total P (tons-P/yr)	Estimated % P Reduction	Total P after Reduction (tons-P/yr)
Improved Pastures	542797	22.34%	0.72	195	30	137
Unimproved Pastures	110435	4.55%	0.49	27	20	21
Rangeland and Woodland Pasture	142757	5.88%	0.27	19	10	17
Urban	161878	6.66%	0.66	53	10	48
Dairies	22432	0.92%	3.38	38	37	24
Citrus	177259	7.30%	1.62	144	32	98
Field Crops - Sugarcane	399679	16.45%	0.63	126	33	84
Sod Farms	29575	1.22%	2.52	37	47	20
Row Crops	19766	0.81%	6.30	62	60	25
Ornamentals	4500	0.19%	4.10	9	67	3
Other Areas	19170	0.79%	0.70	7	10	6
Natural Areas	753188	31.00%	0.20	75	0	75
Tree Plantations	45944	1.89%	0.18	4	11	4
<b>Grand Total</b>	<b>2429381</b>	<b>100.00%</b>		<b>797</b>	<b>29</b>	<b>562</b>

# ATTACHMENT 1

**Current condition assumptions, existing P loads, potential P load reductions,  
and costs of implementation for the primary land uses within the Okeechobee  
basin.**

**(Updated 8/8/06)**

## **Table of Contents for BMP Assessment Tables**

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# BMPs for Citrus

Assume for Typical Condition							
Two row crown bedded Assumed average farm size of 200 ac Grass Management between Trees Pond retention with limited wetland restoration Micro jet irrigation and fertigation of young stock Existing P Load (conc.=0.6 ppm with 12 " of runoff)				1.62	lbs-P/ac/yr		
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 25	10	0	0	0	Slow
Better N and Micros Fertilization	Owner	0 to 5	2	0	0	0	Slow
Water Management (irrigation and drainage)	Typical	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds	Typical	0 to 50	10	33	10.56	65	Fast
Grass Management between Trees	Owner	0 to 5	2	22	7.04	217	Moderate
Grassed Waterways	Alternative	0 to 15	5	110	35.2	434	Fast
Stormwater R/D <sup>4</sup>	Typical	10 to 60	40	440	140.8	217	Fast
Wetland Restoration	Typical	5 to 20	10	44	14.08	87	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment	Alternative	20 to 90	70	220	70.4	62	Fast
<p>1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP</p> <p>2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&amp;M Cost</p> <p>3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&amp;M.</p> <p>4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly.</p> <p>5 Average of pre/post 1984 stormwater management requirements, i.e. P &gt; .6ppm if developed prior to 1984 and less if developed after 1984. Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves.</p> <p>6 High O&amp;M Costs</p>							
<b>Typical/Owner BMP Program</b> Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention		10 to 50	32	75	24	145	Moderate
<b>Owner BMP Program</b> Reduced P Fertilization, Better N Management, and Grass Management between Trees		0 to 25	12	5.5	0	0	Slow
<b>Typical BMP Program</b> Stormwater R/D and Wetland Restoration		5 to 50	20	77	24.64	76	Fast
<b>Alternative BMP Program</b> Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D with Chemical Treatment		20 to 90	42	242	77	114	Fast

# BMPs for Cow Calf Production

## Improved Pastures

Assume for Typical Condition								
3 ac / cow Assumed average farm size of 500 ac Existing P fertilization of 3 lbs P/ac No retention or wetland restoration Bahia grass Animals have access to streams Existing P Load (conc.=0.4 ppm with 8" of runoff)      0.72 lbs-P/ac/yr								
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response	
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)		
Fertility	Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 30	10	2.2	2.2	31	Slow
	Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	255	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)		Owner	0 to 20	2	5.5	1.76	122	Slow
Improved Grazing Management								
	Rotational Grazing	Typical	0 to 30	3	5.5	1.76	81	Moderate
	Reduced Stocking Rate <sup>4</sup> (4ac /cow)	Owner	0 to 10	3	165	52.8	2444	Slow
HIA and Direct Water Access Prevention								
	Improved Watering Facilities to move cattle from streams	Typical	0 to 20	10	11	3.52	49	Fast
	Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	16.5	5.28	367	Fast
	Feeder/Minerals and Water Placement	Owner	0 to 30	3	2.2	0.704	33	Fast
	Critical Area Fencing	Typical	2 to 20	5	44	14.08	391	Fast
	Retention Basin by Working Pens	Typical	2 to 10	5	3.3	1.056	29	Fast
Buffer Strips		Typical	0 to 10	5	44	14.08	391	Fast
Stormwater R/D		Typical	5 to 40	15	44	14.08	130	Fast
Wetland Restoration		Typical	2 to 15	5	11	3.52	98	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>5</sup>		Alternative	20 to 90	70	220	70.4	140	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered 5 High O&M Costs								
<b>Typical/Owner BMP Program</b>			10 to 50	30	49.5	15.84	73	Moderate
P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention								
<b>Owner BMP Program</b>			0 to 25	11	11	4	44	Slow
P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement								
<b>Typical BMP Program</b>			10 to 50	19	38.5	12	90	Moderate
Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention								
<b>Alternative BMP Program</b>			20 to 90	49	110	35	100	Fast
Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment								

# BMPs for Cow Calf Production

## Unimproved Pasture

Assume for Typical Condition								
8 ac per cow Assumed average farm size of 500 ac Existing P fertilization of 1 lbs P/ac No retention or wetland restoration Bahia grass / native Animals have access to streams Existing P Load (conc.=0.27 ppm with 8 " of runoff)      0.49   lbs-P/ac/yr								
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response	
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)		
Fertility	Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	453	Slow
Grass Management (chopping, mowing, burning, etc.)		Owner	0 to 10	2	2.2	0.704	72	Slow
Improved Grazing Management	Rotational Grazing (limited)	Typical	0 to 5	3	5.5	1.76	121	Moderate
HIA and Direct Water Access Prevention	Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	72	Fast
	Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	48	Fast
	Critical Area Fencing	Alternative	2 to 10	3	11	3.52	241	Fast
	Retention Basin by Working Pens	Typical	2 to 10	3	3.3	1.056	72	Fast
Stormwater R/D		Typical	2 to 15	7	22	7.04	207	Fast
Wetland Restoration		Typical	2 to 10	4	11	3.52	181	Fast
Edge-of-farm stormwater R/D and Chemical Treatment		Alternative	20 to 70	50	110	35.2	145	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs								
<b>Typical/Owner BMP Program</b>			5 to 30	20	13.2	4.224	43	Moderate
Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention								
<b>Owner BMP Program</b>			0 to 20	7	2.2	1	21	Slow
Improved Grass Management, Watering Facilities, and Feed Placement								
<b>Typical BMP Program</b>			5 to 25	13	11	4	56	Moderate
Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention								
<b>Alternative BMP Program</b>			20 to 70	44	55	18	82	Fast
Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment								

# BMPs for Cow Calf Production

## Rangeland and Wooded Pasture

Assume for Typical Condition								
16ac per cow Assumed average farm size of 500 ac Existing P fertilization of 0 lbs P/ac No retention or wetland restoration Bahia grass / native Animals have access to streams Existing P Load (conc.=0.15 ppm with 8 " of runoff)      0.27   lbs-P/ac/yr								
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response	
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)		
Fertility	Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2.2	2.2	815	Slow
Grass Management (chopping, mowing, burning, etc.)		Owner	0 to 10	2	2.2	0.704	130	Slow
Improved Grazing Management	Rotational Grazing (limited)	Typical	0 to 5	3	5.5	1.76	217	Moderate
HIA and Direct Water Access Prevention	Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5.5	1.76	130	Fast
	Feeder/Minerals and Water Placement	Owner	0 to 10	3	2.2	0.704	87	Fast
	Critical Area Fencing	Alternative	2 to 10	3	11	3.52	434	Fast
	Retention Basin by Working Pens	Typical	2 to 10	3	3.3	1.056	130	Fast
Stormwater R/D		Typical	2 to 20	10	22	7.04	261	Fast
Wetland Restoration		Typical	2 to 10	4	11	3.52	326	Fast
Edge-of-farm stormwater R/D and Chemical Treatment		Alternative	20 to 70	40	110	35.2	326	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs								
<b>Typical/Owner BMP Program</b>			5 to 30	10	13.2	4.224	156	Moderate
Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention								
<b>Owner BMP Program</b>			0 to 20	4	2.2	1	65	Slow
Improved Grass Management, Watering Facilities, and Feed Placement								
<b>Typical BMP Program</b>			5 to 25	6	11	4	217	Moderate
Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention								
<b>Alternative BMP Program</b>			20 to 70	35	55	18	186	Fast
Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment								

## BMPs for Dairies

Assume for Typical Condition							
1000 head Dairy, dry cows pastured on site, 400 heifer/springers on site Assumed average farm size of 700 ac Existing P fertilization of 0 lbs P/ac No existing retention or wetland restoration Stargrass Pastures Animals are fenced from streams Existing P Load <sup>6</sup> (conc.=1.5 ppm with 10 " of runoff)      3.38      lbs-P/ac/yr							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
<b>Barn Waste</b>							
Feed Ration Management	Owner	0 to 25	8	2.2	2.2	8	Slow
Solids Separation for Off Site Disposal	Alternative	0 to 10	3	5.5	1.76	17	Slow
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	16.5	5.28	8	Moderate
Improved Forage/Sprayfield Management - P balanced, new crops	Owner	0 to 15	5	0	0	0	Slow
<b>HIA Management</b>							
Add Housing to Move Animals off Fields <sup>4</sup>	Alternative	30 to 70	50	3,929	1257	745	Slow
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	440	140.8	104	Moderate
Edge-of-field Chemical Treatment <sup>5</sup>	Alternative	50 to 90	70	550	176	74	Fast
<b>Buffer Strips</b>							
Stormwater R/D	Typical	15 to 50	30	1100	352	348	Fast
Wetland Restoration	Typical	5 to 20	10	11	3.52	10	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>5</sup>	Alternative	50 to 90	70	550	176	74	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Value only include implementation cost, i.e. doesn't include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 Includes associated waste pond and sprayfield expansions 5 High O&M Costs 6 Only 5% of the shown load will reach Lake Okeechobee from dairies in the Caloosahatchee Basin							
<b>Typical/Owner BMP Program</b>		20 to 65	37	1045	334.4	837	Moderate
Stormwater R/D and Wetland Restoration Feed Management							
<b>Owner BMP Program</b>		0 to 25	9	2.2	2	7	Slow
Feed Ration Management							
<b>Typical BMP Program</b>		20 to 60	28	1042.8	333.696	316	Fast
Stormwater R/D and Wetland Restoration							
<b>Alternative BMP Program</b>							
<b>Barn Waste</b>							
Solids Separation for Off Site Disposal		0 to 10	3	6	1.76	17	Slow
Expanded Waste Storage Ponds <sup>4</sup>		----	----	----	----	----	----
Expanded Sprayfields <sup>4</sup>		----	----	----	----	----	----
<b>HIA Management</b>							
Add Housing to Move Animals off Fields <sup>4</sup>		30 to 70	50	3929	1257	745	Slow
Stormwater Retention / Expanded Sprayfield		20 to 70	40	440	141	104	Moderate
Edge-of-field Chemical Treatment <sup>5</sup>		50 to 90	70	550	176	74	Fast
<b>Buffer Strips</b>							
Stormwater R/D		15 to 50	30	1100	352	348	Fast
Wetland Restoration		5 to 20	10	11	3.52	10	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>5</sup>		50 to 90	70	550	176	74	Fast

## BMPs for Field Crop (Hayland) Production

Assume for Typical Condition							
Assumed average farm size of 500 ac Existing P fertilization of 60 lbs P/ac No retention or wetland restoration Stargrass  Existing P Load (conc.=1.0 ppm with 8 " of runoff)                      1.80    lbs-P/ac/yr							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 50	15	2.2	2.2	8	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5.5	5.5	102	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5.5	1.76	49	Slow
Buffer Strips	Typical	0 to 10	5	44	14.08	156	Fast
Stormwater R/D	Typical	10 to 40	20	55	17.6	49	Fast
Wetland Restoration	Typical	5 to 20	10	11	3.52	20	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>5</sup>	Alternative	20 to 90	36	220	70.4	109	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 This practice would typically be unacceptable to most farmers, but if significant feed is being purchased then it should be considered 5 High O&M Costs							
<b>Typical/Owner BMP Program</b> P reduced to zero, Better N Management, Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Improved Grass Management, Feed Placement, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 60	40	50	15.84	22	Moderate
<b>Owner BMP Program</b> P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement		0 to 25	15	11	4	13	Slow
<b>Typical BMP Program</b> Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention		10 to 50	25	39	12	27	Moderate
<b>Alternative BMP Program</b> Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment		20 to 90	36	110	35	54	Fast

# BMPs for Ornamentals

Assume for Typical Condition							
Ornamental Nursery Assumed average farm size of 10 ac Existing P fertilization of 160 lbs P/ac No retention or wetland restoration Overhead Irrigation Existing P Load (conc.=1.3 ppm with 14 " of runoff) <span style="float: right;">4.10 lbs-P/ac/yr</span>							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	30	11	11	9	Slow
Water Management (irrigation and drainage, riser board control)	Typical	0 to 40	10	11	4	9	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	11	26	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	11	4	43	Fast
Off Season In-Field Retention	Typical	0 to 15	5	11	4	17	Fast
Off Season Cover Crop	Typical	0 to 10	4	55	18	107	Fast
Stormwater R/D	Typical	10 to 65	40	220	70	43	Fast
Wetland Restoration	Typical	0 to 10	4	11	4	21	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>4</sup>	Alternative	20 to 90	50	550	176	86	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs							
<b>Typical/Owner BMP Program</b>		10 to 80	67	220	70	26	Moderate
Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention							
<b>Owner BMP Program</b>		20 to 70	32	11	4	3	Slow
Reduced P Fertilization							
<b>Typical BMP Program</b>		10 to 50	35	209	67	47	Fast
Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention							
<b>Alternative BMP Program</b>		20 to 90	50	440	141	69	Fast
Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment							

## BMPs for Pine Plantation

<b>Assume for Typical Condition</b>							
Planted Pine Plantation (20 yr rotation) Assumed average farm size of 200 ac Existing P fertilization of 5 lbs P/ac No retention or wetland restoration Existing P Load (conc.=0.1 ppm with 8 " of runoff) <span style="float:right">0.18 lbs-P/ac/yr</span>							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 10	1	0	0	0	Slow
Stormwater R/D	Typical	2 to 15	8	22	22	1527	Fast
Wetland Restoration	Typical	1 to 5	2	11	3.52	978	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>4</sup>	Alternative	20 to 70	50	110	35.2	391	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs							
<b>Typical/Owner BMP Program</b> Reduced P Fertilization, Stormwater R/D, and limited Wetland Restoration		2 to 25	11	22	22	1111	Moderate
<b>Owner BMP Program</b> Reduced P Fertilization		0 to 25	1	0	0	0	Slow
<b>Typical BMP Program</b> Stormwater R/D and limited Wetland Restoration		10 to 50	10	22	20	1111	Fast
<b>Alternative BMP Program</b> Edge-of-farm Stormwater R/D and Chemical Treatment		20 to 70	50	100	32	355	Fast

# BMPs for Row Crop

Assume for Typical Condition							
Potatoes Spring Crop Assumed average farm size of 100 ac Existing P fertilization of 100 lbs P/ac No retention or wetland restoration Seepage Irrigation with 60' furrows Existing P Load (conc.=2.0 ppm with 14 " of runoff) <span style="float: right;">6.30 lbs-P/ac/yr</span>							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility	Owner	20 to 70	30	11	11	6	Slow
Reduced P Fertilization (testing, split, placement, and type)	Typical	0 to 40	10	11	3.52	6	Fast
Water Management (irrigation and drainage, riser board control)	Alternative	0 to 20	10	33	10.56	17	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 5	2	11	3.52	28	Fast
Erosion Control (sediment trap in front of risers)	Typical	0 to 15	5	11	3.52	11	Fast
Off Season In-Field Retention	Typical	0 to 10	4	55	17.6	70	Fast
Off Season Cover Crop	Typical	10 to 55	25	220	70.4	45	Fast
Stormwater R/D	Typical	5 to 20	10	11	3.52	6	Fast
Wetland Restoration	Alternative	20 to 90	50	550	176	56	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>4</sup>							
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs							
<b>Typical/Owner BMP Program</b>		10 to 80	60	220	70.4	19	Moderate
Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention							
<b>Owner BMP Program</b>		20 to 70	30	11	3.52	2	Slow
Reduced P Fertilization							
<b>Typical BMP Program</b>		10 to 50	30	209	66.88	35	Fast
Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention							
<b>Alternative BMP Program</b>		20 to 90	50	440	140.8	45	Fast
Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment							

# BMPs for Sod / Turf Grass

Assume for Typical Condition							
Bermudagrass Assumed average farm size of 100 ac Existing P fertilization of 70 lbs P/ac No retention or wetland restoration Seepage Irrigation with 100' furrows Existing P Load (conc.=.80 ppm with 14 " of runoff)                      2.52    lbs-P/ac/yr							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2.2	2.2	4	Slow
Water Management (irrigation and drainage, riser board control)	Typical	0 to 20	10	11	3.52	14	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	55	17.6	140	Fast
Stormwater R/D	Typical	5 to 40	25	110	35.2	56	Fast
Wetland Restoration	Typical	2 to 15	8	11	3.52	17	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>4</sup>	Alternative	20 to 90	50	330	105.6	84	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs							
<b>Typical/Owner BMP Program</b>		10 to 70	47	110	35.2	30	Moderate
Reduced P fertilization, water management, additional stormwater retention, and limited wetland restoration							
<b>Owner BMP Program</b>		10 to 50	20	2.2	2.2	4	Slow
Reduced P Fertilization							
<b>Typical BMP Program</b>		10 to 50	27	107.8	34	51	Fast
Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention							
<b>Alternative BMP Program</b>		20 to 70	50	330	105.6	84	Fast
Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment							

# BMPS for Sugarcane

Assume for Typical Condition							
3 year ratoon Assumed average farm size of 400 ac Existing P fertilization of 30 lbs P/ac Limited retention or wetland restoration Seepage Irrigation with 330' furrows Existing P Load (conc.=.20 ppm with 14 " of runoff) <span style="float: right;">0.63 lbs-P/ac/yr</span>							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility pH management		0 to 20	10	0	0	0	Fast
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	0	0	0	Slow
Water Management (irrigation and drainage, in-field retention)	Typical	0 to 20	10	11	3.52	56	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	33	10.56	168	Fast
Stormwater R/D	Typical	5 to 45	15	110	35.2	372	Fast
Wetland Restoration	Typical	2 to 15	7	11	3.52	80	Fast
Edge-of-farm stormwater R/D and Chemical Treatment <sup>4</sup>	Alternative	20 to 90	70	220	70.4	160	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire farm basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 High O&M Costs							
<b>Typical/Owner BMP Program</b>		10 to 70	33	110	35	169	Moderate
Reduced P fertilization, water management, and limited wetland restoration/retention							
<b>Owner BMP Program</b>		10 to 50	10	2.2	0	0	Slow
Reduced P Fertilization							
<b>Typical BMP Program</b>		10 to 60	23	107.8	34	238	Fast
Water Management and limited Wetland Restoration/Retention							
<b>Alternative BMP Program</b>		20 to 90	52	275	88	269	Fast
Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment							

## BMPs for Urban

Assume for Typical Condition							
Medium Density Residential with Mixed Commercial Assumed average development size of 200 ac Moderately Managed Lawns Limited Pond retention Limited Lawn Irrigation Existing P Load (conc.=0.26 ppm with 12 " of runoff)      0.70 lbs-P/ac/yr							
BMPs	Type	P Reduction <sup>1</sup>		Initial Cost of BMP <sup>2</sup> (\$/ac )	Annual Cost <sup>3</sup>		Quickness of Response
		Range %	Typical %		per acre (\$/ac/yr)	P Removed (\$/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 10	5	0	0	0	Slow
Dry Retention/Swales 0.25"	Typical	20 to 80	50	6400	2048	5833	Fast
Wet Detention - 0.25"	Typical	30 to 90	80	8000	2560	4557	Fast
Street Sweeping	Typical	0 to 25	15	20	6.4	61	Fast
Sediment/Baffle Boxes	Typical	10 to 60	20	440	140.8	1003	Fast
Dry Detention - Regional	Alternative	15 to 35	25	3200	1024	5833	Fast
Wet Detention - Regional	Alternative	40 to 80	65	4000	1280	2804	Fast
Stormwater R/D and Chemical Treatment	Alternative	20 to 90	70	3200	1024	2083	Fast
1 Estimated values assume no other BMPs applied. Note, combined BMPs will reduce effectiveness of individual BMP 2 Costs presented on per acre of entire development basis unless otherwise noted. Costs value only include implementation cost, i.e. does not include O&M Costs. 3 The annual cost include amortized capital costs at 10% interest over a twenty-year life span and a 20% per year of capital cost for annual O&M. 4 Values shown are for using existing ponds for water reuse, if new facilities are needed then cost would increase significantly. 5 Average of pre/post 1984 stormwater management requirements, i.e. P > .25ppm if developed prior to 1984 and less if developed after 1984. Groves developed after 1984 would probably have stormwater R/D systems, so little addition benefit would be expected for newer groves. 6 High O&M Costs							
<b>Typical/Owner BMP Program</b>		0 to 20	10	500	160	2279	Moderate
Reduced P Fertilization, Swales, and limited Dry Retention/Sweeping							
<b>Owner BMP Program</b>		0 to 10	5	0	0	0	Slow
Reduced P Fertilization							
<b>Typical BMP Program</b>		5 to 50	5	500	160	4557	Fast
Limited Dry Retention, Street Sweeping, Sediment R/D and Wetland Restoration							
<b>Alternative BMP Program</b>		20 to 90	70	3200	1024	2083	Fast
Stormwater R/D with Chemical Treatment							