October 20, 2003

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

SUBJECT: Letter Report Entitled: Estimation of Best Management Practices and Technologies Phosphorus Reduction Performance and Implementation Costs in the Northern Lake Okeechobee Watershed

Dear Benita:

Dr. Harvey Harper and I have completed our review of the BMPs documents you provided and have developed this letter report as required as part of our recent contract to estimate the best management practices (BMPs) and technologies phosphorus reduction performance and implementation costs in the Northern Lake Okeechobee Watershed. The agricultural portion of this assessment was completed by me while the urban portion was completed by Dr. Harvey Harper with Environmental Research and Design, Inc. As much as possible the values in this assessment are based on available research data, but where data were not available, we provided our best professional opinion as to the actual P loads and reductions associated with specific land uses and their BMPs.

The current condition assumptions, existing P loads, potential P load reductions, and costs of implementation for the primary land uses within the Okeechobee basin are provided in Attachment 1. For details of the agricultural BMPs and related contributions to Lake Okeechobee the following references should be consulted:

Online at www.dep.state.fl.us/water/nonpoint/pubs.htm

Water Quality / Quantity Best Management Practices for Indian River Area Citrus Groves

Water Quality Best Management Practices for Cow/Calf Operations in Florida

Silviculture Best Management Practices

Comprehensive Nutrient Management Planning - Technical Guidance

Online at www.ifas.ufl.edu

Fertilizer Management - Key to a Sound Water Quality Program
Del Bottcher and Ed Hanlon

Procedural Guide for the Development of Farm-Level Best Management Practice Plans for Phosphorus Control in the Everglades Agricultural Area
Del Bottcher, Forrest Izuno, and Ed Hanlon

Other Publications:

Estimating Phosphorus Load Reductions Resulting from BMP Implementation in the Northern Lake Okeechobee Basin. SFWMD staff internal report.

Bottcher, A.B., T.K. Tremwel, K.L. Campbell. 1995. Best Mangement Practices for Water Quality Improvement in the Lake Okeechobee Watershed. Ecological Engineering (5) 1995 p341-356.

Ray, Susan A.F. and Joyce Zhang. 2001. Evaluation of Phosphorus Load Reduction Alternatives for Dairy Sites in the Lake Okeechobee Watershed. Decision Support for Water Resources Management. SWRA/UCOWR Summer Specialty Conference.

Zhang, J. and A. Essex. 1997. Phosphorus Load Reductions from Out-of-Compliance Sites in the Lake Okeechobee Watershed, Florida. ASAE. Applied Engineering in Agriculture. Vol. 13(2):193-198.

Potential for Phosphorus Load Reduction Alternatives in Dairy Runoff in the Lake Okeechobee Watershed, Florida. ASAE. Applied Engineering in Agriculture. Vol. 12(3):329-334.

Zhang, Joyce, Susan A.F. Ray, and Annoesjka Steinman. 2002. Potential Phosphorus Load Reductions Under the Lake Okeechobee Regulatory Program. J. American Water Resources Association. Vol. 38(6)1613-1624.

Hazen and Sawyer. 2002. Evaluation of Isolated Wetlands Restoration on Pastureland in the Lake Okeechobee Watershed. Final Report to the SFWMD.

The details of the assumptions and references used for the urban land uses are provided in Attachment 2 (Dr. Harvey Harper report).

The overall findings from this assessment are provided in Table 1 below. As can be seen, implementation of BMPs in the urban and agricultural sectors for the assumptions provided will provide approximately a twenty five (25) percent reduction in phosphorus loads into the tributary stream 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 we are calling 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.

Sincerely,

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

Table 1. Estimated Existing and Reduced P Loads Off the Land in the Okeechobee Basin Due to BMP Implementation

FLUCCS Description		Acres	% of Total Landuse Area	Existing Unit Load (lbs-P/ac/yr)	Total P Load (tons)	Estimated % Reduction	Total P after Reduction (tons)
Primary Agricultural Land Use							
	Improved Pastures	431,391	36.24%	0.72	155	30	109
	Unimproved Pastures	70,927	5.96%	0.27	10	20	8
	Woodland Pastures	8,652	0.73%	0.27	1	20	1
	Rangeland	110,579	9.29%	0.23	13	20	10
	Urban	27,280	2.29%	0.66	9	30	6
	Dairies	29,084	2.44%	3.38	49	32	33
	Citrus	54,763	4.60%	1.62	44	40	27
	Field Crops - Sugarcane	16,586	1.39%	0.63	5	25	4
	Sod Farms	10,652	0.89%	2.52	13	40	8
	Row Crops	7,024	0.59%	6.30	22	60	9
SUM OF "Primary Ag Land Uses"		**766,938**	**64.43%**	**Subtotal**	**322**	**33**	**215**
Other Land Uses							
	Field Crops	3,000	0.25%	0.50	1	10	1
	Fruit Orchards	6,665	0.56%	0.50	2	10	1
	Other Groves	16	0.00%	0.50	0	10	0
	Poultry Feeding Operations	49	0.00%	0.50	0	10	0
	Tree Nurseries	411	0.03%	0.50	0	10	0
	Ornamentals	7,320	0.61%	0.50	2	10	2
	Floriculture	21	0.00%	0.50	0	10	0
	Horse Farms	310	0.03%	0.50	0	10	0
	Aquaculture	833	0.07%	0.50	0	10	0
	Fallow Crop Land	2,477	0.21%	0.50	1	10	1
	Upland Forests	115,989	9.74%	0.50	29	0	29
	Pine Plantation	32,600	2.74%	0.18	3	11	3
	Water	12,966	1.09%	0.50	3	0	3
	Wetlands	224,117	18.83%	0.50	56	0	56
	Barren Land	10,646	0.89%	0.50	3	0	3
	Transportation, Communication, and Utilities	5,907	0.50%	0.50	1	0	1
	Special Classifications	0	0.00%	0.50	0	0	0
SUM OF "Other Land Use"		**423,326**	**35.57%**	**Subttotal**	**101**	**1**	**100**
	Grand Total	**1190264**	100.00%		**423**	**25**	**314**

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.

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[6] (conc.=1.5 ppm with 10 " of runoff) 3.38 lbs-P/ac/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2]	Annual Cost[3]		Quickness of Response
		Range %	Typical %	($/ac)	per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Barn Waste							
Feed Ration Management	Owner	0 to 25	8	2	2	7	Slow
Solids Separation for Off Site Disposal	Alternative	0 to 10	3	5	1.6	16	Slow
Expanded Waste Storage Ponds	Alternative	----	----	----	----	----	----
Expanded Sprayfields	Alternative	----	----	----	----	----	----
Improved Pasture Management (See Cow-Calf Imp.. Pasture)	Owner	10 to 40	20	15	4.8	7	Moderate
Improved Forage/Sprayfield Management - P balanced, new crops	Owner	0 to 15	5	0	0	0	Slow
HIA Management							
Add Housing to Move Animals off Fields[4]	Alternative	30 to 70	50	3,571	1143	677	Slow
Stormwater Retention / Expanded Sprayfield	Alternative	20 to 70	40	400	128	95	Moderate
Edge-of-field Chemical Treatment[5]	Alternative	50 to 90	70	500	160	68	Fast
Buffer Strips	Alternative	0 to 10	5	40	12.8	76	Moderate
Stormwater R/D and Wetland Restoration	Typical	20 to 60	30	1000	320	316	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	50 to 90	70	500	160	68	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

Typical/Owner BMP Program Stormwater R/D and Wetland Restoration Feed Management	20 to 65	32	950	304	879	Moderate
Owner BMP Program Feed Ration Management	0 to 25	4	2	2	7	Slow
Typical BMP Program Stormwater R/D and Wetland Restoration	20 to 60	28	948	303.36	316	Fast
Alternative BMP Program	20 to 90	48	500	160	99	Fast
Barn Waste						
Solids Separation for Off Site Disposal	0 to 10	3	5	1.6	16	Slow
Expanded Waste Storage Ponds[4]	----	----	----	----	----	----
Expanded Sprayfields[4]	----	----	----	----	----	----
HIA Management						
Add Housing to Move Animals off Fields[4]	30 to 70	50	3571	1143	677	Slow
Stormwater Retention / Expanded Sprayfield	20 to 70	40	400	128	95	Moderate
Edge-of-field Chemical Treatment[5]	50 to 90	70	500	160	68	Fast
Buffer Strips	0 to 10	5	40	13	76	Moderate
Edge-of-farm stormwater R/D and Chemical Treatment[5]	50 to 90	70	500	160	68	Fast

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)[5] 1.62 lbs-P/ac/yr

BMPs	Type	P Reduction[1]		Initial Cost of BMP[2] ($/ac)	Annual Cost[3]		Quickness of Response
		Range %	Typical %		per acre ($/ac/yr)	P Removed ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, placement, and type)	Owner	0 to 50	25	0	0	0	Slow
Better N and Micros Fertilization	Owner	0 to 5	2	0	0	0	Slow
Fertigation	Alternative	0 to 30	10	0	0	0	Slow
Water Management (irrigation and drainage)	Typical	0 to 20	5	0	0	0	Fast
Water Reuse from Retention/Detention Ponds[4]	Typical	0 to 50	10	30	9.6	59	Fast
Grass Management between Trees	Owner	0 to 5	2	20	6.4	197	Moderate
Grassed Waterways	Alternative	0 to 15	5	100	32	395	Fast
Stormwater R/D and Wetland Restoration[5]	Typical	5 to 50	20	400	128	395	Fast
Edge-of-farm Stormwater R/D and Chemical Treatment[6]	Alternative	20 to 90	70	200	64	56	Fast
Typical/Owner BMP Program Reduced P Fertilization, Better N Management, Grass Management between Trees, additional Stormwater Retention, and limited Wetland Restoration/Retention		10 to 50	40	75	24	116	Moderate
Owner BMP Program Reduced P Fertilization, Better N Management, and Grass Management between Trees		0 to 25	20	5	0	0	Slow
Typical BMP Program Stormwater R/D and Wetland Restoration		5 to 50	20	70	22.4	69	Fast
Alternative BMP Program Fertigation, Grassed Waterways, and Edge-of-farm Stormwater R/D and Chemical Treatment		20 to 90	42	220	70	103	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 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 > .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.
6 High O&M Costs

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 5 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[1]**		**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %		**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	0 to 50	15	2	2	19	Slow
Better N and Micros Fertilization	Owner	0 to 20	3	5	5	231	Slow
Grass Management (variety, mowing, burning, irrigation, etc.)	Owner	0 to 20	2	5	1.6	111	Slow
Improved Grazing Management							
Rotational Grazing	Typical	0 to 30	3	5	1.6	74	Moderate
Reduced Stocking Rate[4] (4ac /cow)	Owner	0 to 30	7	150	48	952	Slow
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Typical	0 to 20	10	10	3.2	44	Fast
Provide Alternative Shade to move cattle from streams	Alternative	0 to 10	2	15	4.8	333	Fast
Feeder/Minerals and Water Placement	Owner	0 to 30	3	2	0.64	30	Fast
Critical Area Fencing	Typical	2 to 20	5	40	12.8	355	Fast
Retention Basin by Working Pens	Typical	2 to 10	5	3	0.96	27	Fast
Buffer Strips	Typical	0 to 10	5	40	12.8	355	Fast
Stormwater R/D and Wetland Restoration	Typical	5 to 50	20	40	12.8	89	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[5]	Alternative	20 to 90	70	200	64	127	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

Typical/Owner BMP Program 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 50	30	45	14.4	67	Moderate
Owner BMP Program P Reduced to zero, Better N Management, Grass Management, and Feeder/Minerals and Water Placement	0 to 25	11	10	3	40	Slow
Typical BMP Program Rotational Grazing, New Water Facilities, Retention Basin by Working Pens, Critical Area Fencing, and Moderate Wetland Restoration/Retention	10 to 50	19	35	11	82	Moderate
Alternative BMP Program Provide Alternative Shade to move cattle from streams and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 90	49	100	32	91	Fast

BMPs for Cow Calf Production

Unimproved Pasture / Range

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[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Better N and Micros Fertilization - No P added	Owner	0 to 10	1	2	2	741	Slow
Grass Management (chopping, mowing, burning, etc.)	Owner	0 to 10	2	2	0.64	118	Slow
Improved Grazing Management							
Rotational Grazing (limited)	Typical	0 to 5	3	5	1.6	197	Moderate
HIA and Direct Water Access Prevention							
Improved Watering Facilities to move cattle from streams	Owner	0 to 10	5	5	1.6	118	Fast
Feeder/Minerals and Water Placement	Owner	0 to 10	3	2	0.64	79	Fast
Critical Area Fencing	Alternative	2 to 10	3	10	3.2	395	Fast
Retention Basin by Working Pens	Typical	2 to 10	3	3	0.96	118	Fast
Stormwater R/D and Wetland Restoration	Typical	2 to 20	10	20	6.4	237	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	100	32	237	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

Typical/Owner BMP Program Some rotational grazing, new water facilities, retention basin basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention	5 to 30	20	12	3.84	71	Moderate
Owner BMP Program Improved Grass Management, Watering Facilities, and Feed Placement	0 to 20	7	2	1	34	Slow
Typical BMP Program Some Rotational Grazing, retention basin basin by working pens, and moderate wetland restoration/retention	5 to 25	13	10	3	91	Moderate
Alternative BMP Program Critical Area Fencing and Edge-of-farm Stormwater R/D and Chemical Treatment	20 to 70	44	50	16	135	Fast

BMPS for Pine Plantation

Assume for Typical Condition		
Planted Pine Plantation (20 yr rotation)		
Assumed average farm size of 200 ac		
Existing P fertilization of 10 lbs P/ac		
No retention or wetland restoration		
Existing P Load (conc.=0.1 ppm with 8 " of runoff)	0.18	lbs-P/ac/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/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 and Wetland Restoration	Typical	2 to 20	10	20	20	1111	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 70	50	100	32	355	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

Typical/Owner BMP Program Reduced P Fertilization, Stormwater R/D, and limited Wetland Restoration	2 to 25	11	20	20	1111	Moderate
Owner BMP Program Reduced P Fertilization	0 to 25	1	0	0	0	Slow
Typical BMP Program Stormwater R/D and limited Wetland Restoration	10 to 50	10	20	20	1111	Fast
Alternative BMP Program 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)	6.30	lbs-P/ac/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]** ($/ac)	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %		**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	20 to 70	45	10	10	4	Slow
Water Management (irrigation and drainage, riser board control)	Typical	0 to 40	10	10	3.2	5	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	30	9.6	15	Fast
Erosion Control (sediment trap in front of risers)	Alternative	0 to 5	2	10	3.2	25	Fast
Off Season In-Field Retention	Typical	0 to 15	5	10	3.2	10	Fast
Off Season Cover Crop	Typical	0 to 10	4	50	16	63	Fast
Stormwater R/D and Wetland Restoration	Typical	5 to 50	30	200	64	34	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Altermative	20 to 90	70	500	160	36	Fast
Typical/Owner BMP Program Reduced P Fertilization, Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention		10 to 80	60	200	64	17	Moderate
Owner BMP Program Reduced P Fertilization		20 to 70	30	10	3.2	2	Slow
Typical BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention		10 to 50	30	190	60.8	32	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds, Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment		20 to 90	28	400	128	73	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

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[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
Reduced P Fertilization (testing, split, placement, and type)	Owner	10 to 50	20	2	2	4	Slow
Water Management (irrigation and drainage, riser board control)	Typical	0 to 20	10	10	3.2	13	Fast
Erosion Control (Buffer Strips and sediment traps)	Alternative	0 to 15	5	50	16	127	Fast
Stormwater R/D and Wetland Restoration	Typical	5 to 50	30	100	32	42	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	300	96	54	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

Typical/Owner BMP Program Reduced P fertilization, water management, additional stormwater retention, and limited wetland restoration	10 to 70	40	100	32	32	Moderate
Owner BMP Program Reduced P Fertilization	10 to 50	13	2	2	6	Slow
Typical BMP Program Water Management, additional Stormwater Retention, Cover Crop, and limited Wetland Restoration/Retention	10 to 50	27	98	31	46	Fast
Alternative BMP Program Erosion Control, and Edge-of-farm stormwater R/D and Chemical Treatment	20 to 70	42	300	96	91	Fast

BMPS for Sugarcane

Assume for Typical Condition		
3 year ratoon on sand land		
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)	0.63	lbs-P/ac/yr

BMPs	**Type**	**P Reduction[1]**		**Initial Cost of BMP[2]**	**Annual Cost[3]**		**Quickness of Response**
		Range %	Typical %	($/ac)	**per acre** ($/ac/yr)	**P Removed** ($/lb/ac/yr)	
Fertility							
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	10	3.2	51	Fast
Water Reuse from Retention/Detention Ponds	Alternative	0 to 20	10	30	9.6	152	Fast
Stormwater R/D and Wetland Restoration	Typical	5 to 50	20	100	32	254	Fast
Edge-of-farm stormwater R/D and Chemical Treatment[4]	Alternative	20 to 90	70	200	64	145	Fast
Typical/Owner BMP Program Reduced P fertilization, water management, and limited wetland restoration/retention		10 to 70	25	100	32	203	Moderate
Owner BMP Program Reduced P Fertilization		10 to 50	10	2	0	0	Slow
Typical BMP Program Water Management and limited Wetland Restoration/Retention		10 to 60	23	98	31	216	Fast
Alternative BMP Program Water Reuse from Retention/Detention Ponds and Edge-of-farm stormwater R/D and Chemical Treatment		20 to 90	52	250	80	244	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

ATTACHMENT 2

Evaluation of Runoff Load Reductions from Urban Land Uses

By

Dr. Harvey H. Harper
Environmental Research and Design, Inc.

EVALUATION OF RUNOFF LOAD REDUCTIONS FROM URBAN LAND USES

1. Urban Area Characteristics

A summary of existing urban land uses and areal coverage in the Lake Okeechobee northern watershed area was provided by FDEP. Land uses in the Okeechobee basin are divided into the three primary categories of residential, commercial, and recreational. Residential land use categories within the basin include low-density residential, medium-density residential, high-density residential, and mobile home units. Areas classified in the residential category occupy approximately 20,710 acres or 1.75% of the total Lake Okeechobee northern watershed area. Commercial activities include commercial and service areas, industrial, extractive, and institutional land uses. Land use areas included in the commercial category occupy approximately 2333 acres, comprising 0.2% of the total Lake Okeechobee northern watershed. Recreational areas primarily include golf courses and general recreational fields. These areas occupy 934 acres or 0.08% of the basin area.

A summary of assumed characteristics of urban land use categories in the Okeechobee Basin is given in Table 1. Mobile home parks are assumed to have >5 homes/acre, with approximately 50% of the total area covered with impervious surface. Low-density residential areas are assumed to have less than 1 home/acre, with approximately 10% of the total area covered with impervious surface. Medium-density residential land uses are assumed to have 2-5 homes/acre, with approximately 50% of the area covered with impervious surface. High-density residential includes anything greater than 5 homes/acre, including categories such as apartments, condominiums, and mobile home parks. Approximately 75% of these areas are assumed to be impervious. Commercial areas, which include restaurants, strip malls, office buildings, light industrial, and extractive uses, are assumed to have approximately 80% impervious coverage. Recreational areas are assumed to be approximately 10% impervious. Due to the relatively high water table elevations within the Lake Okeechobee urban areas, each of these land use categories is assumed to be present in Hydrologic Soil Group C. The mobile homes, low-density residential, and medium-density residential areas are assumed to have on-site septic tank systems, with sanitary sewer service assumed for high-density residential and commercial.

Based on current characteristics of urban areas in the Lake Okeechobee urban area, none of the low-density residential areas are assumed to have existing stormwater management BMPs. Approximately 5% of the mobile homes and 15% of the medium-density residential areas are assumed to have existing BMPs, with 10% of the high-density residential and 15% of the mixed commercial also with existing BMPs. An estimated annual phosphorus reduction of approximately 50% is assumed for areas with existing BMPs within the basin.

The City of Okeechobee has established a street sweeping program for many of the existing urban areas. For purposes of this evaluation, it is assumed that street sweeping provides reductions in runoff characteristics for medium-density residential, high-density residential, and commercial areas within the basin. Street sweeping is assumed to provide a 15% reduction in phosphorus loadings from medium-density residential areas and a 20% phosphorus reduction for high-density and commercial areas. Street sweeping activities are not assumed for low-density residential or mobile home areas.

TABLE 1

ASSUMED CHARACTERISTICS OF EVALUATED URBAN LAND USE CATEGORIES IN THE OKEECHOBEE BASIN

LAND USE CATEGORY	UNIT DENSITY	IMPERVIOUS AREA (%)	DCIA[1] (%)	HYDROLOGIC SOIL GROUP	WASTEWATER TREATMENT	EXISTING STORMWATER BMPs	
						PERCENT IMPLEMENTATION[2] (%)	PHOSPHORUS REDUCTION[3] (%)
Mobile Homes	> 5 homes/ac	75	60	C	on-site septic tank	5	50
Low-Density Residential	# 1 home/ac	10	50	C	on-site septic tank	0	--
Medium-Density Residential[4]	2-5 homes/ac	50	50	C	on-site septic tank	15	50
High-Density Residential[5]	> 5 homes/ac	75	60	C	sanitary sewer	10	50
Commercial (mixed)[6]	--	80	75	C	sanitary sewer	15	50
Recreational[7]	--	10	50	C	on-site septic tank	0	--

1. Percentage of project area that is directly connected
2. Percentage of land use with existing stormwater management systems
3. Estimated annual phosphorus reduction from implemented BMPs
4. Traditional single-family subdivision
5. Includes apartments, condominiums, and mobile home parks
6. Includes restaurants, strip malls, office buildings, light industrial, etc.
7. Includes golf courses and recreational fields

TABLE 2

ANNUAL TOTAL PHOSPHORUS LOADING CHARACTERISTICS FOR URBAN LAND USE CATEGORIES IN THE OKEECHOBEE BASIN

LAND USE CATEGORY	ANNUAL RUNOFF		TYPICAL RUNOFF TOTAL P CONCENTRATION (mg/l)			ANNUAL TOTAL P LOADING (kg/ac-yr)
	VOLUME (inches/yr)	RUNOFF COEFFICIENT[1]	HARPER (1994)[2]	STITES, et al. (2000)[3]	MEAN VALUE	
Mobile Homes	24.39	0.567	0.18	0.22	0.20	0.50
Low-Density Residential	8.28	0.193	0.18	0.22	0.20	0.17
Medium-Density Residential	13.75	0.320	0.30	0.34	0.32	0.45
High-Density Residential	21.13	0.491	0.49	0.51	0.50	1.09
Commercial (Mixed)	25.22	0.586	0.29	0.29	0.29	0.75
Recreational	7.34	0.171	0.30	0.34	0.32	0.24

1. Fraction of annual rainfall which becomes stormwater runoff

2. Harper, H.H. (October 1994). "Stormwater Loading Rate Parameters for Central and South Florida."

3. Stites, D.L.; Coveney, M.; Battoe, L.; and Lowe, E. (September 2000). "An External Phosphorus Budget for Lake Apopka, 1989-1994." Technical Memorandum No. (TBA).

2. Evaluation of Current Loadings

Estimates of annual runoff volumes were generated for each land use category summarized in Table 1 based upon a probability distribution of rainfall event characteristics occurring in the Lake Okeechobee basin from 1942-1990. Average annual rainfall during this period is approximately 43.01 in/yr. Estimates of runoff volumes were generated for individual rain events occurring in the basin during this 49-year period, which were then summed together on an annual basis to provide estimates of annual runoff volume. A summary of estimated annual runoff volumes and runoff coefficients for the evaluated land use categories is given in Table 2.

Estimates of typical total phosphorus concentrations in runoff for each of the four land use categories were estimated based upon the literature review by Harper (1994) titled "Stormwater Loading Parameters for Central and South Florida" and the study performed by Stites, et al. (2000) for the Lake Apopka basin. The mean values from these two studies are used to represent typical total phosphorus concentrations for land use categories in the Okeechobee basin. Estimates of annual areal total phosphorus loadings from each land use category are obtained by multiplying the estimated annual runoff volume times the typical runoff total phosphorus concentration for each land use category.

Estimates of generated annual total phosphorus loadings from urban areas in the Okeechobee basin are summarized in Table 3. The theoretical total phosphorus loadings generated by each major land use category and sub-category are obtained by multiplying the area of each sub-category land use times the areal annual phosphorus loadings summarized in Table 2. These values are presented near the middle of Table 3 and reflect the total theoretical phosphorus loading produced in each land use category. However, the City of Okeechobee currently has street sweeping operations for urban areas which affect loadings generated in the medium-density residential, high-density residential, and mixed commercial areas. For purposes of this evaluation, it is assumed that existing street sweeping operations remove approximately 15% of the total phosphorus generated in medium-density residential areas and 20% of the total phosphorus generated in high-density residential and commercial areas. The phosphorus load reductions from existing street sweeping operations are subtracted from the theoretical phosphorus loadings to obtain the generated annual phosphorus load from each land use category before treatment in any existing or future stormwater management systems.

TABLE 3

ESTIMATED ANNUAL GENERATED TOTAL PHOSPHORUS LOADINGS FROM URBAN AREAS IN THE OKEECHOBEE BASIN

MAJOR LAND USE CATEGORY	SUB-CATEGORY	AREA (acres)	THEORETICAL TOTAL P LOAD (kg/yr)	REDUCTION BY EXISTING STREET SWEEPING OPERATIONS (%)	GENERATED ANNUAL TOTAL P LOAD (kg/yr)
Residential	Mobile Homes	1,819	910	0	910
	Low-Density	13,826	2,350	0	2,350
	Medium-Density	4,233	1,905	15	1,619
	High-Density	832	907	20	726
	TOTAL:	20,710	5,952	--	5,605
Commercial	Mixed Commercial	2,333	1,750	20	1,400
	TOTAL:	2,333	1,750	--	1,400
Recreational	Recreational	934	224	0	224
	TOTAL:	934	224	0	224

3. Efficiency of Common BMPs

Estimated removal efficiencies for common stormwater management practices were obtained from a literature review performed by Harper (1995) of previous research performed within the State of Florida which quantifies pollutant removal efficiencies associated with common stormwater management systems. This information is summarized in the publication titled "Pollutant Removal Efficiencies for Typical Stormwater Management Systems in Florida". A copy of this publication is attached for reference purposes.

Removal efficiencies for stormwater treatment alternatives are summarized in Table 4. Current stormwater BMPs used in this basin include retention systems (such as dry ponds or swales), dry detention, wet detention, sediment/baffle boxes, and street sweeping. Estimated removal efficiencies for these practices are also included in Table 4. The highest removal efficiencies are achieved for retention practices and wet detention ponds, with minimal phosphorus removal achieved in dry detention and street sweeping.

Relative cost information for evaluated BMPs is included in the attached spreadsheets. Construction of dry detention or dry retention ponds is assumed to be $6400/acre of watershed area based on a treatment volume of 0.25-0.5 inch of runoff over the contributing area. Construction of a wet detention pond with a 14-day minimum wet season residence time is assumed to be $8000/acre treated, with an estimated cost of $8000/ac treated for roadside swales which provide a treatment volume of 0.5 inch of runoff. Street sweeping is assumed to cost $40/curb mile and varies depending upon the assumed length of roadways contained within each land use category.

TABLE 4

ESTIMATED REMOVAL EFFICIENCIES FOR STORMWATER TREATMENT ALTERNATIVES

TYPE OF SYSTEM	TOTAL P REMOVAL (%)	ASSUMED PERCENT TOTAL P REMOVAL FOR OKEECHOBEE BASIN
1. Owner BMPs		
A. Reduced P Applications	--	5
2. Cost-Share BMPs		
A. Dry Retention/Swales		
0.25 inch	60	50
0.50 inch	80	70
B. Street Sweeping	10-20	Medium-Density: 15 High-Density: 20 Commercial: 20
C. Sediment/Baffle Boxes	20	20
3. Alternative/Regional BMPs		
A. Dry Detention	25	25
B. Wet Detention	65	65
C. Alum Treatment	85	85

4. Estimated Urban Load Reductions

Estimated annual total phosphorus loadings discharging from urban areas in the Okeechobee basin are summarized on Table 5. Mass removal in stormwater management systems is assumed based upon the percentage of BMP implementation and phosphorus reduction efficiencies summarized in Table 1 for each land use category. Estimates of the existing total phosphorus load discharging from each land use category is obtained by subtracting the mass removal in stormwater management systems from the annual generated total phosphorus loads. The values summarized in the final column of Table 5 represent the estimated annual loadings from each land use category. On an annual basis, urban land areas in the Okeechobee basin contribute approximately 6944 kg of total phosphorus each year.

Based upon an evaluation of existing conditions for urban areas in the Lake Okeechobee basin, implementation of roadside swales appears to be the most feasible stormwater management alternative for both low-density and medium-density residential areas. These roadside swales could be used both as conveyance and as treatment systems by constructing raised inlets which cause portions of the volume within the swale to be retained and infiltrated into the ground. The most feasible BMPs for high-density residential areas appear to be construction of retention areas in existing landscape areas. Construction of retention in landscaped areas is estimated to provide approximately 50% total phosphorus removal. Retention in existing landscaped areas also appears to be the most feasible BMPs for the mixed commercial areas.

TABLE 5

ESTIMATED ANNUAL TOTAL PHOSPHORUS LOADINGS DISCHARGING FROM URBAN AREAS IN THE OKEECHOBEE BASIN

MAJOR LAND USE CATEGORY	SUB-CATEGORY	AREA (ac)	ANNUAL GENERATED TOTAL P LOAD (kg/yr)	MASS TOTAL P REMOVAL IN STORMWATER MANAGEMENT SYSTEMS (kg/yr)	MASS TOTAL P LOAD DISCHARGED OFF-SITE (kg/yr)
Residential	Mobile Homes	1,819	910	23	887
	Low-Density	13,826	2,350	0	2,350
	Medium-Density	4,233	1,619	121	1,498
	High-Density	832	726	36	690
	TOTAL:	20,710	5,605	180	5,425
Commercial	Mixed Commercial	2,333	1,400	105	1,295
	TOTAL:	2,333	1,400	105	1,295
Recreational	Recreational	924	224	0	224
	TOTAL:	924	224	0	224
	TOTALS:	23,967	7,229	285	6,944

A summary of feasible BMPs is given in Table 6. These BMPs assume that implementation will occur within each individual land use category prior to discharge into primary stormwater conveyance systems. This analysis does not include regional BMPs which could be constructed at the downstream end of the primary conveyance system, immediately prior to discharge into Lake Okeechobee.

Estimates of potential urban load reductions of total phosphorus from feasible BMPs are summarized in Table 6 based upon a 50% BMP implementation rate for areas which do not have existing BMPs and the anticipated total phosphorus removals selected for each evaluated BMP. A 50% BMP implementation rate is assumed to be the highest achievable implementation rate due to limitations on land availability in the urban areas. Implementation of BMPs within 50% of the urban areas which do not have existing BMPs will reduce total phosphorus discharges by approximately 1736 kg/yr, equivalent to approximately 1.7 metric tons/yr.

Implementation costs for the evaluated BMPs are summarized in the attached spreadsheet. The least expensive BMPs, in terms of cost per kg of phosphorus removed, appear to be street sweeping and retention practices, such as dry ponds and roadside swales. Street sweeping is clearly the least expensive method for removing phosphorus from the basin, although the removal efficiencies are somewhat limited and this practice is currently implemented in much of the urban basin.

Estimated implementation costs for feasible BMPs for the urban land use categories are summarized in the final column of Table 6. This information is based upon the BMP cost per acre, summarized in the attached spreadsheet, and a 50% BMP implementation rate. Implementation of feasible BMPs for 50% of the urban areas which do not have existing stormwater management systems is estimated to cost approximately $77,000,000 for removal of approximately 1736 kg total phosphorus per year. This equates to a unit cost of approximately $144,355/kg total phosphorus removed.

The cost estimates summarized in Table 6 reflect costs for implementation of BMPs within the urban watershed. However, implementation costs can be reduced substantially if regional BMPs are used in downstream portions of the watershed, provided that adequate space can be obtained. Implementation of regional BMPs will reduce the cost per unit of phosphorus removed from $144,355/kg to approximately $10,000/kg or less. Regional BMPs are clearly less expensive per mass of total phosphorus removed, but space availability in urban areas is often limited.

TABLE 6

ESTIMATED URBAN LOAD REDUCTIONS FROM FEASIBLE BMPs

LAND USE CATEGORY	ESTIMATED CURRENT LOADING (kg/yr)	MOST FEASIBLE BMP	ANTICIPATED TOTAL P REMOVAL (%)	MASS REMOVAL WITH 50% BMP IMPLEMENTATION (kg/yr)	REMAINING LOADING (kg/yr)	IMPLEMENTATION COST ($)
Residential	5,425	Roadside swales	50	1,356	4,069	63,682,880
Commercial	1,295	Retention in landscaped areas	50	324	971	12,691,520
Recreational	224	Retention in landscaped areas	50	56	168	716,800
			TOTALS:	1,736	5,208	77,091,200