Natural Resource Analysis of Lake Okeechobee Phosphorus Management Strategies

Contract C-11677

Phase II
Summary Report

Prepared for the South Florida Water Management District

December 2003

HAZEN AND SAWYER
Environmental Engineers & Scientists

In association with
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Natural Resource Analysis of
Lake Okeechobee Phosphorus
Management Strategies, C- 11677
Phase II Summary Report and
Documentation Report

Dear Ms. O'Dell:

We are pleased to submit six copies of the Phase II Summary Report and Documentation Report for the project titled "Natural Resource Analysis of Lake Okeechobee Phosphorus Management Strategies", prepared under contract C-11677. The summary report presents the results of the desktop evaluation of Lake Okeechobee alternative nutrient reduction technologies and of evaluating 18 combinations of ten phosphorus control alternatives with respect to ten evaluation criteria. The documentation report explains the data and methods used to estimate the benefits and costs of the ten phosphorus control alternatives. The evaluation was prepared using the best available information.

Project team members responsible for this study include Grace Johns, Ph.D., Project Manager; Del Bottcher, Ph.D., P.E., of Soil and Water Engineering Technology, Inc.; Phil Cooke, P.E.; Robert Fergen, P.E; and Dave Sayers, Economist.

We have enjoyed working with you, Liz Abbott, Joyce Zhang and the many District staff members who contributed to this project over the past three years.

Very truly yours,

HAZEN AND SAWYER, P.C.

Grace Johns

Grace M. Johns, Ph.D.
Senior Associate
Project Manager

Enclosure
c: File No. 40507

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Phase II – Summary Report Natural Resource Analysis of Lake Okeechobee Phosphorus Management Strategies

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Executive Summary

Study Purpose

This study provides a benefit-cost analysis of 18 combinations of alternatives to further reduce the amount of phosphorus entering Lake Okeechobee. These alternatives are called phosphorus control alternatives or PCAs. Benefits and costs of each alternative combination to the District, to landowners and to the regional economy were described and quantified using the best available information.

A computerized Evaluation and Full Cost Accounting Model was developed for use during this study to evaluate the phosphorus control alternatives (PCAs) and to allow for updating as new data and information become available. Full cost accounting of the PCAs was incorporated into an evaluation model that uses evaluation criteria to measure the relative benefits and costs of the alternatives and to provide a ranking of alternatives based on the magnitude of itemized benefits and costs.

This study is the first attempt to collect, organize and use the available information to estimate benefits and costs of the PCAs. In the process of conducting this study, some major assumptions were used due to a lack of sufficient information. Therefore, this study does not justify any specific regulatory or public works action. Recommendations for additional research and analysis are provided which will improve the evaluation of phosphorus control alternatives. Also, this study did not seek to recommend projects that will necessarily meet the phosphorus Total Maximum Daily Load (TMDL) for Lake Okeechobee although the information provided in this report will assist in this effort.

The Lake Okeechobee Protection Act (F.S. 373.4595) establishes extensive and comprehensive requirements for surface water improvement and management within Lake Okeechobee and its watershed. Feasibility of nutrient reduction technologies and cost-effectiveness in reducing phosphorus is an implicit part of the overall legislation, and explicitly referred to in various activities. This project provides the framework and detailed information on the feasibility of the different alternate nutrient reduction technologies applicable to the Lake Okeechobee watershed and compares the cost-effectiveness of various phosphorus reduction treatments. The information from this study will assist in the development of the 2004 Lake Okeechobee Protection Plan.

Background

Lake Okeechobee supports valuable recreational and commercial fisheries, provides flood control, and acts as a reservoir for both potable and irrigation waters for much of south Florida. Land use (agricultural) and hydrological changes (more efficient delivery of stormwater) in the agricultural watersheds surrounding Lake Okeechobee have contributed to a serious decline in lake and downstream water quality, affecting most all flora and fauna communities, and causing substantial blue-green algae blooms during the mid-1980's.

Best Management Practices (BMPs) and regulatory programs have been implemented over the past 25 years to reduce in-lake phosphorus loads. However, these programs, by themselves will not be sufficient to achieve the required in-lake phosphorus concentration of 40 parts per billion (ppb) or the Total Maximum Daily Load (TMDL) of 140 metric tons per year from all sources. Phosphorus loads delivered to the lake during the period 1995 through 2000 have been estimated to be about 573 metric tons/year. Thus, the overall load reduction goal for the lake is 433 metric tons/year, based on the referenced five-year average load, or 75 percent. Thus, the current programs need to be supplemented by additional programs, and non-regulatory measures to augment the load reductions with willing landowners.

The study area is north of Lake Okeechobee. A map of the study area is provided in Figure ES-1. The study area is primarily agricultural. Parts of Okeechobee, Highlands and Glades counties comprise most of the study area. The area also includes small portions of Polk, Osceola, and Martin counties.

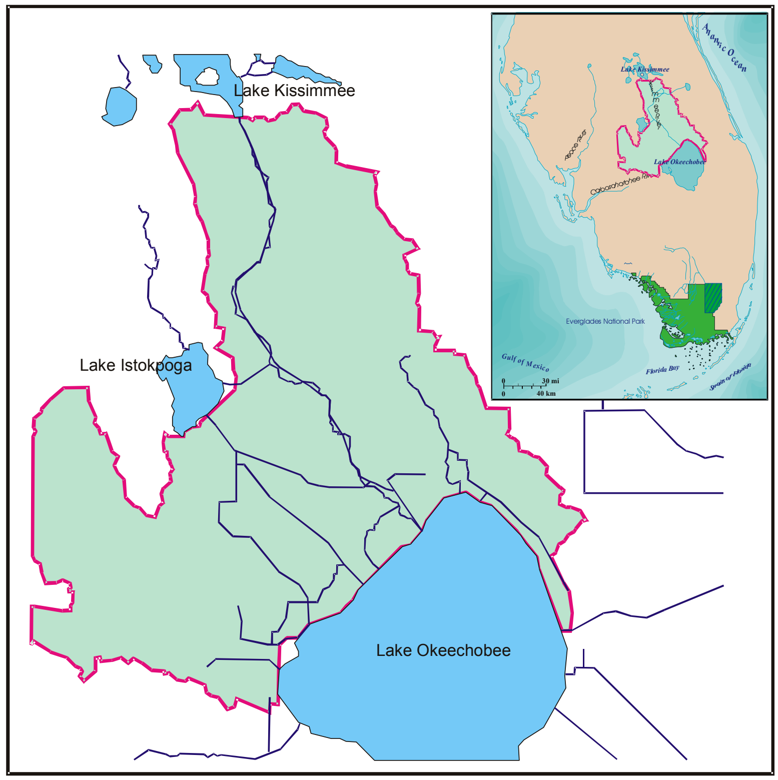


Figure ES-1 – Project Study Area

The study period is sixty years in order to adequately consider the time series of benefits and costs. The general baseline conditions from which the benefits and costs of a PCA are measured are as follows.

- The following programs and regulations are effective as is currently written throughout the study period: the FDEP Dairy Rule, the Lake Okeechobee Works of the District Rule (WOD Rule), the District's Environmental Resource Permitting Rule and the District's Water Use Permitting Rules.

- The rules and programs that existed as of September 2000 are in effect throughout the study period. No new rules or programs affecting landowners in the study area are promulgated during the study period, including new or additional water quality standards or new NPDES permitting requirements.

- None of the projects described in the Corps' and the District's Comprehensive Everglades Restoration Plan are built during the study period.

- The land uses in the study area during the study period are those that are projected in Table ES-1.

Table ES-1
Land Uses within the Lake Okeechobee Study Area – Baseline Conditions

Land Use Description	Acreage 2002	Projected Acreage 2021	Percent Change
Improved Pasture	432,806	402,751	-7%
Water & Wetlands	241,388	241,388	0%
Unimproved Pasture, Rangeland & Upland Forest	361,883	348,585	-4%
Citrus Groves	55,222	70,477	28%
Urban & Built-up and Transportation, Communications & Utilities	46,846	69,697	49%
Dairies [a]	20,200	20,200	0%
Sugarcane	9,384	9,384	0%
Row Crops	10,663	14,722	38%
Field Crops	9,415	9,415	0%
Aquaculture, floriculture, fruit orchards, horse farm, ornamentals, other grove, sod farms, tree nurseries,	6,700	7,888	18%
Woodland pastures, barren land fallow crop land and other.	25,308	25,308	0%
Total	1,219,814	1,219,814	

[a] The dairy land uses include the total farm acreage used for dairy cows.

Desktop Evaluation of Alternative Nutrient Reduction Technologies

Pursuant to the Lake Okeechobee Protection Act, Section 373.4595, F.S., an evaluation of the feasibility of alternate nutrient reduction technologies was performed. The list of the technologies evaluated is provided in Table ES-2.

The screening criteria used to determine if an alternate nutrient reduction technology will be considered for evaluation with respect to the Full Cost Accounting Evaluation Model are as follows.

(1) Sufficient information - There is sufficient information to allow for an adequate evaluation of benefits and costs associated with the technology.

(2) Phosphorus reduction potential - The technology has the potential to successfully reduce phosphorus loads to Lake Okeechobee.

(3) Confidence of Sustained Performance – The technology has been demonstrated to be effective in reducing phosphorus loads and its operational theory and application indicates that the technology is likely to reduce phosphorus loads on a long-term basis.

(4) Timeliness - The technology is timely in that it is available and is, or could be, considered in planning programs.

(5) No Significant Negative Side Effects – The technology will not have a significant negative side effect that is thought to be detrimental to the region from the perspectives of public health and safety and the District's mission.

In order for the technology to be considered for inclusion in the benefit-cost evaluation of phosphorus control alternatives, the technology must pass all of the screening criteria.

Table ES-2
List of Alternate Nutrient Reduction Technologies Screened

Regional Technologies

1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals
2. Aquaculture and/or Algal-Based Water Treatment Systems
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)
4. Terminal Large Scale Water Treatment Facility Using Chemical Treatment and Solids Separation (CTSS)
5. Canal and Tributary Maintenance Program
6. Tributary Sediment Traps
7. Modify Design and Operation of Regional Water Control Structures

On-Farm Technologies

8. Isolated Wetlands Restoration
9. Improved Dairy Farm Waste Processing Technologies
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties
11. Wetlands Treatment of Runoff at Edge of Properties
12. Non-Structural Management at the Land Parcel Level
13. Enhanced Cow-Calf Best Management Practices
14. Alternative Land Uses
15. Phosphorus Absorption, Binding and Filtration Technologies
16. Additional Farm Level Best Management Practices
17. On-Farm Composting of Animal Solid Waste

The technologies that passed all five screening criteria are provided in Table ES-3.

Table ES-3
Alternate Nutrient Reduction Technologies that Passed All Screening Criteria

Technology Category	Evaluated During This Study - PCA Number (a)
Regional Technologies	
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)	PCAs 7 and 8
4. Terminal Large Scale Water Treatment Facility Using CTSS	PCA 10
5. Canal and Tributary Maintenance Program – Sediment Removal from Primary Canals	PCA 9
On-Farm Technologies	
8. Isolated Wetlands Restoration	PCA 11
9. Improved Dairy Farm Waste Processing Technologies	PCA 4
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties	PCA 1
11. Wetlands Treatment of Runoff at Edge of Properties	PCA 2
12. Non-Structural Management at the Land Parcel Level	PCA 3
13. Enhanced Cow-Calf Best Management Practices	PCA 5
14. Alternative Land Uses	PCA 6
17. On-Farm Composting of Animal Solid Waste	PCA 12

PCA stands for Phosphorus Control Alternative. These PCAs represent a specific implementation method.

For Technology Category 5, only specific technologies within the category passed all of the screening criteria. In addition, it is not known if sediment and vegetation removal will reduce influent phosphorus loads by at least 25 percent. However, these technologies will likely be necessary in order to avoid re-suspension of phosphorus from the sediment as phosphorus concentrations fall due to implementation of other nutrient reduction technologies.

Ten of the 11 technologies were evaluated during this project. For PCA 11, The Nature Conservancy had contracted Hazen and Sawyer to use the Full Cost Accounting Evaluation Model to evaluate a specific type of isolated wetlands program in 2002. The results are presented in the report titled, "Evaluation of Isolated Wetlands Restoration on Pastureland in the Lake Okeechobee Watershed", Final Report, December 2002, by Hazen and Sawyer for The Nature Conservancy, Altamonte Springs, Florida.

Dairy Farm Composting became PCA 12 and was evaluated using the Full Cost Accounting Model. It was not included in the combinations evaluated during Phase II because its overall score and rank were lower than that for a similar alternative that was included in the combinations, Optimization of Dairy Rule Design (PCA 4).

Description of Technology Combinations

The 18 combinations include 3 regional technologies and 6 on-farm technologies that would be considered for implementation in the Lake Okeechobee study area. Each individual technology is called a Phosphorus Control Alternative or PCA. The individual technologies are described as follows.

PCA 1 - Chemical Treatment of Runoff at Edge of Properties. Each landowner would be responsible for constructing, operating and maintaining a chemical system that treats runoff and stormwater at the edge of the property prior to it entering the local streams and tributaries. This PCA was evaluated for the following land uses: dairy, cow/calf, citrus, field crops, row crops, tree nurseries, and sod operations. These land uses comprise 44 percent of all land in the study area and 80 percent of developed land in the study area in 2001 and in 2021.

PCA 2 -Wetlands Treatment of Runoff at Edge of Properties. Each landowner would be responsible for constructing, operating and maintaining a wetland system that treats runoff and stormwater at the edge of the property prior to it entering the local streams and tributaries. This PCA was evaluated for the following land uses: dairy; cow/calf; citrus; field crops; row crops; tree nurseries; and sod operations.

PCA 3 - Non-Structural Management at the Land Parcel Level. Under this PCA, all landowners would use non-structural practices to reduce imports of phosphorus and to reduce the transportability of phosphorus from their land. Examples of new management methods include the following: (1) use of calibrated soil testing and leaf sampling to determine optimal fertilization using the services of the University of Florida Cooperative Extension Service; (2) application of soil amendments to reduce the solubility and transportability of phosphorus and (3) no applications of phosphorus to pasture land.

PCA 4 - Optimization of Dairy Rule Design. This PCA is an optimization of the existing Dairy Rule design to significantly increase the removal of phosphorus from stormwater. All lactating cows would be totally confined to the high intensity area (HIA). This area includes the milking parlor and feed/shade barns. The dry cows would reside in surrounding pastures. The improvements to the existing Dairy Rule design within the HIA would include the collection of rainwater from roofs for deposit outside the HIA; expansion of the HIA perimeter ditch to accommodate all lactating cows; larger ponds in the HIA; and additional shade barns for feeding and cooling. The manure and the wastewater from the HIA would be treated in the same manner as the existing Dairy Rule modifications and these modifications would be expanded to treat the larger volumes of water.

PCA 5 - Enhanced Cow-Calf BMPs. Under this PCA, a BMP program would be implemented at all cow-calf operations in the study area. The Enhanced Cow-Calf BMPs include the following elements: fencing to separate the cattle from the natural water courses; ponds, troughs and/or tanks for cattle watering; and the setting of stocking rates for individual pastures based on the phosphorus loading characteristics of the site. The average stocking rate used under this PCA is one cow per 4 acres from the estimated current average of one cow per three acres.

PCA 6 - Alternative Land Uses. Under this PCA, land uses that contribute relatively high phosphorus loads would be converted to land uses that contribute relatively low or no phosphorus loads to Lake Okeechobee. The land use changes are presented in Table ES-4.

Table ES-4
Alternative Land Use Changes Evaluated

Existing Land Use	Acres Converted 1995	Acres Converted 2021	Alternative Land Use
6A. Dairy operations – baseline management	20,200	20,200	Cow-calf operations – improved management
6B. Citrus operations – baseline management	55,222	58,683	Natural areas
6C. Field crop operation (sugarcane) – baseline management	9,384	9,384	Wetlands and/or natural areas
6D. Row crop operation – baseline management	10,663	14,722	Cow-calf operations – baseline management
6E. Cow calf operation – baseline management	11,794	11,794	Citrus operation – aggressive BMPs

PCA 7 - Watershed Reservoir-Assisted Stormwater Treatment Areas (RASTAs). The U.S. Army Corps of Engineers and the South Florida Water Management District identified two RASTA projects as priority projects for Everglades Restoration during their Restudy. They include the Taylor Creek / Nubbin Slough Stormwater Treatment Area (STA); and two Lake Okeechobee Watershed Water Quality Treatment Facilities. Each project includes an above ground reservoir and stormwater treatment areas. Each project will be located within one of three sub-basins: S-191, S-154, and S-65D.

PCA 8 – Taylor Creek / Nubbin Slough RASTA with Lake Okeechobee Supplemental Water Source. This PCA was evaluated during the Phase I study but was not evaluated as a combination. This PCA is the Taylor Creek / Nubbin Slough Reservoir-Assisted Stormwater Treatment Area (TC/NS RASTA) as described under PCA 7 - Watershed RASTAs. In addition, under PCA 8, one-half of this RASTA would have access to water from Lake Okeechobee. The purpose of using Lake Okeechobee as a supplementary water source would be to keep the STA vegetation wet during dry conditions to increase phosphorus removal. During dry watershed conditions, water would be pumped from the lake through a pipeline to the reservoir at Grassy Island. A pumping system would transfer the water from the lake to the reservoir. Overall, water would flow from the lake to the RASTA through the pipeline about five percent of the time. This PCA was not included in the combinations because its rank and score was lower than that of PCA 7 – RASTAs, which is similar to PCA 8.

PCA 9 - Tributary Sediment Removal. Under this PCA, sediment would be dredged from 10 miles of primary canals within eight sub-basins of the study area. This project is part of the Lake

Okeechobee Watershed Project being evaluated by the U.S. Army Corps of Engineers and the South Florida Water Management District.

PCA 10 - Terminal Large Scale Water Treatment Facility. Under this PCA, water would be diverted from the Kissimmee River prior to entering Lake Okeechobee and treated to reduce the total phosphorus content. The treated effluent would then be returned to the source water at a downstream location. This alternative considers the construction of a water treatment plant using chemical treatment followed by solids separation advanced technology to achieve the necessary reduction in total phosphorus.

PCA 11 – Isolated Wetlands Restoration on Pastureland. Under this PCA, the owner of improved pastureland would restore a portion of his/her improved pastureland to isolated wetlands. The owner would implement certain best management practices (BMPs) on the remaining improved pastureland. For the purposes of this analysis, on average in the study area, a given improved pasture area would have 40 percent of the land restored to isolated wetlands with a cattle stocking rate of one cow per 16 acres (1/16 cows/acre) and 60 percent of the land would remain as improved pasture with a stocking rate of one cow per four acres (1/4 cows/acre). On the improved pasture, the owner would not apply any phosphorus. Fencing of cattle from watercourses would not be required but additional cooling ponds and watering troughs would be provided to encourage cattle to stay away from natural watercourses. This program would be implemented on 200,000 acres of improved pastureland in the Lake Okeechobee watershed study area. As of 2002, there are about 433,000 acres of improved pastureland in the study area.

PCA Combinations. The 18 technology combinations are presented in Table ES-5. The proposed tributary phosphorus TMDLs have not yet been considered in developing these combinations. Such TMDLs will be considered prior to initiating any regional phosphorus management projects.

Table ES-5
Combinations of Phosphorus Control Alternatives (PCAs) Evaluated

Comb. No.	Regional PCA	On-Farm PCA
1	PCA 7 – RASTAs	PCA 11: Isolated Wetlands Restoration on Pastureland
2		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
3		PCA 1 – Chemical Treatment at Edge of Property
4		PCA 2 – Wetland Treatment at Edge of Property
5		PCA 3 – Non-Structural Management at Land Parcel Level
6		PCA 6 – Alternative Land Uses
7	PCA 10 – Terminal Large Scale Water Treatment Facility	PCA 11: Isolated Wetlands Restoration on Pastureland
8		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
9		PCA 1 – Chemical Treatment at Edge of Property
10		PCA 2 – Wetland Treatment at Edge of Property
11		PCA 3 – Non-Structural Management at Land Parcel Level
12		PCA 6 – Alternative Land Uses
13	PCA 9 – Tributary Sediment Removal	PCA 11: Isolated Wetlands Restoration on Pastureland
14		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
15		PCA 1 – Chemical Treatment at Edge of Property
16		PCA 2 – Wetland Treatment at Edge of Property
17		PCA 3 – Non-Structural Management at Land Parcel Level
18		PCA 6 – Alternative Land Uses

Evaluation Criteria

Ten evaluation criteria were developed and each PCA combination was scored based on each of the 10 criteria. The evaluation criteria are comprised of: (A) Phosphorus Reduction Benefits; (B) Cost-Effectiveness; (C) External Benefits and Costs; and (D) Risk and Uncertainty Measures. The criteria are summarized as follows.

A. Phosphorus Reduction Benefits

1. Average annual change in the amount of phosphorus entering Lake Okeechobee in pounds per year
2. Expected phosphorus concentration at the edge of the field as measured in parts per billion (ppb)

B. Cost-Effectiveness

3. Present value cost per pound of phosphorus removed from the Lake

C. External Benefits and Costs

4. Success in achieving surface water management objectives
5. Water supply benefits
6. Acres of increased/improved wildlife habitat
7. Present value change in regional income
8. Potential for increased recreation opportunities

D. Risk and Uncertainty Measures

9. Engineering / Technological Track Record
10. Permitting Uncertainty

The values associated with each PCA for criteria 1 through 4 were assigned a “moderate” or “high” confidence level that refers to the level of uncertainty associated with the data and information used to estimate the value in terms of obtaining "planning level" estimates. Moderate means that the studies used to obtain the estimates provided reservations about the accuracy of the results or that insufficient data and information exists to provide a high level of confidence. The high level implies that the data and information used to develop planning estimates are reasonable for a planning-level analysis.

Summary of PCA Criteria Values

A summary of the values for each criteria and each PCA combination is provided in Table ES-6 and Table ES-7. The targeted land uses and sub-basins of each PCA combination are summarized in Table ES-8. These targets are based on the predominant land uses in the sub-basins.

Table ES-6
Summary of Values for Criteria 1, 2, and 3 for Each PCA Combination, In Order of Ranking

Rank	PCA Combination	Criterion 1: Pounds P Removed per Year	Criterion 2: Resulting P Concenraton in ppb	Criterion 3: Present Value Cost per Pound Removed, 2001$	% of Controllable Load to Lake Removed (545,076 lbs/year)
RASTAS					
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Optimization & Enhanced Cow-Calf BMPs**	301,242	40	$54	55%
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	327,788	40	$68	60%
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	188,078	40	$121	35%
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	232,516	40	$121	43%
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	295,426	40	$134	54%
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	159,312	40	$181	29%
TERMINAL LARGE SCALE WATER TREATMENT FACILITY					
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	319,592	10	$103	59%
6	Comb. 11: PCAs 10 & 3 –**Water Treatment Fac. w/ Non-Structural Mgmt at Land Parcel Level**	345,732	10	$83	63%
10	Comb. 7: PCAs 10 & 11 - **Water Treatment Fac. w/ Isol. Wetlands Restoration on Pastureland**	211,550	10	$139	39%
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	253,053	10	$136	46%
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	313,993	10	$177	58%
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Facility with Alternative Land Uses**	182,186	10	$196	33%
TRIBUTARY SEDIMENT REMOVAL					
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sediment Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	261,258	233	$58	48%
9	Comb. 17: PCAs 9 & 3 – **Trib. Sediment Removal w/ Non-Structural Mgmt at Land Parcel Level**	289,473	216	$46	53%
12	Comb. 13: PCAs 9 & 11 – **Trib. Sediment Removal w/ Isolated Wetlands Restored on Pastureland**	149,710	193	$72	27%
14	Comb. 16: PCAs 9 & 2 – **Trib. Sediment Removal w/ Wetlands Treatment of Runoff at Edge of Property**	183,544	306	$103	34%
15	Comb. 15: PCAs 9 & 1 – **Trib. Sediment Removal w/ Chem. Treatment of Runoff at Edge of Property**	254,545	125	$157	47%
18	Comb. 18: PCAs 9 & 6 - **Tributary Sediment Removal w/ Alternative Land Uses**	100,738	501	$194	18%

Table ES-7
Summary of Values for Criteria 4 through 10 for Each PCA Combination, In Order of Ranking

Rank	PCA Combination Description	4. Surface Water Mgmt Objectives	5. Water Supply Increase	6.Acres of Wildlife Habitat	7. PV Change in Regional Income (2001 $)	8. Recreation Opport.	9. Engin. / Tech. Track Record	10. Environ. Compliance / Permitting Ease
RASTAS								
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	2	11,000	$182,504,000	1	4	4
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	3	2	11,000	$71,510,000	1	3	4
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	4	3	91,000	$7,696,000	1	3	4
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	4	2	35,000	-$279,715,000	1	3	3
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	4	2	26,000	-$150,998,000	1	3	2
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	4	4	79,000	-$5,834,223,000	1	4	4
TERMINAL LARGE SCALE WATER TREATMENT FACILITY								
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	2	1,000	$196,671,000	1	2	1
6	Comb. 11: PCAs 10 & 3 –**Water Trtmt Fac. w/ Non-Structural Mgmt at Parcel Level**	3	2	1,000	$85,677,000	1	2	1
10	Comb. 7: PCAs 10 & 11 - **Water Trtmt Fac. w/ Isol. Wetlands Restored on Pasture**	4	3	81,000	$21,863,000	1	2	1
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	4	2	25,000	-$265,548,000	1	2	1
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	4	2	16,000	-$136,831,000	1	2	1
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Fac. with Alternative Land Uses**	4	4	69,000	-$5,820,056,000	1	2	1
TRIBUTARY SEDIMENT REMOVAL								
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sed. Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	1	0	$131,178,000	0	3	3
9	Comb. 17: PCAs 9 & 3 – **Trib. Sed. Removal w/ Non-Structural Mgmt at Parcel Level**	2	0	0	$20,184,000	0	3	3
12	Comb. 13: PCAs 9 & 11 – **Trib. Sed. Removal w/ Isolated Wetlands Restored on Pastureland**	4	3	80,000	-$43,630,000	0	3	3
14	Comb. 16: PCAs 9 & 2 – **Trib. Sed. Removal w/ Wetlands Treatment of Runoff at Edge of Property**	4	1	24,000	-$331,041,000	0	3	3
15	Comb. 15: PCAs 9 & 1 – **Trib. Sed. Removal w/ Chem. Treatment of Runoff at Edge of Property**	4	1	15,000	-$202,324,000	0	3	2
18	Comb. 18: PCAs 9 & 6 – **Tributary Sediment Removal w/ Alternative Land Uses**	4	4	68,000	-$5,843,894,000	1	3	3

Table ES-8
Targeted Land Uses and Basins of the PCA Combinations

Table ES-8
Targeted Land Uses and Basins of the PCA Combinations

Rank	PCA Combination	Targeted Land Uses	Targeted Sub-Basins	% of Developed Land in Study Area (a)
RASTAS				
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	all agricultural land uses	all sub-basins	92%
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	cow-calf operations	all sub-basins (see Table A-4 in Appendix for acreages by sub-basin)	33%
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%
TERMINAL LARGE SCALE WATER TREATMENT FACILITY				
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
6	Comb. 11: PCAs 10 & 3 –**Water Trtmt Fac. w/ Non-Structural Mgmt at Parcel Level**	all agricultural land uses	all sub-basins	92%
10	Comb. 7: PCAs 10 & 11 - **Water Trtmt Fac. w/ Isol. Wetlands Restored on Pasture**	cow-calf operations	all sub-basins (see Table A-4 on page A-5 in Appendix for acreages by sub-basin)	33%
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%

Table ES-8
Targeted Land Uses and Basins of the PCA Combinations

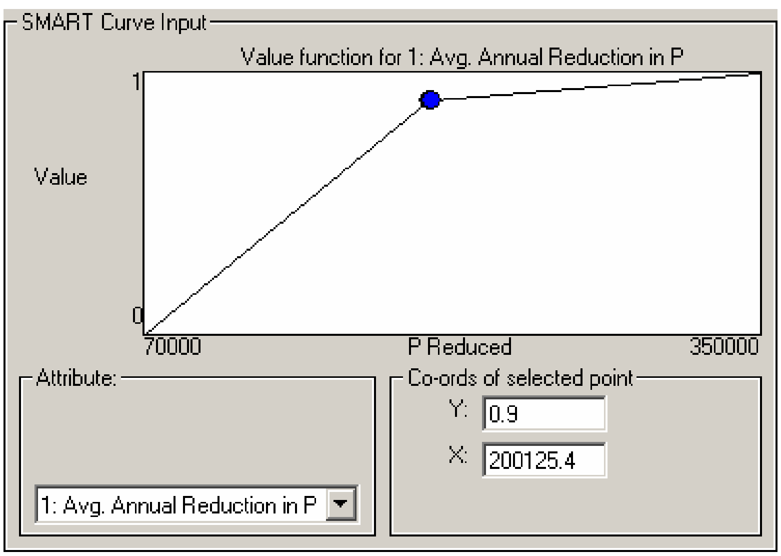
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Fac. with Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%
TRIBUTARY SEDIMENT REMOVAL				
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sed. Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
9	Comb. 17: PCAs 9 & 3 – **Trib. Sed. Removal w/ Non-Structural Mgmt at Parcel Level**	all agricultural land uses	all sub-basins	92%
12	Comb. 13: PCAs 9 & 11 – **Trib. Sed. Removal w/ Isolated Wetlands Restored on Pastureland**	cow-calf operations	all sub-basins (see Table A-4 in Appendix for acreages by sub-basin)	33%
14	Comb. 16: PCAs 9 & 2 – **Trib. Sed. Removal w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
15	Comb. 15: PCAs 9 & 1 – **Trib. Sed. Removal w/ Chem. Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
18	Comb. 18: PCAs 9 & 6 – **Tributary Sediment Removal w/ Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%

(a) Developed acreage is land in agriculture and residential uses and is 613,593 acres. Excludes water, wetlands, unimproved pasture, rangeland and upland forest.

Evaluation of Phosphorus Control Alternatives

The 18 PCA combinations were evaluated with respect to the ten evaluation criteria. The Criterium Decision Plus (CDP) model was used for the evaluation.[1] This model scales the quantitative and qualitative scores assigned to each criteria and each PCA, as presented in Tables ES-6 and ES-7, to a number between zero and one. For each PCA combination, the scaled value of each criterion was then weighted based on the importance of each criterion and them summed among all ten criteria to obtain the total score. The lowest possible total score is zero and the highest possible total score is one (0 < total score < 1).

Scaling of the Criteria Values. Before the criteria weights are applied to the results of the evaluation criteria, the results are scaled to a number between 0 and 1. For example, for Criterion 1 – Average Annual Reduction on Phosphorus to the Lake, the values among the PCA combinations ranged from 101,000 pounds per year to 346,000 pounds per year. These numbers were scaled to values between 0 and 1, based on the function presented in the figure below. The horizontal axis is the estimated average annual phosphorus reduction in pounds and the vertical axis is the scaled value. The scaling functions for each criterion are presented in Appendix B of the Documentation Report.



Criteria Weights. Each criterion was assigned a number between 0 and 100 that reflects the relative importance of the criterion among the ten criteria. The relative importance is determined by the preferences of the decision makers and the ranges of PCA values associated with each criterion. Given a specific preference of the importance of one criterion relative to the others, adjustments to the numbers might be necessary to reflect the relative sizes of the criteria ranges. For example, the numbers for criteria with relatively small ranges might be reduced and the numbers for criteria with relatively large ranges might be increased in order to effectively judge the PCAs.

[1] *InfoHarvest, Inc., Criterium Decision Plus, Version 3.0, Seattle, Washington, 2001.*

The assigned numbers were converted to the weights used in the evaluation. The conversion is the proportion of the criterion's number that represents the total of the numbers of all ten criteria. The numbers and weights for each criterion are presented in Table ES-9.

Table ES-9
Weighting of Evaluation Criteria

	Phosphorus Control Alternative (PCA)	Value	Weight
1	Average Annual Reduction in Phosphorus to Lake	100	0.179
2	Phosphorus Concentration at Site After PCA Implemented	75	0.134
3	Present Value Cost/lb of Phosphorus Removed from Lake	100	0.179
4	Surface Water Management Objectives	25	0.045
5	Water Supply Benefits	25	0.045
6	Enhanced Wildlife Habitat	25	0.045
7	Present Value Change in Regional Income	100	0.179
8	Increased Recreation Opportunities	10	0.018
9	Engineering Track Record	50	0.089
10	Environmental Compliance & Permitting Ease	50	0.089
Total		**560**	**1.000**

The values and weights indicate the importance of the criterion relative to the other criteria. For example, Criterion 1, Average Annual Reduction in Phosphorus to Lake Okeechobee, received 100 points and Criterion 5, Water Supply Benefits, received 25 points. This means that Criterion 1 is four times more important in the evaluation of the PCAs than is Criterion 5.

Scoring and Ranking of PCAs. The scoring and ranking of the PCA combinations are presented in Figure ES-2. The PCA combination name is presented in the first column, the total score is presented in the second column and a bar chart reflecting the total score is presented in the third column. Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs has the highest score of all 18 combinations. For informational purposes, the scoring and ranking of the individual PCAs is provided in Table ES-10.

Table ES-10
Scoring and Ranking of Individual PCAs

Rank	PCA Name (Number)	Score
1	Enhanced Cow-Calf BMPs (5)	0.669
2	RASTAs (7)	0.630
3	Non-Structural Management at the Land Parcel Level (3)	0.614
4	Isolated Wetlands Restoration on Pastureland (11)	0.593
5	Chemical Treatment of Runoff at Edge of Property (1)	0.553
6	Terminal Large Scale Water Treatment Facility (10)	0.542
7	Wetlands Treatment of Runoff at Edge of Property (2)	0.539
8	Tributary Sediment Removal (9)	0.461
9	Alternative Land Uses (6)	0.431
10	Optimization of Dairy Rule Design (4)	0.418

Impact of Uncertainty in Criteria Values on Number One Ranking. The CDP model allows the user to examine the sensitivity of the total scoring and ranking results to uncertainty in the criteria values. For each PCA and each of the continuous, quantitative criteria, criteria 1, 2, 3, 6 and 7, a probability distribution of values was specified. The average (mean) of the distribution was the value that was used in the evaluation. The model used these distributions to recalculate the total scores based on the probability distribution of the criterion values. The distributions were based on the best available information regarding the criterion values for each PCA.

The percent of the time that the combination would be ranked number 1 given the uncertainty distributions of the individual criteria scores was calculated. The probability distributions of the criteria values for each PCA combination results in Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs being ranked number 1 98 percent of the time with second ranked Combination 5: PCAs 7 and 3 – RASTAs with Non-Structural Management at the Land Parcel Level ranked number 1 two percent of the time.

Summary of Results. Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs has the highest score of all 18 combinations even when uncertainty in the criteria values is considered. Its score is 0.924 and it is ranked highest above all the others 98 percent of the time when uncertainty is considered. The second ranked combination is number 5: PCAs 7 and 3 - RASTAs with Non-Structural Management at the Land Parcel Level. Its score is 0.787. Combination 8: PCAs 10, 4 and 5 - Terminal Large Scale Water Treatment Facility with Dairy Farm Optimization and Enhanced Cow-Calf BMPs is a close third with a score of 0.756. The rankings of the 18 combinations are not sensitive to the weighting of the criteria values.

Impact of Uncertainty on Scores and Rankings. The impact of uncertainty on the total score for the top five PCA combinations is provided in Figure ES-3. The horizontal axis indicates the combination's score and the vertical axis indicates the frequency at which the combination obtains that score given the uncertainty in the criteria values. The distribution of scores for top ranked Combination 2 is to the right of the other combinations and would score higher than all the other combinations under practically all uncertainty scenarios. The distribution of fourth-ranked Combination 14 overlaps the distributions of Combinations 1, 5, and 8. Of these three combinations, 5 and 8 have higher scores and rankings than Combination 14. Thus, when uncertainty is considered, Combination 14 would rank higher than Combination 8 under many uncertainty scenarios and would rank higher than Combination 5 under a small portion of uncertainty scenarios.

Contributions of Criteria to Total Scores. The contributions of the individual criteria to the total score for each PCA combination are provided in Figure ES-4. The scores by criteria and in total are shown on the vertical axis and the PCAs are shown on the horizontal axis. The top ranked Combination 2 (PCAs 7, 4 and 5), scored well with respect to all ten criteria. Second-ranked Combination 5 (PCAs 7 and 3) also scored well with respect to all ten criteria, but its score for present value change in regional income was not nearly as large as was Combination 2's.

Figure ES-2
Summary of Evaluation Results - PCA Combination Scores

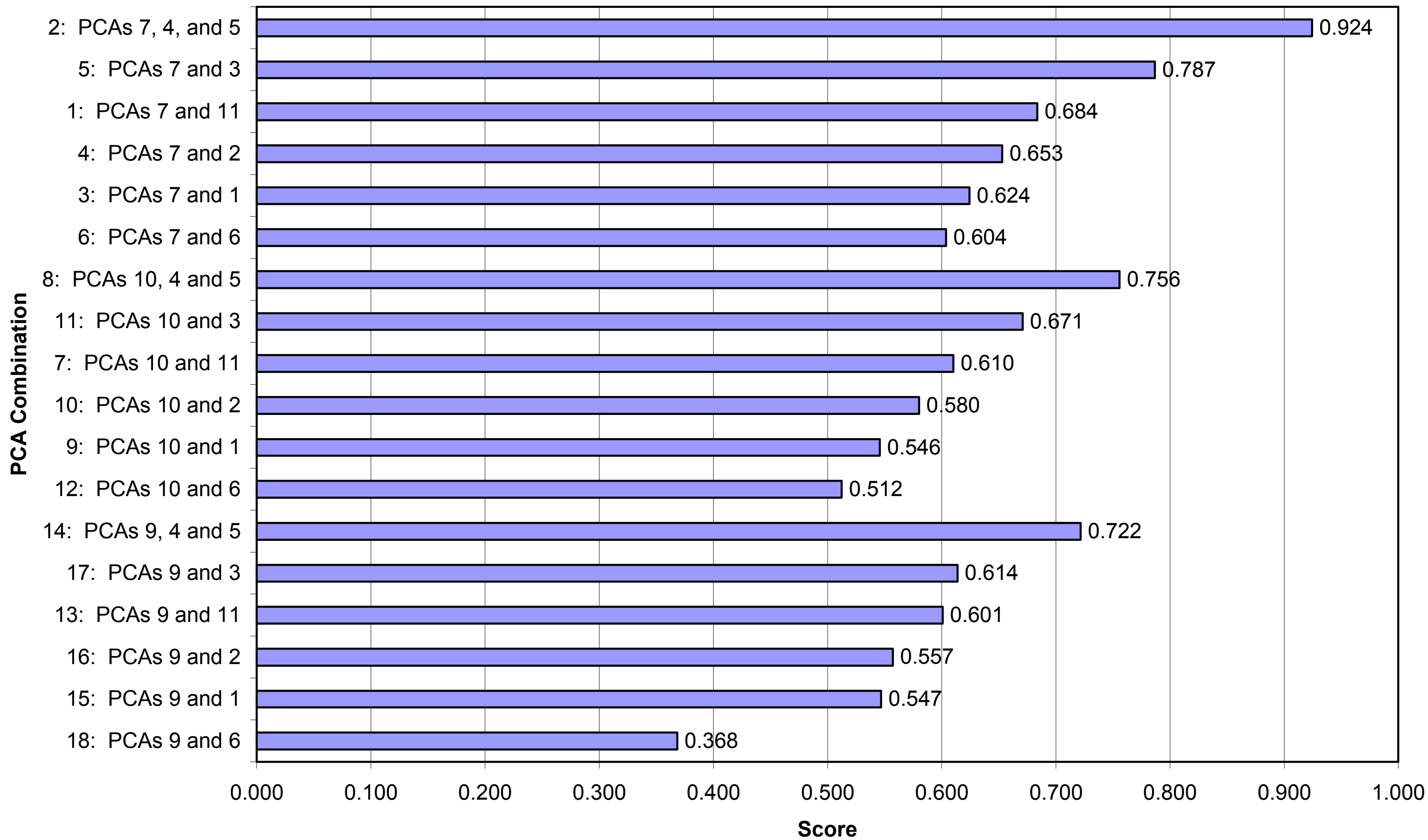


Figure ES-3
Impact of Uncertainty on Total Score for Top Five PCA Combinations

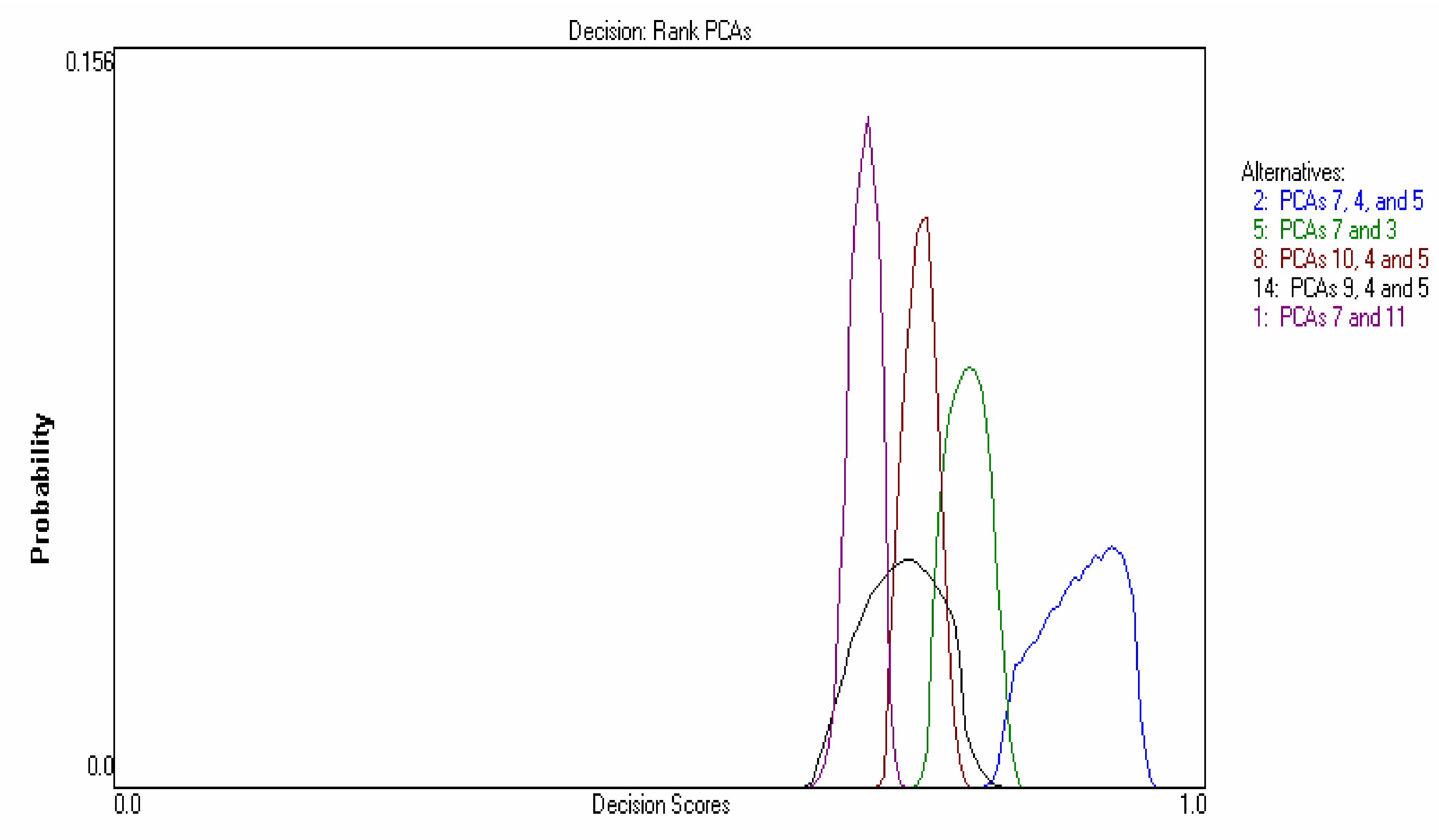
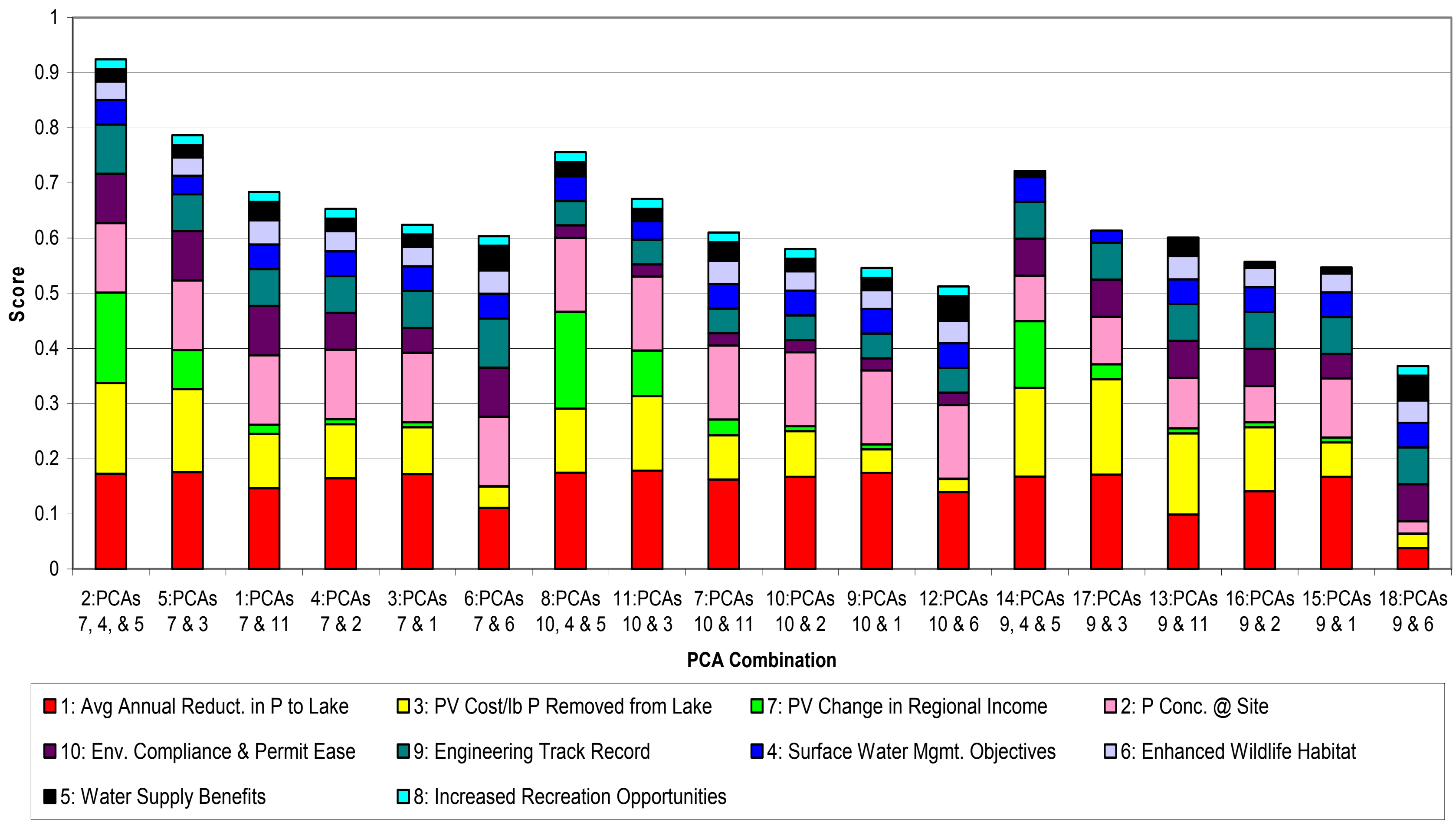


Figure ES-4
Contributions of Criteria to Total Score



Research Needs
Research needs were identified for five of the ten phosphorus control alternatives evaluated during this study. The recommendations are numbered in sequential order.

PCA 3 – Non-Structural Management at the Land Parcel Level
Of the PCAs evaluated, this one is the most in need of additional research to verify the estimates used in this study. The research recommendations are as follows.

1. **Soil Amendments to Reduce Phosphorus Loads in Water Runoff.** Of the research completed to date, only silicon appears to have potential to reduce phosphorus loads in water runoff. Research by the University of Florida Institute of Food and Agricultural Sciences (IFAS) on the use of silicon as a soil amendment to reduce phosphorus loads in water runoff has been successful. The research was conducted using beef pasture, dairy pasture, citrus and sod on the sandy soils of central and south Florida, including the study area. IFAS researchers have concluded that using silicon as a soil amendment reduces phosphorus leaching by 30 percent to 90 percent.[2] Once the District's study regarding the efficacy of applied limestone and gypsum is complete, the District will then be able to evaluate the use of soil amendments in practical farm management applications. The research should quantify the expected phosphorus reduction and the costs associated with on-farm application of these soil amendments.

2. **Fertilizer Management.** Calibrated soil testing and leaf sampling to determine optimal fertilization[3] holds great potential to minimize the application of phosphorus and nitrogen. No studies currently exist that address phosphorus load reductions from increased use of testing in Florida. Future research should address the phosphorus load reduction, the cost and yield impacts of calibrated nutrient testing and incentives for farmers to use this method when planning fertilizations.

3. **Area- and Crop- Specific Phosphorus Fertilization Requirements.** IFAS now recommends that applied phosphorus is not needed for bahia grass in the study area. The District should support and keep abreast of research regarding applied phosphorus needed by other crops in the study area including other types of pasture grasses, citrus, sod, vegetables, field crops and ornamentals.

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2 *Vladimir Matichenkov, Ph.D., University of Florida, Institute of Food and Agricultural Sciences, "Silicon Fertilization for Florida Dairy Farms and Beef Ranches" (no date – this is a summary of research results); V.V. Matichenkov, D.V. Calvert and E.A. Bocharnikova, University of Florida, Institute of Food and Agricultural Sciences, Florida Agricultural Experiment Station, "Effect of Si Fertilization on Growth and P Nutrition of Bahiagrass", Journal Series No. N-02067, 2001; Vladimir Matichenkov, Elena Bocharnikova and David Calvert, , University of Florida, Institute of Food and Agricultural Sciences, "Response of Citrus to Silicon Soil Amendments", Proceedings of the Florida State Horticultural Society, 2001.*

3 *Calibrated soil testing determines the minimum fertilization necessary for desired plant response.*

PCA 5 – Enhanced Cow-Calf Best Management Practices
The District, the University of Florida, the Florida Cattlemen's Association and the USDA Natural Resource Conservation Service (NRCS) support current research that identifies methods to reduce phosphorus in runoff from beef cattle pastures. The District's current project titled, "Beef Cattle Optimization Research at Buck Island" supports this effort. The overall goal of this project is to design cattle BMPs to reduce phosphorus loads from pastures while not substantially increasing costs to the rancher. Phase I of this research is underway and focuses on manipulation of cattle stocking rates to reduce phosphorus loads. Upon completion of Phase I, other management issues and potential cattle BMPs will be evaluated.

The following research recommendations address the need for estimates of phosphorus reduction and net revenue impacts associated with specific cow-calf BMPs that either comprise PCA 5 or were not evaluated as part of PCA 5 because cost and benefit information did not exist. These BMPs were selected from the document titled "Water Quality Best Management Practices for Cow/Calf Operations in Florida", June 1999. The selection of BMPs from this document was based on interviews with experts in cow-calf operations in the study area. The BMP report was prepared by staff of the Florida Cattlemen's Association, the NRCS, the Florida Department of Agriculture and Consumer Services (FDACS), the five Water Management Districts, the Florida Department of Environmental Protection and the University of Florida Institute of Food and Agricultural Sciences. The Florida Department of Agriculture and Consumer Services is considering these BMPs as they develop a Comprehensive Nutrient Management Plan that will be used for State rulemaking.

4. **Cattle BMP Research.** This study's estimates of the phosphorus reduction benefits and changes in net revenue from cattle operations associated with the following BMPs should be verified through current and future research efforts. Net revenue is revenue minus cost.

    a. **Animal Stocking Rates.** Identify cattle stocking rates that are effective in reducing phosphorus loads while minimizing negative farm impacts. Research results should include the impact of changing existing stocking rate levels on phosphorus loads and the net revenue impact per acre to landowners and identifying the current stocking rates of cow-calf operations in the study area such that an average stocking rate could be calculated. The District's Beef Cattle Optimization Project should address these issues.

    b. **Water Management to Slow or Eliminate Movement of Off-site Drainage.** Under this BMP, water control structures would be constructed in ditches within pastures to control the flow of surface water. Water would be held or released in selected pastures to maximize retention of phosphorus during and after storm events and minimize detrimental effects of flooding on vulnerable pasture grasses. Selected conveyance ditches that drain water directly off the property would be filled to slow the off-site movement of phosphorus-laden stormwater.

c. **Filter Strips.** A strip of herbaceous vegetation would be planted between surface waters and grazing land to filter nutrients from runoff water. Filter strips would be applied in association with fencing.

d. **Nutrient Management.** A nutrient budget for the operation would be developed so that phosphorus from all sources is accounted for. Nutrient sources include soil residuals, crop residues, organic and chemical fertilizer, and irrigation water. The nutrient budget would be used to determine the appropriate amount of fertilizer phosphorus to be added to pastures. Forage phosphorus content would be tested to determine the amount of phosphorus needed in the dry feed rations. Nutrients would be applied at times with the lowest likelihood of runoff occurring.

e. **Alternative Pasture Grasses.** Existing grasses would be replaced with types that do not require phosphorus fertilization and are flood tolerant to support extended on-site water retention in selected areas of pastures.

f. **All of the Above BMPs.** Conduct research to obtain estimates of the phosphorus load reductions and changes in net revenue from implementing all or a combination of the above listed BMPs.

5. **PCA 10 - Flow Equalization Associated with PCA 10 – Terminal Large Scale Water Treatment Facility.** PCA 10’s conceptual design requires about 4,000 acres of land to support a flow equalization area. The overland flow hydraulics and spillway control strategy should be reviewed in detail to assess the best alternative for flow equalization in the area. The feasibility of using aquifer storage and recovery (ASR) instead of surface storage should be investigated. In addition, it may be possible to use the reservoirs of local CERP projects for storage. ASR and/or the reservoirs of local CERP projects have the potential to reduce the cost of PCA 10 by about four percent.

6. **PCAs 7 and 8 - Influent Phosphorus Concentrations of Water Entering the RASTAs (PCAs 7 and 8).** The influent phosphorus concentrations used in this study were based on existing historic measurements at structures that were closest to the locations of the RASTAs. This parameter and the availability of a continuous supply of water are important determinants of phosphorus load reductions to the Lake. The District’s Lake Okeechobee Watershed Project – Project Implementation Plan, which has recently begun, will address these issues.

1.0 Introduction

1.1 Project Background

Lake Okeechobee, located in central Florida, is one of the most important resources of the state, providing agricultural and urban water supply, flood protection, recreation and ecological habitat to many diverse species of plants and animals. Lake Okeechobee is the second largest freshwater body within the contiguous United States and supports a valuable commercial and recreational fishery.[1] With an average depth of only 2.7 meters (8.9 ft), it has a surface area of 669 square miles and a maximum storage capacity of 1.05 trillion gallons.

The lake's drainage basin covers more than 4,600 square miles. The economy of the Lake Okeechobee watershed is primarily dependent on agricultural production, government transfer payments, and tourism. Livestock, citrus and milk production are the primary agricultural activities.

Land use development (primarily agricultural) and hydrologic changes (more efficient drainage of stormwater) in the 39 predominately agricultural watersheds surrounding Lake Okeechobee contributed to a serious decline in lake and downstream water quality, affecting most flora and fauna communities, and causing substantial blue-green algal blooms during the mid-1980s. The agricultural activities in the contributing basins have significantly impacted the ecological condition of the lake, with phosphorus as the main contributor.[2]

Best Management Practices (BMPs) and regulatory programs have been implemented over the past 28 years to reduce in-lake phosphorus loads. These programs included the Federal Clean Waters Program, the Taylor Creek headwaters project, the Works of the District (WOD) program for non-dairy land uses, the Florida Department of Environmental Protection's (FDEP) Dairy Rule and the District's/Florida Department of Agriculture and Consumer Services' Dairy Buyout Program. The collective effect of these management programs initially led to a decrease in the external phosphorus load to Lake Okeechobee, especially in the early to mid-1990s. However, the target values identified by water quality modeling efforts conducted in the late 1970s and early 1980s have not been met. Indeed, total loads to the lake are no longer declining because high internal loading, from sediments to the overlying water column, has offset the external reductions in phosphorus (P) loads.[3]

An in-lake phosphorus concentration goal of 40 ppb was developed in the early 1980s and legally mandated in the Surface Water Improvement and Management Plan (SWIM) in Sections 373.451 and 373.4595 of the Florida Statutes. In 2001, the Florida Department of Environmental Protection (FDEP) established a Total Maximum Daily Load (TMDL) for Lake Okeechobee of

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[1] *Lake Michigan is the largest freshwater lake in the contiguous United States.*

[2] *Steinman, Alan D., Karl E. Havens, Nicholas G. Aumen, R. Thomas James, Kang-Ren Jin, Joyce Zhang, and Barry H. Rosen, "Phosphorus in Lake Okeechobee: Sources, Sinks, and Strategies." Chapter 23, Phosphorus Biogeochemistry of Subtropical Ecosystems, K.R. Reddy, G.A. O'Connor, and C.L. Schelske (editors), Lewis publishers, Boca Raton, FL. 1999.*

[3] *Harvey, Richard and Karl Havens, "Lake Okeechobee Action Plan," United States Environmental Protection Agency and South Florida Water Management District, December 1999, West Palm Beach, Florida.*

140 metric tons per year of total phosphorus from all sources, including atmospheric deposition. The rule includes the allocation, implementation and management strategies needed to achieve the TMDL (Chapter 62-304, F.A.C., "Total Maximum Daily Loads"). The 1995 through 2000 average total phosphorus load to the Lake from all sources, including atmospheric deposition, was 573 metric tons per year.[4] Thus, the overall load reduction goal for the lake is 433 metric tons/year, based on the referenced five-year average load, or 75 percent.

It has become apparent that the existing programs, by themselves, will not be sufficient to achieve the required in-lake concentration or the proposed TMDL, and will need to be supplemented by similar programs in other regions of the watershed, and non-regulatory measures to augment the load reductions with willing landowners. District studies are underway to address how to mitigate the in-lake phosphorus loading from lake sediments. Many other District studies are addressing methods to reduce the amount of phosphorus entering the lake.

The Lake Okeechobee Protection Act (F.S. 373.4595) establishes extensive and comprehensive requirements for surface water improvement and management within Lake Okeechobee and its watershed. Feasibility of nutrient reduction technologies and cost-effectiveness in reducing phosphorus is an implicit part of the overall legislation, and explicitly referred to in various activities. This project provides the framework and detailed information on the feasibility of the different alternate nutrient reduction technologies applicable to the Lake Okeechobee watershed and compares the cost-effectiveness of various phosphorus reduction treatments. The information from this study will assist in the development of the 2004 Lake Okeechobee Protection Plan.

1.2 Project Objectives

This project provides a benefit-cost analysis of phosphorus control alternatives (PCAs) to further reduce the amount of phosphorus entering Lake Okeechobee using the best available information. The project was conducted in two phases.

Under Phase I, a computerized Full Cost Accounting Evaluation Model and ten phosphorus control alternatives were developed. Using this model, the alternatives were evaluated and ranked based on the magnitude of their itemized benefits and costs. Benefits and costs of each alternative to the District, to landowners and to the regional economy were described and quantified using the best available information. The model allows for updating as new data and information become available.

This study was the first attempt to estimate benefits and costs of the PCAs. In the process, some assumptions were used when sufficient information was lacking and recommendations for further research to improve the data were provided. The results of Phase I are reported in two documents titled, "Natural Resource Analysis of Lake Okeechobee Phosphorus Management Strategies, Phase I, Summary Report and Documentation Report", prepared by Hazen and

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[4] *South Florida Water Management District, West Palm Beach, Florida.*

Sawyer for the South Florida Water Management District under Contract C-11677, September 2002.

Under Phase II, a formal desktop feasibility evaluation of nutrient reduction technologies was prepared. All potential phosphorus reduction technologies were identified and evaluated to determine if sufficient information existed to evaluate additional technologies using the Full Cost Accounting Evaluation Model. The desktop evaluation identified two additional technologies: Isolated Wetlands Restoration on Pastureland and Dairy Farm Composting. Dairy Farm Composting was then evaluated under Phase II. Hazen and Sawyer had previously evaluated isolated wetlands restoration on pastureland using the model under contract for The Nature Conservancy, with permission from the District. The results were reported in the document titled, "Evaluation of Isolated Wetlands Restoration on Pastureland in the Lake Okeechobee Watershed, Final Report", prepared by Hazen and Sawyer for The Nature Conservancy under contract FCO-061402, December 2002. Ten of the twelve PCAs were then combined into 18 PCA combinations and evaluated using the Full Cost Accounting Evaluation Model.

This document presents the method and results of Phase II of this study.

The 12 PCAs that were evaluated, either under Phase I, Phase II or The Nature Conservancy are listed as follows.

1. Chemical Treatment of Runoff at Edge of Property (Phase I)
2. Wetlands Treatment of Runoff at Edge of Property (Phase I)
3. Non-Structural Management at the Land Parcel Level (Phase I)
4. Optimization of Dairy Rule Design (Phase I)
5. Enhanced Cow-Calf Best Management Practices (Phase I)
6. Alternative Land Uses (Phase I)
7. Reservoir-Assisted Stormwater Treatment Areas (RASTAs) (Phase I)
8. Taylor Creek / Nubbins Slough RASTA with Lake Okeechobee Supplemental Water Source (Phase I)
9. Tributary Sediment Removal (Phase I)
10. Terminal Large Scale Water Treatment Facility (Phase I)
11. Isolated Wetlands Restoration on Pastureland (The Nature Conservancy)
12. Dairy Farm Composting (Phase II)

Ten of these PCAs were combined and evaluated. The 18 PCA combinations are provided in Table 1-1. The combinations include one of six on-farm technologies combined with each three regional technologies. For example, Combination No. 1 is PCA 7 – RASTAs combined with PCA 11 – Isolated Wetlands Restoration on Pastureland.

Table 1-1
Combinations of Phosphorus Control Alternatives to be Evaluated During Phase II

Comb. No.	Regional PCA	On-Farm PCA
1	PCA 7 – RASTAs	PCA 11: Isolated Wetlands Restoration on Pastureland
2		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
3		PCA 1 – Chemical Treatment at Edge of Property
4		PCA 2 – Wetland Treatment at Edge of Property
5		PCA 3 – Non-Structural Management at Land Parcel Level
6		PCA 6 – Alternative Land Uses
7	PCA 10 – Terminal Large Scale Water Treatment Facility	PCA 11: Isolated Wetlands Restoration on Pastureland
8		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
9		PCA 1 – Chemical Treatment at Edge of Property
10		PCA 2 – Wetland Treatment at Edge of Property
11		PCA 3 – Non-Structural Management at Land Parcel Level
12		PCA 6 – Alternative Land Uses
13	PCA 9 – Tributary Sediment Removal	PCA 11: Isolated Wetlands Restoration on Pastureland
14		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
15		PCA 1 – Chemical Treatment at Edge of Property
16		PCA 2 – Wetland Treatment at Edge of Property
17		PCA 3 – Non-Structural Management at Land Parcel Level
18		PCA 6 – Alternative Land Uses

The Taylor Creek / Nubbins Slough RASTA with Lake Okeechobee Supplemental Water Source (PCA 8) and Dairy Farm Composting (PCA 12) were not included in the combinations because their overall score and ranking were lower than that for two similar alternatives, Reservoir-Assisted Stormwater Treatment Areas (PCA 7) and Optimization of Dairy Rule Design (PCA 4). The methods and data used to estimate the benefits and costs for each of the ten PCAs included in the combinations are provided in Sections 4 through 13 of the Phase II Documentation Report.

1.3 Full Cost Accounting

This study identified the benefits and costs of each PCA using a full cost accounting approach. Full cost accounting attempts to identify and quantify the social benefits and costs resulting from a policy decision. Social benefits and costs include private and external benefits and costs. Benefits and costs realized by those directly affected by the policy decision are called “private”. Benefits and costs to third parties, such as water utility customers in the case where a PCA increases water supply, are called “external”.

For benefits and costs that could not be assigned a monetary value, they were described and quantified to the extent practical. Decades of research into phosphorus reduction strategies in the Lake Okeechobee Basin and many current and new research and planning projects have and will provide a wealth of data that may be used to provide an economic evaluation of alternatives.

The potential benefits and costs of the alternatives include one or more of the following.

- The primary benefit of the PCAs is to reduce the amount of phosphorus in the runoff and stormwater entering Lake Okeechobee. This benefit can be considered both “private” and “external”. It is considered to be a “private” benefit because it allows the District to comply with state law. It is also considered an “external” benefit because phosphorus load reductions are expected to improve native fish populations in Lake Okeechobee resulting in increased recreation values and tourism and increased income to businesses surrounding the Lake.

- The “private” costs include the capital and O&M costs to government agencies and to landowners from implementing the alternative.

- “Private” benefits and costs also include changes in net revenues to landowners caused by: (1) changes in animal productivity such as milk production per cow or productivity of pastureland; and (2) changes in costs as the alternative affects management practices.

- The “private” costs of the PCA, if financed by the landowners, may reduce the ability of landowners to continue economic activities under the PCA. If agricultural land leaves production due to the PCA, the result would be reductions in regional sales, income and employment. Under Phase II of this study, the District requested that the estimated changes in regional income recognize that landowners may share the cost of the on-farm PCAs with other entities. Thus, the Lake Okeechobee Interagency Committee requested that the study assume that landowners contribute to a portion of the cost equivalent to approximately 12.5 percent of the cost of the on-farm PCAs.

- For the purposes of this study, as requested by the District and as provided for in the Phase II Scope of Services, this study also assumes that landowners would be able to afford the 12.5 percent cost share and that no change in land use would occur due to this cost share.

- Another "external" benefit of the PCAs is the increase in regional income as investments are made to implement, maintain and use the PCAs. For this study, regional income is defined as employee compensation, proprietor's income, interest, rents, profits, sales taxes, excise taxes and property taxes. This definition is also called "Total Value Added". Regional income would increase if money from outside the regional area is used to purchase goods and services within the area to implement the PCAs.

- This study assumes that 87.5 percent of the costs are financed with money from sources outside the regional area, so regional income would increase as this money is spent on the PCA investments. Regarding the 12.5 percent of costs financed by area landowners, if the cost paid by the landowner is simply a shift from one type of local expenditure to another, then the shift in expenditures will not change regional income. For the purposes of this study it was assumed that landowners would reduce other local expenditures to pay for the cost share, so no change in regional income will result from landowner expenditures.

- For those PCAs that require land use changes, such as converting improved pasture to RASTAs, a corresponding reduction in regional income from displaced agricultural operations would be expected.

- Additional "external" benefits include water supply benefits from increased groundwater recharge, reduced water use, and increased water storage

- Reductions in soil erosion and sediment transport that would result from a PCA provides "private" and "external" benefits to landowners.

- For those who value the watershed's native environment, improvements and increases in wildlife habitat and native areas provide "external" benefits to the extent that the PCA provides a net increase in the amount or quality of available wildlife habitat.

The true measure of the benefits and costs associated with an investment is the change in total economic value caused by the investment. The change in total economic value is the sum of the changes in producer surplus and consumer surplus caused by an investment, such as building and operating the RASTAs.

Producer surplus is profit, where profit is measured as total revenue minus the opportunity costs of production including the opportunity cost of labor and capital, and the value of the entrepreneurial skills and natural resources when placed in their best alternative use. The values of the skills and natural resources are usually reflected in salaries paid to managers and company leaders, and rents paid to owners of the natural resources.

Consumer surplus is the maximum amount of money a consumer would be willing to pay for the benefit above the price actually paid. Consumer surplus is analogous to producer surplus, or "profit". However, unlike producer surplus, consumer surplus does not represent real money changing hands. Instead, it represents the value, in monetary terms, of the human well-being associated with current use of the resource.

Because data and information constraints prevented the estimation of changes in consumer and producer surplus for this study, proxy measures were developed and are summarized in the above listing of benefits and costs. Future research that addresses the data needed to estimate changes in producer and consumer surplus associated with the PCAs would allow the evaluation criteria to be modified to measure changes in total economic value.

In addition, the inclusion of changes in regional income, as defined above, as an evaluation criterion is not a true measure of the societal economic benefits or costs of the PCA, although it would represent benefits and costs to an individual person or government agency. When looking at society as a whole, labor costs associated with producing a particular output are not considered a societal benefit. If this were true, then only those industries that utilized significant labor resources to produce an output would be considered beneficial to society and labor saving improvements, such as computer capabilities, would be considered detrimental to society. This is why "producer surplus" or "profit" is considered to be the appropriate measure of societal benefit. It is the value of the benefits minus all the costs of producing the benefit and represents how efficiently a good or service can be produced. Labor not needed to produce one product can be used to produce other products resulting in a higher level of societal well-being.

On the other hand, there is a legitimate reason for local leaders, such as county and city commissioners, and District governing board members, to be concerned about how large investments, such as the RASTAs, will affect regional employment and income. From their perspective, removing significant acreages from agricultural production could have serious negative economic consequences for a local community. Because these leaders are responsible for the well-being of their constituents, it is necessary to understand how these investments will affect the economic well-being of the regional area. Therefore, at the request of the District, the change in regional income was included as an evaluation criterion.

A computerized Full Cost Accounting Evaluation Model was developed for use during this study and to allow for updating as new data and information become available. The benefit-cost analysis is used in conjunction with an evaluation model that uses ten evaluation criteria to measure the relative benefits and costs of the alternatives and to provide a ranking of alternatives based on the magnitude of itemized benefits and costs. The computerized model will allow the District to add and evaluate additional PCAs.

1.4 Study Area

The study area is defined as the area where the PCAs will be implemented. This study area is depicted in Figure 1-1. It includes sub-basins 2 through 6, and 8 through 26 of the Lake Okeechobee watershed. These sub-basins were chosen because, within the Lake Okeechobee watershed, water drains into the lake from these areas. Lake Istokpoga (sub-basin 7) and Arbuckle Creek (sub-basin 1), which is north of Lake Istokpoga, were excluded from the study area because the District is evaluating these two sub-basins separately. The study area includes the four sub-basins that contribute the largest phosphorus loads to the lake: S-65D; S-65E; S-154 and S-191 (Taylor Creek / Nubbin Slough). The study area includes large portions of Okeechobee, Highlands and Glades counties; a small portion of Polk and Osceola counties and a very small portion of Martin and St. Lucie counties.

1.5 Land Uses in the Study Area

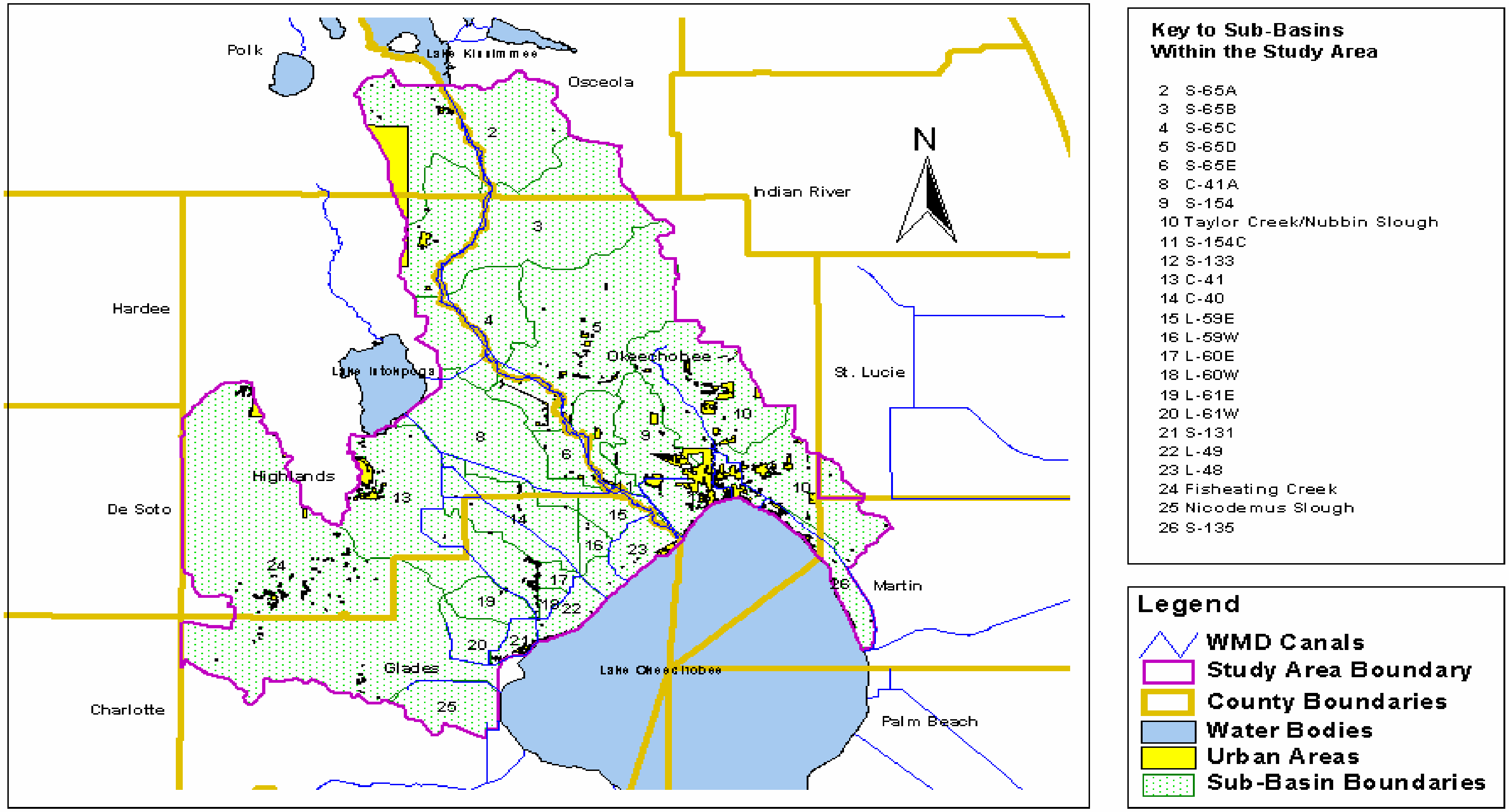
A summary of the current and forecasted land uses in the study area is provided in Table 1-1. The 2002 acreages reflect actual 1995 land uses and a 2000 update of dairy land use. There has not been a significant change in land use since 1995. The current distribution of land uses in the study area is presented in Figure 1-2. About one-third of the current land use is improved pasture and another third is in unimproved pasture, rangeland and upland forest. Water and wetlands comprise 20 percent of the study area. Urban uses comprise 4 percent of the study area.

The 2021 forecasts are from the forecasting method described in Section 15.0 of the Phase II Documentation Report. Acreages in citrus groves and urban uses are expected to increase by 28 percent and 49 percent, respectively from 2002 to 2021. Row crops are expected to increase by 38 percent. Aquaculture, sod farms and ornamentals are expected to increase by a total of 18 percent. The acreage in improved pasture is expected to fall by seven percent. Land in unimproved pasture, rangeland and upland forest is expected to fall by four percent.

1.6 Methodology for Estimating Benefits and Costs

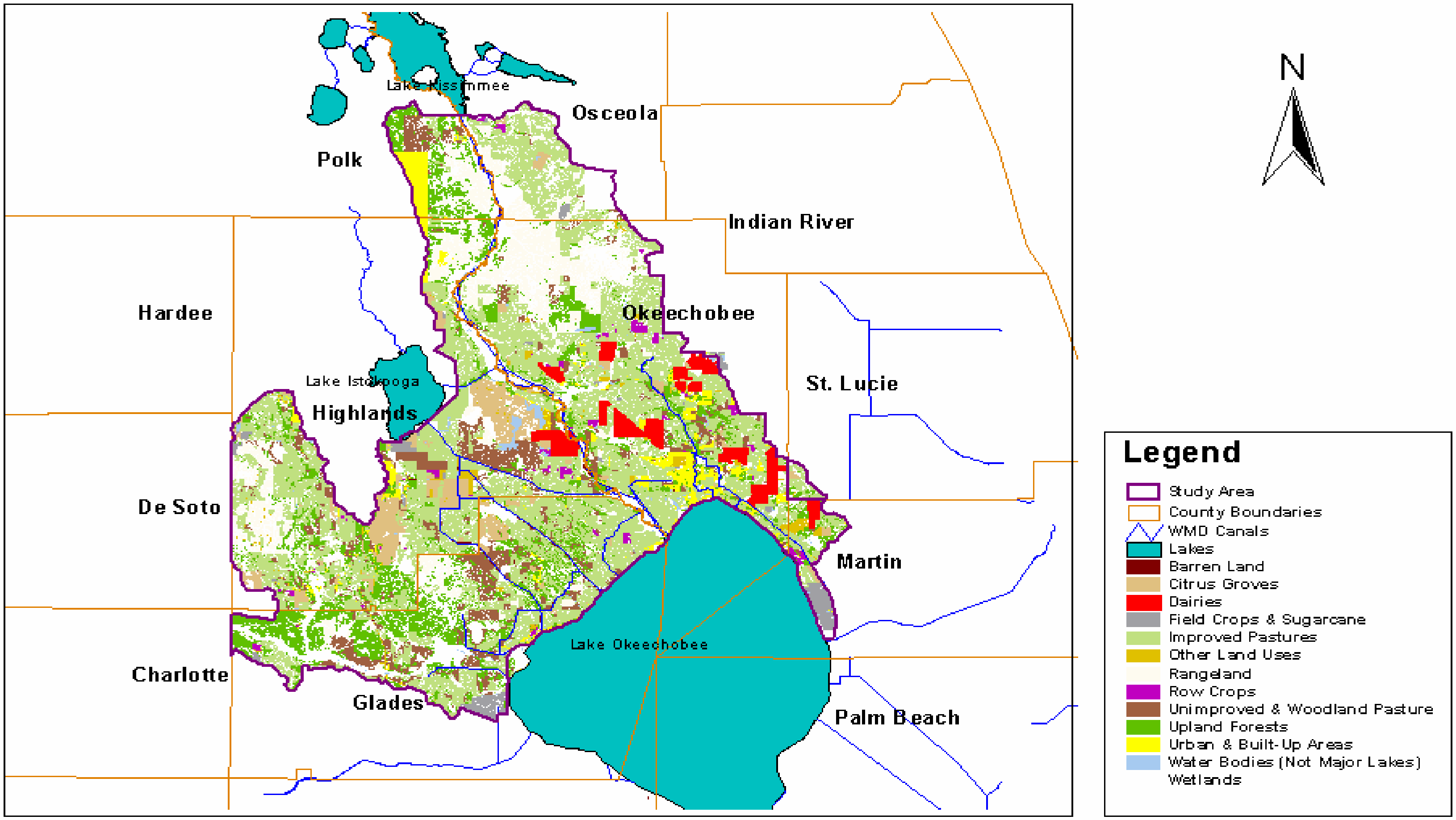
The benefits and costs of each PCA were estimated using the best available information. The methods used for each PCA are described in the Phase II Documentation Report. Benefits and costs were measured relative to baseline conditions of land uses, farm practices and regulatory requirements. The general baseline conditions are described below. Model farms were developed to estimate the benefits and costs of the on-farm PCAs. These model farms are summarized below. Baseline conditions specific to these model farms are described in Section 15 of the Phase II Documentation Report.

Figure 1-1
Natural Resource Analysis of Lake Okeechobee Phosphorus Management Strategies
Map of Study Area: Sub-Basins, County Boundaries & Urban Areas



Source:
South Florida Water Management District (SFWMD), "Lake Okeechobee Agricultural Decision Support System (LOADSS)." Revised 1998.

Figure 1-2
Land Uses in the Study Area



Source:
South Florida Water Management District (SFWMD), "Lake Okeechobee Agricultural Decision Support System (LOADSS)." Revised 1998.
Dairy locations represent 1998 conditions. All other land uses represent 1995 conditions.

General Baseline Conditions. All benefits and costs of each PCA are relative to that which would occur under baseline conditions. Baseline conditions are defined as those land uses, farm practices and regulatory requirements that would occur during the study period if none of the PCAs were implemented. These conditions are the same for all of the ten PCAs. The general baseline conditions are as follows:

- The following programs and regulations are effective throughout the study period in the manner that existed in September, 2000: The FDEP Dairy Rule, the Lake Okeechobee Works of the District Rule, the District's Environmental Resource Permitting Rule and the District's Water Use Permitting Rules.

- All rules and programs that existed as of September 2000 are in effect throughout the study period. No new rules or programs affecting landowners in the study area are promulgated during the study period, including new or additional water quality standards or new NPDES permitting requirements.

- None of the projects described in the Corps' and the District's Comprehensive Everglades Restoration Plan are built during the study period.

- The land uses in the study area during the study period are those that are projected in Table 1-1.

Table 1-1
Land Uses within the Lake Okeechobee Study Area

Land Use Description	Acreage 2002	Projected Acreage 2021	Percent Change
Improved Pasture	432,806	402,751	-7%
Water & Wetlands	241,388	241,388	0%
Unimproved Pasture, Rangeland & Upland Forest	361,883	348,585	-4%
Citrus Groves	55,222	70,477	28%
Urban & Built-up and Transportation, Communications & Utilities	46,846	69,697	49%
Dairies [(a)]	20,200	20,200	0%
Sugarcane	9,384	9,384	0%
Row Crops	10,663	14,722	38%
Field Crops	9,415	9,415	0%
Aquaculture, floriculture, fruit orchards, horse farm, ornamentals, other grove, sod farms, tree nurseries	6,700	7,888	18%
Woodland pastures, barren land, fallow cropland and other	25,308	25,308	0%
Total	1,219,814	1,219,814	

(a) The dairy land uses include the total farm acreage used for dairy cows.

Model Land Uses. In order to estimate the benefits and costs of the on-farm PCAs, the benefits and costs to individual "model farms" were estimated and the results inferred to the total population of farms in the study area. A summary of the model land uses is provided in Table 1-2. The acreage associated with each model land use was based on number of farms and acreage data reported in the 1997 Census of Agriculture, Florida, County Data, available from the USDA, National Agricultural Statistics Service. Data for Okeechobee, Highlands and Glades counties were used to calculate average farm size in 1997. Census data for Polk and Osceola counties were not used because only a small portion of these large agricultural counties is included in the study area.

Table 1-2
Summary of Model Land Uses

Model Land Use	Description	Acres
Large Cow-Calf Operation	A cow-calf operation with at least 100 head of cattle of all types (beef cows, heifers, steers, bulls and calves). This model land use has 959 head of cattle.	4,200
Small Cow-Calf Operation	A cow-calf operation with fewer than 100 head of cattle of all types (beef cows, heifers, steers, bulls and calves). This model land use has 27 head of cattle.	120
Citrus Operation	Citrus grove with bearing and non-bearing acres	240
Field Crop Operation	Farm produces sugarcane	1,150
Dairy Operation	Dairy farm with a milking herd of 1,100 cows, 1,300 cows total	1,010
Row Crop Operation	Farm produces vegetables for sale	160
Tree Nursery Operation	Farm produces ornamental trees	20
Sod Operation	Farm produces sod	270

1.7 Study Period

The benefits and costs of each PCA were evaluated over a sixty-year period. This time period was chosen because it adequately considers the time lags between the start of PCA development and the point at which the PCA is fully operational. It also allows all capital improvements made during the study period to be fully depreciated to obtain an apples-to-apples comparison among the PCAs. While benefits and costs will accrue past twenty years, the reliability of land use forecasts under baseline conditions that affect the benefits and costs falls considerably after twenty years. Therefore, the forecasted land uses in 2021, the end of the land use forecast period, are presumed to remain unchanged from 2021 to the end of the sixty-year study period. This forecast is the best available at this time.

All benefits and costs are reported in year 2001 dollars. Years are incremented by units of one year. Therefore, the first year for which benefits and costs are reported is Year 1, the second year is Year 2 and so on through Year 60. The discount rate, net of inflation, is 3.2 percent as recommended by the U.S. Office of Management and Budget.[5]

1.8 Key Information Sources

The key data and information sources included District models, District tributary water flow and phosphorus concentration/load spreadsheets, District publications, and the IMPLAN regional input-output model. Three of the models used are summarized below. Details regarding the methods used to estimate benefits and costs are provided for each PCA in Sections 4 through 13 of the Phase II Documentation Report.

Lake Okeechobee Agricultural Decision Support System (LOADSS). LOADSS is owned by the District and is a GIS-based tool for evaluating the environmental and economic impacts of different agricultural management practices in the Lake Okeechobee watershed that reduce phosphorus loads to the Lake. The Lake Okeechobee watershed coverage incorporates information about land uses, soil associations, weather regions, management practices, hydrologic features and political boundaries for approximately 1.5 million acres of land and consists of 7,000 polygons. LOADSS runs on SUN SPARC stations using ARC/INFO GIS software and requires 80 mb of hard disk storage. It has a mouse and menu driven user interface.

The LOADSS user identifies the baseline and the alternative phosphorus control practices (PCPs) within the Lake Okeechobee Watershed. LOADSS performs the following functions.

1. Creates thematic maps and reports, detailing existing features of the watershed (land uses, soil associations, weather regions, roads, hydrography, basin and county boundaries, etc.).

2. Changes land uses and management practices on polygons selected using a mouse or using selected logical criteria (for example, a particular land use or soil association).

3. Calculates phosphorus runoff from the property, phosphorus assimilation along streams and canals, and the final phosphorus loading to Lake Okeechobee for a particular regional plan. The phosphorus runoff and phosphorus concentrations are twenty-year average annual values. Annual values will change from year to year due primarily to changes in rainfall.

4. Creates maps and reports detailing material imports and exports, economic and financial impacts (changes in direct farm and District costs, changes in other farm costs, changes in farm production (sales), and changes in regional income), environmental effects of selected land uses and management practices. The user may compare the net effects of different regional plans.

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[5] *U.S. Office of Management and Budget, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs", Circular No. 94, Appendix C, revised January 2001, http://www.whitehouse.gov/OMB/circulars/a094/ao94.html.*

The land uses supported by the LOADSS model include: improved and unimproved beef pasture; dairies; citrus; sugarcane; sewage treatment plant; sugar mill; sod; lettuce; caladium bulbs; slash pine; and forage production. The model also provides the cost to convert from one land use to another. The land use conversions supported by LOADSS includes: converting from unimproved pasture to citrus; improved pasture to citrus; dairy to citrus; sugarcane to truck crops; citrus to truck crops; improved pasture to truck crops; dairy to sugarcane; dairy to improved beef pasture; dairy to unimproved beef pasture; unimproved beef pasture to improved beef pasture; and improved beef pasture to unimproved beef pasture.

LOADSS was first created in 1989 and was updated in 1999. The updated LOADSS model was re-calibrated using observed tributary phosphorus loads from 1991 to 1995. The economic information was updated to reflect 1997 dollars.

While the LOADSS model supports 188 land uses and practices, the model does not allow the user to evaluate other management practices. For this reason, the Okeechobee Update to EAAMOD was used for management practices considered during this study that are not supported by LOADSS.

Okeechobee Update to EAAMOD (EAAMODOKEE). This District model simulates the impact of on-farm phosphorus management strategies on phosphorus loads leaving properties in the Lake Okeechobee watershed. This model was recently completed by updating the Everglades Agricultural Area Model (EAAMOD). The EAAMODOKEE model assists in developing effective best management practices (BMPs) for reducing phosphorus losses from farms in the Lake Okeechobee watershed and in developing a field-scale model to evaluate the long-term effect of various BMPs. The model predicts water flows and the levels of phosphorus and nitrogen from a field given specific farm management strategies. Modeled phosphorus processes include mineralization and sorption-desorption while inputs of phosphorus can be from fertilizer, rainfall, irrigation water, manures and biosolids.

The user may specify one of a menu of management strategies to evaluate or may design his/her own set of management strategies. Examples of management strategies include changing fertility rates; changing crop rotation; changing herd densities; and changing irrigation rates. The crops supported by EAAMODOKEE include beef pasture (eight different grasses); dairy pastures and sprayfields; citrus; green peppers; tomatoes; cotton; watermelon; sugarcane; sweet corn; lettuce and radishes.

LOADSS and EAAMODOKEE models do not require the user to provide raw data inputs. The user simply defines the baseline and alternative regional land management practices to be evaluated.

IMPLAN Regional Economic Input-Output Model. This computer model simulates the supply of and demand for goods and services within a county or within groups of counties. It allows the user to estimate the extent to which new investments or increases in demand affect a region's economy in terms of sales, income and employment. IMPLAN stands for IMpact

Analysis for PLANning and was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the USDI Bureau of Land Management to assist the Forest Service in land and resource management planning. The developers of this model formed the Minnesota IMPLAN Group in 1993 to privatize the development of IMPLAN data and software.

The IMPLAN model was used to estimate the change in regional income (or total valued added) associated with each PCA. The Florida county input-output data represents 1998 economic conditions. This was the most recent year available from the Minnesota IMPLAN Group.

The multipliers used to estimate the direct, indirect and induced impacts of a land use change on income and tax revenues, also called total value added multipliers, represent the economy of Okeechobee, Highlands and Glades counties. Total value added (TVA) multipliers represent the sum of employee compensation, proprietor's income, interest, rents, profits, sales taxes, excise taxes and property taxes. The definitions of these TVA multipliers are provided as follows.

- Direct TVA Effect - Change in the dollar value of the TVA as the change in output from the study area affects the industry producing the output.
- Indirect TVA Effect - Change in the dollar value of the TVA resulting from the output-producing industry purchasing goods and services from other local industries per dollar change in output from the study area.
- Induced TVA Effect - Change in the dollar value of TVA resulting from local purchases by households who receive income from the direct and indirect industries per dollar change in output from the study area.
- Total TVA Effect – The sum of the direct, indirect and induced TVA effects.

The outputs of this model were used to estimate the change in regional income due to the PCAs.

1.9 Report Organization

This document is divided into a Summary Report and a Documentation Report. This Summary Report includes an executive summary, Sections 1, 2, 3 and the Bibliography. Section 1.0 is the Introduction. Section 2.0 describes the results of the desktop evaluation of nutrient reduction alternatives. Section 3.0 presents the evaluation model and evaluation results. The Documentation Report contains Sections 4 through 16 and all Appendices. Sections 4 through 13 focus on each of the ten PCAs and describe the data and methods used to estimate the values for the ten evaluation criteria. Section 14 describes the assimilation model used to estimate the change in phosphorus load as the water travels from the PCA sites to the lake. Section 15 presents the baseline conditions for the model farms and the method used to forecast land use in the study area. Section 16 is the Bibliography. Appendix A describes the methods used to estimate the input phosphorus concentrations for the regional PCAs given implementation of the on-farm PCAs. Appendix B presents the scaling functions for each of the ten evaluation criteria. Appendix C presents the uncertainty distributions for the PCA combinations. Appendix D provides the tables that calculate the present value cost per pound of phosphorus removed and the present value change in regional income for the PCA combinations. Appendix E provides the current and forecasted land uses by sub-basin.

2.0 Desktop Evaluation of Nutrient Reduction Technologies

The Lake Okeechobee Protection Act, Section 373.4595, F.S., requires that an evaluation of the feasibility of alternate nutrient reduction technologies be performed by July 1, 2003. This shall include evaluation of sediment traps, canal and ditch maintenance, fish production or other aquaculture, bioenergy conversion processes, and algal or other biological treatment technologies.

This Section summarizes the desktop evaluation that identifies and screens various alternate nutrient reduction technologies with respect to the feasibility of evaluating these technologies using the Full Cost Accounting Evaluation Model developed during this study. This desktop evaluation utilized a literature search and the analysis of the 10 PCAs evaluated under Phase I to screen alternate nutrient reduction technologies for benefit-cost analysis. The full report is provided in "Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies" prepared by Hazen and Sawyer in association with Soil and Water Engineering Technology, Inc. for the South Florida Water Management District, December 2002.

2.1 Summary of Screening Criteria

The screening criteria used to determine if an alternate nutrient reduction technology will be considered for evaluation with respect to the Full Cost Accounting Evaluation Model are as follows.

(1) Sufficient information - There is sufficient information to allow for an adequate evaluation of benefits and costs associated with the technology.

(2) Phosphorus reduction potential - The technology has the potential to successfully reduce phosphorus loads to Lake Okeechobee.

(3) Confidence of Sustained Performance – The technology has been demonstrated to be effective in reducing phosphorus loads and its operational theory and application indicates that the technology is likely to reduce phosphorus loads on a long-term basis.

(4) Timeliness - The technology is timely in that it is available and is, or could be, considered in planning programs.

(5) No Significant Negative Side Effects – The technology will not have a significant negative side effect that is thought to be detrimental to the region from the perspectives of public health and safety and the District's mission.

In order for the technology to be considered for inclusion in the benefit-cost evaluation of phosphorus control alternatives, the technology must pass all of the screening criteria. The determination of whether a technology passes each screening criterion is described as follows.

Screening Criterion 1 - Sufficient Information. Each technology was evaluated with respect to the availability of information needed to achieve a moderate or high level of confidence in the estimated benefits and costs from a planning level perspective. The scoring for this screening criterion follows. An example using four technologies is provided in Table 2-1.

Table 2-1
Screening Criteria 1: Availability of Sufficient Information (yes or no)

	Information Needed (moderate or high level of confidence in estimates)			
Technology	**P Reduction**	**Costs**	**Existing Conditions**	**Points (no. of yeses)**
Technology 1	Yes	No	No	1
Technology 2	No	Yes	Yes	2
Technology 3	Yes	Yes	Yes	3
Technology 4	Yes	Yes	Yes	3

"P Reduction" means that documentation exists that will provide a quantitative estimate of the pounds of phosphorus that would be prevented from entering Lake Okeechobee if the technology were implemented. "Costs" mean that documentation exists that will allow one to obtain quantitative estimates of the capital and O&M costs, and other relevant costs and revenues, associated with implementing the technology. "Existing Conditions" means that documentation is available regarding existing management practices needed to estimate the benefits and costs of the technology's use. Benefits and costs are measured relative to baseline conditions.

In order to pass Screening Criterion 1, the technology must score 3 points. Under this example, Technologies 3 and 4 would pass screening criteria 1. Insufficient information exists to conduct an adequate benefit-cost analysis of Technologies 1 and 2.

Screening Criterion 2 - Phosphorus Reduction Potential. The technology must have the potential to reduce phosphorus loads to Lake Okeechobee. The phosphorus load reduction referred to under this criterion applies to the water being treated by the technology. The scoring for this screening criterion is as follows.

> 0 points = The technology is not likely to reduce phosphorus loads to the Lake or the technology cannot reduce the applicable phosphorus loads to the Lake by more than 25 percent or cannot reduce phosphorus concentration to 40 ppb or below if a regional technology or to 100 ppb or below if an on-farm technology or it is not known if phosphorus loads would be reduced.
>
> 1 point = The technology is likely to reduce the applicable phosphorus loads to the Lake by at least 25 percent or the technology will reduce phosphorus concentrations to at or below 40 ppb if it is a regional technology or the technology would reduce phosphorus concentrations to at or below 100 ppb if it is an on-farm technology.

In order to pass Screening Criterion 2, the technology must score 1 point.

Screening Criterion 3 - Confidence of Sustained Performance. The technology has been demonstrated to be effective in reducing phosphorus loads and its operational theory and application indicates that the technology is likely to reduce phosphorus loads on a long-term basis. The scoring for this screening criterion is 1 point if the above statement is true and 0 points if the above statement is false. In order to pass Screening Criterion 3, the technology must score 1 point.

Screening Criterion 4 - Timeliness. The technology is timely in that it is available and is, or could be, considered in planning programs. The scoring for this screening criterion is 1 point if the above statement is true and 0 points if the above statement is false. In order to pass Screening Criterion 4, the technology must score 1 point.

Screening Criterion 5 - No Significant Negative Side Effects. The technology will not have a significant negative side effect that is thought to be detrimental to the region from the perspectives of public health and safety and the District's mission. The scoring for this screening criterion is 1 point if the above statement is true and 0 points if the above statement is false. In order to pass Screening Criterion 5, the Technology must score 1 point.

2.2 Alternate Nutrient Reduction Technologies

The alternate nutrient reduction technologies screened during this desktop evaluation are separated into two categories, regional and on-farm. A list of these technologies is provided in Table 2-2.

Table 2-2
List of Alternate Nutrient Reduction Technologies Screened
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Regional Technologies

1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals
2. Aquaculture and/or Algal-Based Water Treatment Systems
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)
4. Terminal Large Scale Water Treatment Facility Using Chemical Treatment and Solids Separation (CTSS)
5. Canal and Tributary Maintenance Program
6. Tributary Sediment Traps
7. Modify Design and Operation of Regional Water Control Structures

On-Farm Technologies

8. Isolated Wetlands Restoration
9. Improved Dairy Farm Waste Processing Technologies
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties
11. Wetlands Treatment of Runoff at Edge of Properties
12. Non-Structural Management at the Land Parcel Level

Table 2-2 (Continued)
List of Alternate Nutrient Reduction Technologies Screened
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

13. Enhanced Cow-Calf Best Management Practices
14. Alternative Land Uses
15. Phosphorus Absorption, Binding and Filtration Technologies
16. Additional Farm Level Best Management Practices
17. On-Farm Composting of Animal Solid Waste

2.3 Results of Screening

The technologies that passed all five screening criteria are provided in Table 2-3.

Table 2-3
Alternate Nutrient Reduction Technologies that Passed All Screening Criteria
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Technology Category	Evaluated During This Study - PCA Number [(a)]
Regional Technologies	
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)	PCAs 7 and 8
4. Terminal Large Scale Water Treatment Facility Using CTSS	PCA 10
5. Canal and Tributary Maintenance Program – Sediment Removal from Primary Canals	PCA 9
On-Farm Technologies	
8. Isolated Wetlands Restoration [(b)]	PCA 11
9. Improved Dairy Farm Waste Processing Technologies	PCA 4
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties	PCA 1
11. Wetlands Treatment of Runoff at Edge of Properties	PCA 2
12. Non-Structural Management at the Land Parcel Level	PCA 3
13. Enhanced Cow-Calf Best Management Practices	PCA 5
14. Alternative Land Uses	PCA 6
17. On-Farm Composting of Animal Solid Waste [(c)]	PCA 12

(a) PCA stands for Phosphorus Control Alternative. PCAs represent a specific implementation method.

(b) The Nature Conservancy contracted Hazen and Sawyer to use the Full Cost Accounting Evaluation Model to evaluate a specific type of isolated wetlands program. The results are presented in the report titled, "Evaluation of Isolated Wetlands Restoration on Pastureland in the Lake Okeechobee Watershed", Final Report, December 2002, by Hazen and Sawyer for The Nature Conservancy, Altamonte Springs, Florida.

(c) *Dairy Farm Composting became PCA 12 and was evaluated using the Full Cost Accounting Model during Phase II of this study. It was not included in the combinations evaluated during Phase II because its overall score and rank were lower than that for a similar alternative that was included in the combinations, Optimization of Dairy Rule Design (PCA 4).*

For Technology Category 5, only specific technologies within the category passed all of the screening criteria. In addition, it is not known if sediment and vegetation removal will reduce influent phosphorus loads by at least 25 percent. However, these technologies will likely be necessary in order to avoid re-suspension of phosphorus from the sediment as phosphorus concentrations fall due to implementation of other nutrient reduction technologies.

The technologies that did not pass all five screening criteria are provided in Table 2-4.

Table 2-4
List of Alternate Nutrient Reduction Technologies That Did Not Pass All Screening Criteria
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Regional Technologies	
1.	Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals
2.	Aquaculture and/or Algal-Based Water Treatment Systems
5.	Canal and Tributary Maintenance Program - sediment removal from smaller canals and structure vegetation traps
6.	Tributary Sediment Traps
7.	Modify Design and Operation of Regional Water Control Structures
On-Farm Technologies	
15.	Phosphorus Absorption, Binding and Filtration Technologies
16.	Additional Farm Level Best Management Practices

These technologies require additional research and/or pilot study results in order to obtain estimates of phosphorus reduction and/or costs with a moderate to high degree of confidence.

The evaluation of the technologies with respect to the screening criteria is summarized in Tables 2-5, 2-6 and 2-7.

Table 2-5
Results for Screening Criterion 1: Availability of Sufficient Information (yes or no)
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Technology	Information Needed			
	P Reduction	Costs	Existing Conditions	Points (no. of yeses)
Regional Technologies				
1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals	No	No	Yes	1
2. Aquaculture and/or Algal-Based Water Treatment Systems	No	No	Yes	1
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)	Yes	Yes	Yes	3
4. Terminal Large Scale Water Treatment Facility Using CTSS	Yes	Yes	Yes	3
5. Canal and Tributary Maintenance Program				
PCA 9 - CERP Tributary Sediment Removal	Yes	Yes	Yes	3
Other methods	No	No	Yes	1
6. Tributary Sediment Traps	No	No	Yes	1
7. Modify Design and Operation of Regional Water Control Structures	No	No	Yes	1
On-Farm Technologies				
8. Isolated Wetlands Restoration	Yes	Yes	Yes	3
9. Improved Dairy Farm Waste Processing Technologies	Yes	Yes	Yes	3
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties	Yes	Yes	Yes	3
11. Wetlands Treatment of Runoff at Edge of Properties	Yes	Yes	Yes	3
12. Non-Structural Management at the Land Parcel Level	Yes	Yes	Yes	3
13. Enhanced Cow-Calf Best Management Practices	Yes	Yes	Yes	3
14. Alternative Land Uses	Yes	Yes	Yes	3
15. Phosphorus Absorption, Binding and Filtration Technologies	No	No	Yes	1
16. Additional Farm Level Best Management Practices	No	Yes	No	1
17. On-Farm Composting of Animal Solid Waste	Yes	Yes	Yes	3
Total Passed				11

(a) These technologies will likely be necessary in order to avoid re-suspension of phosphorus from the sediment as phosphorus concentrations fall due to implementation of other nutrient reduction technologies. Therefore, these technologies received 1 point for this criterion.

Table 2-6
Results for Screening Criterion 2: Phosphorus Reduction Potential
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Technology	P load reduction estimates available?	Likely to reduce influent P loads by more than 25%	Will likely reduce P to at or below 40 ppb for regional systems or 100 ppb for on-farm systems	Number of Points
Regional Technologies				
1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals	Yes	Yes	DK	1
2. Aquaculture and/or Algal-Based Water Treatment Systems	Yes	Yes	DK	1
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)	Yes	Yes	Yes	1
4. Terminal Large Scale Water Treatment Facility Using CTSS	Yes	Yes	Yes	1
5. Canal and Tributary Maintenance Program	Yes [a]	DK	DK	1
6. Tributary Sediment Traps	Yes [a]	DK	DK	1
7. Modify Design and Operation of Regional Water Control Structures	No	DK	DK	0
On-Farm Technologies				
8. Isolated Wetlands Restoration	Yes	Yes	No	1
9. Improved Dairy Farm Waste Processing Technologies	Yes	Yes	No	1
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties	Yes	Yes	No	1
11. Wetlands Treatment of Runoff at Edge of Properties	Yes	Yes	No	1
12. Non-Structural Management at the Land Parcel Level	Yes	Yes	No	1
13. Enhanced Cow-Calf Best Management Practices	Yes	Yes	No	1
14. Alternative Land Uses	Yes	Yes	No	1
15. Phosphorus Absorption, Binding and Filtration Technologies	Yes	Yes	DK	1
16. Additional Farm Level Best Management Practices	Yes	Yes	DK	1
17. On-Farm Composting of Animal Solid Waste	Yes	Yes	No	1
Total Passed				16

(a) These technologies will likely be necessary in order to avoid re-suspension of phosphorus from the sediment as phosphorus concentrations fall due to implementation of other nutrient reduction technologies. Therefore, these technologies received 1 point for this criterion.

Note: DK = Do not know

Table 2-7
Results for Screening Criteria 3, 4 and 5
Desktop Evaluation of Lake Okeechobee Alternate Nutrient Reduction Technologies

Technology	Criterion 3: Confidence of Sustained Performance	Criterion 4: Timeliness	Criterion 5: No Negative Side Effects	Total Number of Yeses
Regional Technologies				
1. Regional Processing of Sewage Sludge and/or Animal Solid Waste Residuals	Yes	Yes	Yes	3
2. Aquaculture and/or Algal-Based Water Treatment Systems	Yes	Yes	Yes	3
3. Reservoir-Assisted Stormwater Treatment Areas (RASTAs)	Yes	Yes	Yes	3
4. Terminal Large Scale Water Treatment Facility Using CTSS	Yes	Yes	Yes	3
5. Canal and Tributary Maintenance Program	Yes	Yes	Yes	3
6. Tributary Sediment Traps	No	Yes	Yes	2
7. Modify Design and Operation of Regional Water Control Structures	No	Yes	Yes	2
On-Farm Technologies				
8. Isolated Wetlands Restoration	Yes	Yes	Yes	3
9. Improved Dairy Farm Waste Processing Technologies	Yes	Yes	Yes	3
10. Stormwater Retention, Reuse and Chemical Treatment at Edge of Properties	Yes	Yes	Yes	3
11. Wetlands Treatment of Runoff at Edge of Properties	Yes	Yes	Yes	3
12. Non-Structural Management at the Land Parcel Level	Yes	Yes	Yes	3
13. Enhanced Cow-Calf Best Management Practices	Yes	Yes	Yes	3
14. Alternative Land Uses	Yes	Yes	Yes	3
15. Phosphorus Absorption, Binding and Filtration Technologies	No	Yes	Yes	2
16. Additional Farm Level Best Management Practices	No	Yes	Yes	2
17. On-Farm Composting of Animal Solid Waste	Yes	Yes	Yes	3
Total Passed				13

3.0 Evaluation of Phosphorus Control Alternative Combinations

This Section presents the results of evaluating the 18 technology combinations for reducing phosphorus loads to Lake Okeechobee. The evaluation used the Full Cost Accounting Evaluation Model developed under Phase I of this project and refined during Phase II. The Criterium Decision Plus model was used to score and rank the combinations, perform uncertainty analysis, and test the sensitivity of the scores to the criteria weighting.

3.1 Description of Technology Combinations

The 18 combinations include 3 regional technologies and 6 on-farm technologies that would be considered for implementation in the Lake Okeechobee study area. Each individual technology is called a Phosphorus Control Alternative or PCA. The individual technologies are described as follows.

PCA 1 - Chemical Treatment of Runoff at Edge of Properties. Each landowner would be responsible for constructing, operating and maintaining a chemical system that treats runoff and stormwater at the edge of the property prior to it entering the local streams and tributaries. This PCA was evaluated for the following land uses: dairy, cow/calf, citrus, field crops, row crops, tree nurseries, and sod operations. These land uses comprise 44 percent of all land in the study area and 80 percent of developed land in the study area in 2001 and in 2021. The methods used to estimate the benefits and costs of PCA 1 are provided in Section 4.0 of the Phase II Documentation Report.

PCA 2 -Wetlands Treatment of Runoff at Edge of Properties. Each landowner would be responsible for constructing, operating and maintaining a wetland system that treats runoff and stormwater at the edge of the property prior to it entering the local streams and tributaries. This PCA was evaluated for the following land uses: dairy; cow/calf; citrus; field crops; row crops; tree nurseries; and sod operations. The methods used to estimate the benefits and costs of PCA 2 are provided in Section 5.0 of the Phase II Documentation Report.

PCA 3 - Non-Structural Management at the Land Parcel Level. Under this PCA, all landowners would use non-structural practices to reduce imports of phosphorus and to reduce the transportability of phosphorus from their land. Examples of new management methods include the following: (1) use of calibrated soil testing and leaf sampling to determine optimal fertilization using the services of the University of Florida Cooperative Extension Service; (2) application of soil amendments to reduce the solubility and transportability of phosphorus and (3) no applications of phosphorus to pasture land. The methods used to estimate the benefits and costs of PCA 3 are provided in Section 6.0 of the Phase II Documentation Report.

PCA 4 - Optimization of Dairy Rule Design. This PCA is an optimization of the existing Dairy Rule design to significantly increase the removal of phosphorus from stormwater. All lactating cows would be totally confined to the high intensity area (HIA). This area includes the milking parlor and feed/shade barns. The dry cows would reside in surrounding pastures. The improvements to the existing Dairy Rule design within the HIA would include the collection of rainwater from roofs for deposit outside the HIA; expansion of the HIA perimeter ditch to accommodate all lactating cows; larger ponds in the HIA; and additional shade barns for feeding and cooling. The manure and the wastewater from the HIA would be treated in the same manner as the existing Dairy Rule modifications and these modifications would be expanded to treat the larger volumes of water. The methods used to estimate the benefits and costs of PCA 4 are provided in Section 7.0 of the Phase II Documentation Report.

PCA 5 - Enhanced Cow-Calf BMPs. Under this PCA, a BMP program would be implemented at all cow-calf operations in the study area. The Enhanced Cow-Calf BMPs include the following elements: fencing to separate the cattle from the natural water courses; ponds, troughs and/or tanks for cattle watering; and the setting of stocking rates for individual pastures based on the phosphorus loading characteristics of the site. The average stocking rate used under this PCA is one cow per 4 acres from the estimated current average of one cow per three acres. The methods used to estimate the benefits and costs of PCA 5 are provided in Section 8.0 of the Phase II Documentation Report.

PCA 6 - Alternative Land Uses. Under this PCA, land uses that contribute relatively high phosphorus loads would be converted to land uses that contribute relatively low or no phosphorus loads to Lake Okeechobee. The land use changes are presented in Table 3-1. The methods used to estimate the benefits and costs of PCA 6 are provided in Section 9.0 of the Phase II Documentation Report.

Table 3-1
Alternative Land Use Changes Evaluated

	Existing Land Use	Acres Converted 1995	Acres Converted 2021	Alternative Land Use
6A.	Dairy operations – baseline management	20,200	20,200	Cow-calf operations – improved management
6B.	Citrus operations – baseline management	55,222	58,683	Natural areas
6C.	Field crop operation (sugarcane) – baseline management	9,384	9,384	Wetlands and/or natural areas
6D.	Row crop operation – baseline management	10,663	14,722	Cow-calf operations – baseline management
6E.	Cow calf operation – baseline management	11,794	11,794	Citrus operation – aggressive BMPs

PCA 7 - Watershed Reservoir-Assisted Stormwater Treatment Areas (RASTAs). The U.S. Army Corps of Engineers and the South Florida Water Management District identified two RASTA projects as priority projects for Everglades Restoration during their Restudy. They include the Taylor Creek / Nubbin Slough Stormwater Treatment Area (STA); and two Lake Okeechobee Watershed Water Quality Treatment Facilities. Each project includes an above ground reservoir and stormwater treatment areas. Each project will be located within one of three sub-basins: S-191, S-154, and S-65D. The methods used to estimate the benefits and costs of PCA 7 are provided in Section 10.0 of the Phase II Documentation Report.

PCA 8 – Taylor Creek / Nubbin Slough RASTA with Lake Okeechobee Supplemental Water Source. This PCA was evaluated during the Phase I study but was not evaluated as a combination. This PCA is the Taylor Creek / Nubbin Slough Reservoir-Assisted Stormwater Treatment Area (TC/NS RASTA) as described under PCA 7 - Watershed RASTAs. In addition, under PCA 8, one-half of this RASTA would have access to water from Lake Okeechobee. The purpose of using Lake Okeechobee as a supplementary water source would be to keep the STA vegetation wet during dry conditions to increase phosphorus removal. During dry watershed conditions, water would be pumped from the lake through a pipeline to the reservoir at Grassy Island. A pumping system would transfer the water from the lake to the reservoir. Overall, water would flow from the lake to the RASTA through the pipeline about five percent of the time. This PCA was not included in the combinations because its rank and score was lower than that of PCA 7 – RASTAs, which is a similar to PCA 8.

PCA 9 - Tributary Sediment Removal. Under this PCA, sediment would be dredged from 10 miles of primary canals within eight sub-basins of the study area. This project is part of the Lake Okeechobee Watershed Project being evaluated by the U.S. Army Corps of Engineers and the South Florida Water Management District. The methods used to estimate the benefits and costs of PCA 9 are provided in Section 11.0 of the Phase II Documentation Report.

PCA 10 - Terminal Large Scale Water Treatment Facility. Under this PCA, water would be diverted from the Kissimmee River prior to entering Lake Okeechobee and treated to reduce the total phosphorus content. The treated effluent would then be returned to the source water at a downstream location. This alternative considers the construction of a water treatment plant using chemical treatment followed by solids separation advanced technology to achieve the necessary reduction in total phosphorus. The methods used to estimate the benefits and costs of PCA 10 are provided in Section 12.0 of the Phase II Documentation Report.

PCA 11 – Isolated Wetlands Restoration on Pastureland. Under this PCA, the owner of improved pastureland would restore a portion of his/her improved pastureland to isolated wetlands. The owner would implement certain best management practices (BMPs) on the remaining improved pastureland. For the purposes of this analysis, on average in the study area, a given improved pasture area would have 40 percent of the land restored to isolated wetlands with a cattle stocking rate of one cow per 16 acres (1/16 cows/acre) and 60 percent of the land would remain as improved pasture with a stocking rate of one cow per four acres (1/4 cows/acre). On the improved pasture, the owner would not apply any phosphorus. Fencing of cattle from watercourses would not be required but additional cooling ponds and watering troughs would be provided to encourage cattle to stay away from natural watercourses. This program would be implemented on 200,000 acres of improved pastureland in the Lake Okeechobee watershed study area. As of 2002, there are about 433,000 acres of improved pastureland in the study area. There are 508,000 acres of improved and unimproved pasture in the study area. The methods used to estimate the benefits and costs of PCA 11 are provided in Section 13.0 of the Phase II Documentation Report.

PCA Combinations. The 18 technology combinations are presented in Table 3-2. The proposed tributary phosphorus TMDLs have not yet been considered in developing these combinations. Such TMDLs will be considered prior to initiating any regional phosphorus management projects.

Table 3-2
Combinations of Phosphorus Control Alternatives (PCAs) Evaluated

Comb. No.	Regional PCA	On-Farm PCA
1	PCA 7 – RASTAs	PCA 11: Isolated Wetlands Restoration on Pastureland
2		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
3		PCA 1 – Chemical Treatment at Edge of Property
4		PCA 2 – Wetland Treatment at Edge of Property
5		PCA 3 – Non-Structural Management at Land Parcel Level
6		PCA 6 – Alternative Land Uses
7	PCA 10 – Terminal Large Scale Water Treatment Facility	PCA 11: Isolated Wetlands Restoration on Pastureland
8		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
9		PCA 1 – Chemical Treatment at Edge of Property
10		PCA 2 – Wetland Treatment at Edge of Property
11		PCA 3 – Non-Structural Management at Land Parcel Level
12		PCA 6 – Alternative Land Uses
13	PCA 9 – Tributary Sediment Removal	PCA 11: Isolated Wetlands Restoration on Pastureland
14		PCA 4 and 5: Dairy Farm Optimization and Enhanced Cow-Calf BMPs
15		PCA 1 – Chemical Treatment at Edge of Property
16		PCA 2 – Wetland Treatment at Edge of Property
17		PCA 3 – Non-Structural Management at Land Parcel Level
18		PCA 6 – Alternative Land Uses

3.2 Input Phosphorus Concentration of Regional PCAs 7 and 10

The two regional PCAs whose impact on phosphorus loads depends on the input phosphorus concentration are the RASTAs (PCA 7) and the Terminal Large Scale Water Treatment Facility (PCA 10). The phosphorus load impact of Tributary Sediment Removal (PCA 9) does not depend on input phosphorus concentrations. The input concentrations used to evaluate PCA 7 and 10 will change depending on the on-farm PCAs that are implemented. Therefore, the impact of on-farm PCA effluent phosphorus loads on the input phosphorus concentrations of the regional PCAs was estimated and the methods and results are reported in Appendix A of the Documentation Report. A summary of the input phosphorus concentrations used for the two regional PCAs is provided in Table 3-3.

Table 3-3
Summary of Input Phosphorus Concentrations for Regional PCAs
Given Implementation of On-Farm PCAs

On-Farm Phosphorus Control Alternative (PCA)	PCA 7 - RASTAs			PCA 10 - Terminal Large Scale Water Treatment Facility
	Taylor Creek / Nubbin Slough STA	Lake Okeechobee Watershed Water Quality Treatment Facilities		
	S-191	S-154	S-65D	Kissimmee River, S-65
Input P Concentration without On-Farm PCAs, mg/l	0.63	0.78	0.12	0.20
New Input Phosphorus Concentration with On-Farm PCA, mg/l:				
1 - Chemical Treatment of Runoff at Edge of Property	0.48	0.60	0.09	0.15
2 - Wetlands Treatment of Runoff at Edge of Property	0.53	0.65	0.10	0.17
3 - Non-Structural Management at the Land Parcel Level	0.47	0.58	0.09	0.15
4 and 5 - Optimization of Dairy Rule Design and Enhanced Cow-Calf BMPs	0.46	0.57	0.09	0.15
6 - Alternative Land Uses	0.58	0.72	0.11	0.19
11 - Isolated Wetlands Restoration on Pastureland (80,000 acres of restored wetlands)	0.46	0.61	0.05	0.16

3.3 Evaluation Criteria and Criteria Values

The 18 PCA combinations were evaluated with respect to ten evaluation criteria that were developed during Phase I of this project. The evaluation criteria are comprised of: (A) Phosphorus reduction benefits; (B) Cost-effectiveness; (C) External benefits and costs; and (D) Risk and uncertainty measures. The criteria are summarized as follows.

A. Phosphorus Reduction Benefits

1. Average annual change in the amount of phosphorus entering Lake Okeechobee in pounds per year over the 60-year study period

2. Expected phosphorus concentration after treatment as measured in parts per billion (ppb)

B. Cost-Effectiveness

3. Present value cost per pound of phosphorus removed from the Lake over the 60-year study period (in 2001 dollars)

C. External Benefits and Costs

4. Success in achieving surface water management objectives (0 to 4 points)

5. Water supply benefits (0 to 4 points)

6. Acres of increased/improved wildlife habitat

7. Present value change in regional income (2001 dollars)

8. Potential for increased recreation opportunities (0 to 1 point)

D. Risk and Uncertainty Measures

9. Engineering / technological track record (0 to 4 points)

10. Environmental compliance and permitting ease (0 to 4 points)

The values associated with each PCA for criteria 1 through 4 were assigned a "moderate" or "high" confidence level that refers to the level of uncertainty associated with the data and information used to estimate the value in terms of obtaining "planning level" estimates. Moderate means that the studies used to obtain the estimates provided reservations about the accuracy of the results or that insufficient data and information exists to provide a high level of confidence. The high level implies that the data and information used to develop planning estimates are reasonable for a planning-level analysis.

Each criterion is described in detail as follows.

3.3.1 Criterion 1: Average annual reduction in the amount of phosphorus entering Lake Okeechobee during the Study Period.

This criterion is measured as the average annual difference between the amount of phosphorus entering the Lake under the baseline condition and the amount of phosphorus entering the Lake under the PCA. The average annual phosphorus reduction was calculated over the 60-year study period. All PCAs will reduce phosphorus loads. Therefore, this value is measured as a positive number.

The baseline condition represents the future land uses and phosphorus management practices of the study area if none of the PCAs are implemented. The general baseline conditions were presented in Section 1.0 of this report. For the purposes of this study, the components of the Comprehensive Everglades Restoration Plan (CERP) are presumed not to be built under the baseline condition.

The amount of phosphorus entering the Lake under the PCA and the baseline condition in any year considers the extent to which the PCA is implemented in the study area and the impact of the phosphorus stored in the soil. The phosphorus load is the weighted average over all rainfall conditions in the study area. The phosphorus loads leaving the PCA site were obtained from LOADSS, EAAOKEE MOD or existing studies. The LOADSS phosphorus assimilation model was used to estimate the amount of phosphorus entering the Lake. This model is described in Section 14.0 of the Phase II Documentation Report.

In general, the change in phosphorus loads entering Lake Okeechobee was estimated in three steps. Step 1: The amounts of phosphorus leaving the properties or sites where the PCAs would be implemented under the baseline condition and under the PCA were estimated. Step 2: The amounts of phosphorus (loads) entering the lake under the baseline condition and the PCA are equal to the phosphorus load at the edge of the property times the assimilation rate. Step 3: The phosphorus load reduction at the Lake was calculated as the difference between the phosphorus load at the Lake under the baseline condition and the phosphorus load at the Lake after the PCA is implemented. The actual assimilation rates are provided and their use is described in each section where the PCA is described and evaluated in the Phase II Documentation Report.

For PCAs that involve individual private properties, such as PCAs 1 through 6, two phosphorus load changes were estimated – one that reflects 2002 land use acreage and the other that reflects 2021 land use acreage. For any individual year in between 2002 and 2021, the change in phosphorus load was interpolated between the 2002 values and the 2021 values. This calculation accounts for the impact of changes in land uses on the amount of phosphorus reduction to the Lake provided by the PCA.

The reductions in the amount of phosphorus leaving the properties were calculated as follows. For PCAs 1 through 5, (PCAs implemented by private landowners) the measurement equations for 2002 and 2021 are as follows.

(1) Reduction in P Load Leaving Property Due to PCA_{2002} = (Sum i=1 to I of (RP_{LUi} x $Acres_{LUi,2002}$)

(2) Reduction in P Load Leaving Property Due to PCA_{2021} = (Sum i=1 to I of (RP_{LUi} x $Acres_{LUi,2021}$)

where

RP_{LUi} is the reduction in the pounds of phosphorus entering Lake Okeechobee per acre for model land use i (LU_i);

I equals number of model land uses;

and

$Acres_{LUi,2002}$ and $Acres_{LUi,2021}$ are the acres represented by model land use i in 2002 and 2021, respectively.

For PCA 6, Alternative Land Uses, the measurement equation is as follows.

(3) Reduction in P Load Leaving Property Due to $PCA6_{2002}$ = (Sum j=1 to J of RP_{LU6j} x $Acres_{LU6j,2002}$)

(4) Reduction in P Load Leaving Property Due to $PCA6_{2021}$ = (Sum j=1 to J of RP_{LU6j} x $Acres_{LU6j,2021}$)

where

RP_{LU6j} is the change in the pounds of phosphorus leaving the property under PCA 6 per acre for alternative land use change j (LU6j);

J equals number of land use changes;

and

$Acres_{ALU6j,2002}$ and $Acres_{ALU6j,2021}$ are the acres represented by alternative land use change j in 2002 and 2021, respectively.

For PCA 7 – RASTAs, the measurement equation is just the sum of the phosphorus reduction leaving the properties of the three RASTAs. For PCAs 8, 9, and 10, the measurement is just the phosphorus reduction as the water leaves the site. For PCA 11, the phosphorus reduction is estimated for 200,000 acres of improved pasture in all years after full implementation.

Once the changes in phosphorus loads leaving the properties were estimated using the measurement equations described above, the appropriate assimilation rates were applied, when appropriate, to obtain an estimate of the change in phosphorus loads entering Lake Okeechobee. The method by which this criterion is measured for each PCA is described in the sections that evaluate each PCA in the Phase II Documentation Report.

3.3.2 Criterion 2: Concentration of Phosphorus at the Edge of the Site Due to the PCA

This criterion is included in the model to account for the uncertainties associated with the location of the PCA-properties in the Basin and the assimilation of phosphorus as water leaves the properties and enters the Lake. It is meant to highlight PCAs that are effective in reducing phosphorus loads on-site. It is measured as the expected phosphorus concentration of the water as it leaves the edge of the property after implementing the PCA or as it leaves the regional treatment system, depending on the PCA, as measured in parts per billion (ppb). This measurement is consistent with the expected Total Maximum Daily Load (TMDL) measure (concentration) that will be established for certain tributaries in the basin.

For PCAs associated with multiple land uses, the PCA may result in different effluent phosphorus concentrations among the land uses. To be consistent among the PCAs, the phosphorus concentration is weighted based on the acreage in each land use in the study area. The 2021 forecasted land uses were used as the weights.

3.3.3 Criterion 3: Present value cost per pound of phosphorus removed from the Lake

This criterion considers the cost-effectiveness of each PCA as it reduces phosphorus loads to Lake Okeechobee. The measurement for this criterion is the present value of PCA costs in 2001 dollars divided by the present value of the reduction in phosphorus entering the lake due to the PCA. The change in phosphorus is taken from the measurement equations and assimilation rates described under Criterion 1, *average annual reduction in the amount of phosphorus entering Lake Okeechobee during the study period*.

This formula is as follows:

$$\text{P V Cost Per Pound of Phosphorus Removed} = \frac{\sum_{t=1}^{60} \text{Total Annual Cost}_t \text{ x } (1+d)^{-t}}{\sum_{t=1}^{60} (\text{Annual Pounds of Phosphorus Removed}_t) \text{ x } (1+d)^{-t}}$$

Where “d” is the discount rate which represents the opportunity cost of money; and

t is year 1, 2, 3, ... 60.

All costs include the costs to construct, implement, operate and maintain the PCA, the costs to the District and other government agencies to implement the PCA and any estimated changes in costs or revenues to landowners. The costs and changes in revenues do not include inflation – they are in year 2001 dollars. The discount rate, net of inflation is 3.2 percent as recommended by the U.S. Office of Management and Budget.[1] The study period is 60 years in order to consider the full life cycle of each PCA.

This present value cost per pound of phosphorus removed is directly proportional to the cost-benefit ratio for the PCA (not including other external costs and benefits that are considered by other criteria). To calculate the cost-benefit ratio, the value per pound of phosphorus removed is needed. This value is not known, yet we do know that it has a dollar value. This value was not estimated during this study. However, the amount of phosphorus removed each year must still be discounted because it is the benefit of the PCA and should be discounted in the same manner

[1] *U.S. Office of Management and Budget, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs”, Circular No. 94, Appendix C, revised January 2001,* http://www.whitehouse.gov/OMB/circulars/a094/ao94.html.

as the PCA costs. As with costs, a pound of phosphorus removed today is worth more than a pound of phosphorus removed twenty years from now. The discount rate adjusts the phosphorus load reduction received in the future so that it is equivalent to present value.

3.3.4 Criterion 4: Success in Achieving Surface Water Management Objectives

This criterion measures the additional surface water management benefits that would be provided by the PCA. The list of surface water management benefits is provided below. The measurement for this criterion is as follows.

0 points = The PCA does not provide for any of the listed surface water management benefits.

1 point = The PCA provides for one of the listed surface water management benefits.

2 points = The PCA provides for two of the listed surface water management benefits.

3 points = The PCA provides for three of the listed surface water management benefits.

4 points = The PCA provides for four of the listed surface water management benefits.

The list of surface water management benefits provided below incorporates the goals of the District in protecting water and water-related resources.

1. The PCA will attenuate flood runoff to Lake Okeechobee during flood and wet season conditions.
2. The PCA will not adversely impact water supply availability.
3. The PCA will significantly reduce soil erosion and sediment transport.
4. The PCA will maintain flood control.

The PCA scoring for Criterion 4 is provided in Table 3-4.

Table 3-4
PCA Scoring for Criterion 4 –
Success in Achieving Surface Water Management Objectives

Phosphorus Control Alternative (PCA)	Attenuate Flood Runoff to Lake	Not Adversely Impact Water Supply Availability	Reduce Erosion and Sediment Transport	Maintain Flood Control	Points (Number of Yeses)
1 - Chemical Treatment at Edge of Property	Yes	Yes	Yes	Yes	4
2 - Wetland Treatment at Edge of Property	Yes	Yes	Yes	Yes	4
3 - Non-structural Management at Land Parcel Level	No	Yes	No	Yes	2
4 - Optimization of Dairy Rule Design	No	Yes	Yes	Yes	3
5 - Enhanced Cow-Calf BMPs	Yes	Yes	Yes	Yes	4
6 - Alternative Land Uses	Yes	Yes	Yes	Yes	4
7 - RASTAs	Yes	Yes	No	Yes	3
9 - Tributary Sediment Removal	No	Yes	No	Yes	2
10 - Terminal Large Scale Water Treatment Facility	Yes	Yes	No	Yes	3
11 – Isolated Wetlands Restoration on Pastureland	Yes	Yes	Yes	Yes	4

3.3.5 Criterion 5: Water Supply Benefits

This criterion measures the water supply benefits from the PCA in terms of its contribution to increasing water supply and/or its contribution to increasing groundwater recharge. Water supply increases could occur either through water storage or due to reductions in baseline water use. For PCAs that include water storage, the additional water supply benefits from the PCA are those that provide additional water for reasonable/beneficial use or for the environment. This water would typically be that amount that would have been released to the Atlantic Ocean or the Gulf of Mexico under baseline conditions to protect the Lake's ecosystem or to protect land from flooding. The amount does not include freshwater that, under baseline, would have been released to protect downstream ecosystems or to replenish southern groundwater supplies.

This criterion is measured in qualitative terms similar to that described under PCA 5. The scoring method for this criterion is provided as follows.

Scoring Method for Criterion 5 – Water Supply Benefits

Points	Definition
0	No or very little additional water supply or additional groundwater recharge benefits
1	Potential to supply from 5 percent to 50 percent of on-farm water use per farm for most land uses or potential to provide moderate additional groundwater recharge
2	Potential to supply from 5 percent to 50 percent of on-farm water use per farm for most land uses and potential to provide moderate additional groundwater recharge
3	Potential to supply more than 50 percent of study area on-farm water use or potential to provide significant increase in groundwater recharge
4	Either (a) or (b) applies: (a) Potential for significant additional regional water supplies or significant reductions in regional baseline water use or (b) Potential to supply at least 50 percent of study area on-farm use and potential to provide significant increase in groundwater recharge.

The PCA scoring for Criterion 5 is provided in Table 3-5.

Table 3-5
PCA Scoring for Criterion 5 – Water Supply Benefits

Phosphorus Control Alternative (PCA)	Score (max. 4 points)	Reason for Score
1. Chemical Treatment at Edge of Property	1	Potential to supply 5% to 40% of on-farm water use depending on farm type
2. Wetland Treatment at Edge of Property	1	Potential to supply from 10% to 30% of on-farm water use depending on farm type. No additional water supply for cow-calf operations.
3. Non-structural Management at Land Parcel Level	0	
4. Optimization of Dairy Rule Design	0	
5. Enhanced Cow-Calf BMPs	1	Moderate recharge of surficial aquifer system
6. Alternative Land Uses	4	Significant reduction in agricultural water use and additional groundwater recharge
7. Reservoir Assisted Stormwater Treatment Areas (RASTAs)	2	Moderate ground water recharge / some additional local water supply
9. Tributary Sediment Removal	0	
10. Terminal Large Scale Water Treatment Facility	2	Potential to provide some additional regional water supply and moderate groundwater recharge due to 3,870 acres of water storage (flow equalization).
11. Isolated Wetlands Restoration on Pastureland	3	Potential to significantly increase groundwater recharge due to its capacity to retain water that would otherwise flow into canals.

3.3.6 Criterion 6: Acres of Increased / Improved Wildlife Habitat

This criterion measures the contribution of the PCA in directly increasing or improving wildlife habitat. For example, some PCAs will result in the conversion of existing land uses to wetlands and natural areas, thus increasing the acreage of wildlife habitat. This wildlife habitat has value to households in terms of their willingness-to-pay to protect, expand and improve wildlife habitat areas. The actual value of a particular wetland or natural habitat will depend on its quality, size and location. Because the available information will only allow for the use of one average value per acre for all the acres created or restored regardless of quality or location, the distinction between one PCA and another will be in the number of acres created. Therefore, this criterion is measured as the number of acres of wetlands and natural areas created or improved.

3.3.7 Criterion 7: Present Value Change in Regional Income

This criterion considers the costs or benefits of the PCA to the regional community in terms of changes in income. Income is defined as employee compensation, proprietor's income, interest, rents, profits, sales taxes, and excise taxes, including business and household property taxes.[2] This definition is also called "Total Value Added", which consists of four components:[3]

> "Employee compensation is wage and salary payments as well as benefits including health and life insurance, retirement payments, and any other non-cash compensation. It includes all income to workers paid by the employers.
>
> Proprietary income consists of payments received by self-employed individuals as income. This is income recorded on Federal Tax Form 1040C. This includes income received by private business owners, doctors, lawyers, and so forth. Any income a person receives for payment of self-employed work is counted here.
>
> Other property type income consists of payments from interest, rents, royalties from contracts, and dividends paid by corporations. This also includes corporate profits earned by corporations.
>
> Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses. These taxes occur during the normal operation of these businesses but do not include taxes on profit or income."

The measurement for this criterion is the present value of the annual change in total value added (called regional income for this study) resulting from the PCA relative to baseline conditions over the 60 year study period. The methods used to estimate regional income for each PCA are provided in the Phase II Documentation Report. A 3.2 percent discount rate was used to represent the opportunity cost of money in the present value calculation as recommended by the U.S. Office of Management and Budget. The change in regional income is in year 2001 dollars.

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2 *The inclusion of business and household property taxes in the Total Value Added multipliers was confirmed by the Minnesota IMPLAN Group, Inc. through email.*

3 *Minnesota IMPLAN Group, Inc., "IMPLAN Pro User's Guide, Analysis Guide, Data Guide" Stillwater, Minnesota, February 1997, page 229.*

The change in regional income was estimated for PCAs that directly remove land from profitable use and/or that result in a change in agricultural productivity and/or that result in increased local investment associated with PCA construction and operation activities.

The change in regional income associated with each of the PCAs is very much dependent on how much of the cost of the PCAs is paid for by residents and businesses located within the study area. Regional income would increase if money from outside the regional area is used to purchase goods and services within the area to implement the PCAs. In addition, regional income will fall when land moves from agriculture to wetlands. It will increase if productivity increases and it will fall when productivity falls.

Under Phase II of this study, the District requested that the estimated changes in regional income recognize that landowners may share the cost of the on-farm PCAs with other entities. Thus, the Lake Okeechobee Interagency Committee requested that the study assume that landowners contribute to a portion of the cost equivalent to approximately 12.5 percent of the cost of the on-farm PCAs.

For the purposes of this study, as request by the District and as provided for in the Phase II Scope of Services, this study also assumes that landowners would be able to afford the 12.5 percent cost share and that no change in land use would occur due to this cost share. If landowners are unable to afford this cost share, regional income may fall due to the impact of these costs on the economic feasibility of the land uses.

This study also assumes that 87.5 percent of the costs are financed with money from sources outside the regional area, so regional income would increase as this money is spent on the PCA investments. Regarding the 12.5 percent of costs financed by area landowners, if the cost paid by the landowner is simply a shift from one type of local expenditure to another, then the shift in expenditures will not change regional income. For the purposes of this study it was assumed that landowners would reduce other local expenditures to pay for the cost share, so no change in regional income will result from landowner expenditures.

PCA 7 – Watershed RASTAs and PCA 9 – Tributary Sediment Removal are part of the Comprehensive Everglades Restoration Plan (CERP). The Federal government, the State of Florida and the South Florida Water Management District will finance the expenditures. The cost share for CERP projects is 50 percent, 25 percent and 25 percent, respectively. As a result, residents within the regional area will finance about 0.29 percent of these expenditures and this is reflected in the analysis.

The assumption of funding 87.5 percent of the PCAs from sources outside of the study area means that there would be no negative financial impacts to residents and businesses associated with this financing. Therefore, the increased spending within the study area to implement the PCAs would tend to increase regional income depending on the types and amounts of the expenditures.

The changes in regional income within the study area associated with each PCA were based on regional economic impact multipliers that represent the counties of Okeechobee, Highlands, and Glades. The smallest economic unit that a multiplier can represent is a county. These counties were chosen for three reasons, as follows. (1) The other counties in the study area comprise a very small percentage of the total land area in the study area. If the economies of these entire counties were included in the multipliers, the resulting multipliers would misrepresent the economy of the study area. (2) The bulk of the potential regional economic impacts from the PCAs will be felt in these counties. (3) Significant changes in land use and investments will likely have a noticeable effect on the economy of these counties.[4] Over 90 percent of the study area and the study area's population are included in Okeechobee, Highlands and Glades counties.

3.3.8 Criterion 8: Potential for Increased Recreation Opportunities

Recreational activities include fishing, hunting, hiking, swimming and wildlife viewing. None of the PCAs are expected to directly increase recreational opportunities to a significant degree. The impact of the PCAs on recreation would be felt through reductions in phosphorus loads to the Lake that are already considered under Criteria 1 and 2. However, in the event that a PCA does increase recreational opportunities in the study area over and above its reduction in phosphorus loads to the Lake, this benefit should be recognized. The measurement of this criterion is as follows.

0 Points = The PCA will not provide an increase in recreational opportunities in the study area through additions to capacity and/or increases in recreation quality over and above that which would be achieved by phosphorus removal.

1 Point = The PCA will provide an increase in recreational opportunities in the study area through additions to capacity and/or increases in recreation quality over and above that which would be achieved by phosphorus removal.

Wildlife viewing is included in this criterion because the acres of wetlands and natural areas considered under Criterion 6, *acres of increased/improved wildlife habitat*, will not necessarily be accessible for recreation nor would people necessarily visit the area for wildlife viewing. The four PCAs that received 1 point for this criterion have the potential to increase the acreage of publicly-accessible natural areas and wetland habitats for recreation.

3.3.9 Criterion 9: Engineering / Technological Track Record

This criterion measures the degree to which the PCA can be built and operated successfully in the study area. This criterion includes evaluation of the technologic track record of the PCA that considers whether it has been successfully implemented and operated in the study area or elsewhere. Knowing that a PCA, or its components, has been successfully implemented in a similar application demonstrates its viability and provides information regarding the extent to which the technology can be customized to site-specific conditions. This criterion also considers the extent to which studies have demonstrated the likelihood of the PCA's success.

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[4] *These characteristics and potential counties to include in the regional economic impact area were discussed with Mr. Pat Miller, County Extension Director, Okeechobee County, January 2001.*

There are four aspects to consider when scoring this criterion: 1) whether the PCA, or similar program, has been implemented in other similar situations; 2) whether the PCA, or similar program was successful; 3) whether studies have shown that the PCA is likely to be successful under this application, and 4) whether or not there are specific unresolved issues that may hinder the success of the PCA. The scoring for this criterion is as follows:

0 Points = The PCA has not been successfully implemented elsewhere in similar applications and the PCA is not likely (< 80% probability) to be successful under this application.

1 Point = The PCA has not been successfully implemented in the study area or elsewhere in similar applications but studies have shown that it is likely (> 80% probability) to be successful under this application.

2 Points = The PCA has been successfully implemented elsewhere in similar applications but further experience is needed to assess one or more specific unresolved issues that may hinder the success of the PCA.

3 Points = The PCA has been successfully implemented in a relatively small number of similar applications and is likely (> 80% probability) to be successful under this application.

4 Points = The PCA has been implemented in many similar applications and has demonstrated success and is likely (> 80% probability) to be successful under this application.

This study did not include a literature search regarding the implementation of PCAs in other parts of the country. The evaluation of this criterion for each PCA was based on the documents collected to date for this study and expert judgment provided by the project team and the District. The scoring of this criterion can be improved as additional information becomes available.

3.3.10 Criterion 10: Environmental Compliance and Permitting Ease

This criterion is measured as the relative amount of effort and time needed to obtain all applicable permit approvals and the likelihood of obtaining all necessary permits from all applicable permitting agencies. Due to the type of permits that may be required for some PCAs, this criterion considers potential negative environmental impacts of the project.

Likelihood is defined by probabilities as follows: (1) “not likely” is less than 50% probability of obtaining all necessary permits; (2) “somewhat likely” is between 50% and 70% probability; and (3) “moderately likely” is greater than 70%. Projects that do not need permits would receive the highest score (4 points) for this category.

This criterion does not attempt to measure the cost of permitting. Such a cost is included under the cost criterion. The scoring is as follows. The term “State” refers to the Florida Department of Environmental Protection and South Florida Water Management District.

0 Points = The project is not likely to receive all necessary permits (less than 50% probability) or the State has denied one or more permits for a project of this type and circumstance in the past and would likely do so again.

1 Point = Insufficient information exists to adequately determine the likelihood that the project would obtain all necessary permits.

2 Points = This type of project is somewhat likely (50% to 70%) to receive all necessary permits or specific identified issue(s) will need to be resolved by the permitting agencies that will likely increase the time and effort above "normal" levels needed to obtain all necessary permits.

3 Points = This project is moderately likely (greater than 70%) to receive all necessary permits given "normal" time and effort and the State has never had the opportunity to permit this type of project in the past.

4 Points = This project does not require any permits or this project is moderately likely (greater than 70%) to receive all necessary permits given "normal" time and effort and the State has approved permits for this type of project in the past.

The scoring for this criterion was based on the professional opinions of project team staff members and the District.

3.3.11 Summary of PCA Criteria Values

A summary of the values for each criteria and each PCA is provided in Table 3-6 and Table 3-7.

Table 3-6
Summary of Values for Criteria 1, 2, and 3 for Each Phosphorus Control Alternative (PCA)

PCA Description	1: Average Annual Reduction in P Load Entering Lake		2: P Concentration at Edge of Field/Site After PCA Implemented		3: PV Cost Per Pound of Phosphorus Removed From Lake (2001 $)	
	Pounds per Year	Confidence Level (a)	Parts per Billion	Confidence Level (a)	Dollars per Pound of P Removed	Confidence Level (a)
1. Chemical Treatment of Runoff at Edge of Property	226,000	High	125	High	$173	High
2. Wetlands Treatment of Runoff at Edge of Property	155,000	High	306	High	$119	High
3. Non-Structural Management at the Land Parcel Level	261,000	Moderate	216	Moderate	$50	Moderate
4. Optimization of Dairy Rule Design	35,000	High	750	High	$83	High
5. Enhanced Cow-Calf BMPs	198,000	Moderate	208	Moderate	$49	Moderate
6. Alternative Land Uses	73,000	High	501	High	$266	Moderate
7. Reservoir Assisted Stormwater Treatment Areas (RASTAs)	94,000	High	40	High	$104	High
9. Tributary Sediment Removal	29,000	Moderate	217	Moderate	$6	Moderate
10. Terminal Large Scale Water Treatment Facilities	119,000	High	10	High	$139	High
11. Isolated Wetlands Restoration on Pastureland	121,000	Moderate	193	Moderate	$109	Moderate

(a) Confidence Level refers to the uncertainty associated with the data and information used to estimate the value in terms of obtaining "planning level" estimates. Moderate means that the studies used to obtain the estimates provided reservations about the accuracy of the results or that insufficient data and information exists to provide a High level of confidence. The High level implies that the data and information used to develop planning estimates are reasonable for a planning level analysis.

Table 3-7
Summary of Values for Criteria 4 Through 10 for Each Phosphorus Control Alternative (PCA)

PCA Description	4. Surface Water Mgmt Objectives	5. Water Supply Increase	6. Acres of Wildlife Habitat	7. PV Change in Regional Income (millions of 2001 $)	8. Recreation Opport.	9. Engin. / Tech. Track Record	10. Environ. Compliance / Permitting Ease
1. Chemical Treatment of Runoff at Edge of Property	4	1	15,000	-$157.2	0	3	2
2. Wetlands Treatment of Runoff at Edge of Property	4	1	24,000	-$302.9	0	3	3
3. Non-Structural Management at the Land Parcel Level	2	0	0	$22.1	0	3	4
4. Optimization of Dairy Rule Design	3	0	0	$107.2	0	4	4
5. Enhanced Cow-Calf BMPs	4	1	0	$44.7	0	4	4
6. Alternative Land Uses	4	4	68,000	-$5,838.4	1	4	4
7. Reservoir Assisted Stormwater Treatment Areas (RASTAs)	3	2	11,000	$51.7	1	4	4
9. Tributary Sediment Removal	2	0	0	$0.4	0	3	3
10. Terminal Large Scale Water Treatment Facilities	3	2	1,000	$65.9	1	2	1
12. Isolated Wetlands Restoration on Pastureland	4	3	80,000	-$37.5	0	3	4

3.3.12 Criteria Value Estimates for PCA Combinations

The methods used to calculate the criteria values are provided in Table 3-8.

Table 3-8
Methods Used to Estimate Criteria Values for the PCA Combinations

Criterion	Method
1. Average annual pounds of phosphorus removed per year	On-farm PCAs – previously estimated PCAs 7 and 10 – based on new input phosphorus concentrations. The total each year of the 60-year period is the sum of the annual regional and on-farm P reductions. The calculations for each PCA combination are provided in Appendix D of the Documentation Report.
2. P concentration after treatment	For combinations with regional PCAs 7 and 10, the final output P concentration of the regional system was used. For regional PCA 9, treatment P concentration of the on-farm PCAs was used. For Comb. 14, the weighted average P concentrations of PCAs 4 and 5 were used. The weights were based on the acres in dairy land and improved pasture.
3. Present value cost per pound of P removed from Lake	Pounds of P removed – see Criterion 1 Costs - Total annual costs are the sum of the annual costs for the regional PCA and the on-farm PCA. The calculations for each PCA combination are provided in Appendix D of the Documentation Report.
4. Surface Water Management Objectives 5. Water Supply Increase	For criteria 4 and 5, each combination was evaluated with respect to the definitions associated with each score, 1 to 4.
6. Acres of wildlife habitat created or improved	For each combination, the value is the sum of the acres created or improved under the regional PCA and the on-farm PCA.
7. Present value change in regional income	For each combination, the value is the sum of the regional income created by the regional PCA and the regional income created by the on-farm PCA, adjusted to represent the assumption that landowners pay for 12.5 percent of the on-farm expenses. The calculations for each PCA combination are provided in Appendix D of the Documentation Report.
8. Recreation Opportunities	Value is the maximum of the values for the regional PCA score and the on-farm PCA score.
9. Engin. / tech. track record 10. Environ. comp./ permit ease	For criteria 9 and 10, the value is the minimum of the values for the regional PCA score and the on-farm PCA score.

The values associated with each criterion for each PCA combination are provided in Tables 3-9 and 3-10.

Table 3-9
Summary of Values for Criteria 1, 2, and 3 for Each PCA Combination

PCA Combination	Criterion 1: Pounds P Removed per Year	Criterion 2: Resulting P Concentration in ppb	Criterion 3: Present Value Cost per Pound Removed, 2001$	% of Controllable Load to Lake Removed (545,076 lbs/year)
1. PCAs 7 and 11: RASTAs w/Isolated Wetlands Restoration on Pastureland	188,078	40	$121	35%
2. PCAs 7, 4 and 5: RASTAs w/Dairy Farm Optimization and Enhanced Cow-Calf BMPs	301,242	40	$54	55%
3. PCAs 7 and 1: RASTAs w/Chemical Treatment of Runoff at Edge of Property	295,426	40	$134	54%
4. PCAs 7 and 2: RASTAs w/Wetlands Treatment of Runoff at Edge of Property	232,516	40	$121	43%
5. PCAs 7 and 3: RASTAs w/Non-Structural Management at the Land Parcel Level	327,788	40	$68	60%
6. PCAs 7 and 6 – RASTAs w/Alternative Land Uses	159,312	40	$181	29%
7. PCAs 10 and 11: Terminal Large Scale Water Treatment Facility w/Isolated Wetlands Restoration on Pastureland	211,550	10	$139	39%
8. PCAs 10, 4 and 5: Terminal Large Scale Water Treatment Facility w/Dairy Farm Optimization and Enhanced Cow-Calf BMPs	319,592	10	$103	59%
9. PCAs 10 and 1: Terminal Large Scale Water Treatment Facility w/Chemical Treatment of Runoff at Edge of Property	313,993	10	$177	58%
10. PCAs 10 and 2: Terminal Large Scale Water Treatment Facility w/Wetlands Treatment of Runoff at Edge of Property	253,053	10	$136	46%
11. PCAs 10 and 3: Terminal Large Scale Water Treatment Facility w/Non-Structural Management at the Land Parcel Level	345,732	10	$83	63%
12. PCAs 10 and 6: Terminal Large Scale Water Treatment Facility w/Alternative Land Uses	182,186	10	$196	33%
13. PCAs 9 and 11: Tributary Sediment Removal w/Isolated Wetlands Restoration on Pastureland	149,710	193	$72	27%
14. PCAs 9, 4 and 5: Tributary Sediment Removal w/Dairy Farm Optimization and Enhanced Cow: Calf BMPs	261,258	233	$58	48%
15. PCAs 9 and 1: Tributary Sediment Removal w/Chemical Treatment of Runoff at Edge of Property	254,545	125	$157	47%
16. PCAs 9 and 2: Tributary Sediment Removal w/Wetlands Treatment of Runoff at Edge of Property	183,544	306	$103	34%
17. PCAs 9 and 3: Tributary Sediment Removal w/Non-Structural Management at the Land Parcel Level	289,473	216	$46	53%
18. PCAs 9 and 6: Tributary Sediment Removal w/ Alternative Land Uses	100,738	501	$194	18%

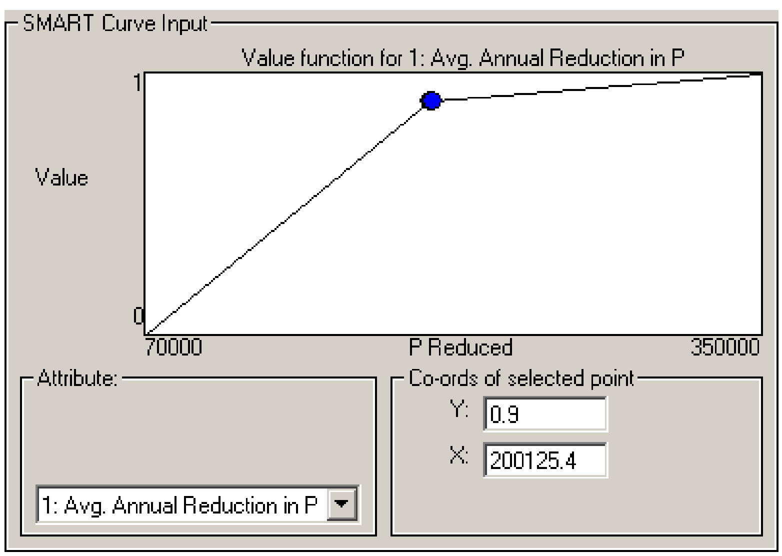
Table 3-10
Summary of Values for Criteria 4 through 10 for Each PCA Combination

PCA Combination Description	4. Surface Water Mgmt Objectives	5. Water Supply Increase	6. Acres of Wildlife Habitat	PV Change in Regional Income (2001 $)	8. Recreation Opport.	9. Engin. / Tech. Track Record	10. Environ. Compliance / Permitting Ease
1. PCAs 7 and 11: RASTAs w/ Isolated Wetlands Restoration on Pastureland	4	3	91,000	$7,696,000	1	3	4
2. PCAs 7, 4 and 5: RASTAs w/Dairy Farm Optimization and Enhanced Cow-Calf BMPs	4	2	11,000	$182,504,000	1	4	4
3. PCAs 7 and 1: RASTAs w/Chemical Treatment of Runoff at Edge of Property	4	2	26,000	-$150,998,000	1	3	2
4. PCAs 7 and 2: RASTAs w/Wetlands Treatment of Runoff at Edge of Property	4	2	35,000	-$279,715,000	1	3	3
5. PCAs 7 and 3: RASTAs w/Non-Structural Management at the Land Parcel Level	3	2	11,000	$71,510,000	1	3	4
6. PCAs 7 and 6: RASTAs w/Alternative Land Uses	4	4	79,000	-$5,834,223,000	1	4	4
7. PCAs 10 and 11: Terminal Large Scale Water Treatment Facility w/Isolated Wetlands Restoration on Pastureland	4	3	81,000	$21,863,000	1	2	1
8. PCAs 10, 4 and 5: Terminal Large Scale Water Treatment Facility w/Dairy Farm Optimization and Enhanced Cow-Calf BMPs	4	2	1,000	$196,671,000	1	2	1
9. PCAs 10 and 1: Terminal Large Scale Water Treatment Facility w/Chemical Treatment of Runoff at Edge of Property	4	2	16,000	-$136,831,000	1	2	1
10. PCAs 10 and 2: Terminal Large Scale Water Treatment Facility w/Wetlands Treatment of Runoff at Edge of Property	4	2	25,000	-$265,548,000	1	2	1
11. PCAs 10 and 3: Terminal Large Scale Water Treatment Facility w/Non-Structural Management at the Land Parcel Level	3	2	1,000	$85,677,000	1	2	1
12. PCAs 10 and 6: Terminal Large Scale Water Treatment Facility w/Alternative Land Uses	4	4	69,000	-$5,820,056,000	1	2	1
13. PCAs 9 and 11: Tributary Sediment Removal w/Isolated Wetlands Restoration on Pastureland	4	3	80,000	-$43,630,000	0	3	3
14. PCAs 9, 4 and 5: Tributary Sediment Removal w/Dairy Farm Optimization and Enhanced Cow-Calf BMPs	4	1	0	$131,178,000	0	3	3
15. PCAs 9 and 1: Tributary Sediment Removal w/Chemical Treatment of Runoff at Edge of Property	4	1	15,000	-$202,324,000	0	3	2
16. PCAs 9 and 2: Tributary Sediment Removal w/Wetlands Treatment of Runoff at Edge of Property	4	1	24,000	-$331,041,000	0	3	3
17. PCAs 9 and 3: Tributary Sediment Removal w/Non-Structural Management at the Land Parcel Level	2	0	0	$20,184,000	0	3	3
18. PCAs 9 and 6: Tributary Sediment Removal w/ Alternative Land Uses	4	4	68,000	-$5,843,894,000	1	3	3

3.4 Evaluation of Phosphorus Control Alternative Combinations

The 18 PCA combinations were evaluated with respect to the ten evaluation criteria. The Criterium Decision Plus (CDP) model was used for the evaluation.[5] This model scales the quantitative and qualitative scores assigned to each criteria and each PCA, as presented in Tables 3-6 and 3-7, to a number between zero and one. For each PCA combination, the scaled value of each criterion was then weighted based on the importance of each criterion and them summed among all ten criteria to obtain the total score. The lowest possible total score is zero and the highest possible total score is one (0 < total score < 1).

Scaling of the Criteria Values. Before the criteria weights are applied to the results of the evaluation criteria, the results are scaled to a number between 0 and 1. For example, for Criterion 1 – Average Annual Reduction on Phosphorus to the Lake, the values among the PCA combinations ranged from 101,000 pounds per year to 346,000 pounds per year. These numbers were scaled to values between 0 and 1, based on the function presented in the figure below. The horizontal axis is the estimated average annual phosphorus reduction in pounds and the vertical axis is the scaled value. The scaling functions for each criterion are presented in Appendix B of the Documentation Report.



Criteria Weights. Each criterion was assigned a number between 0 and 100 that reflects the relative importance of the criterion among the ten criteria. The relative importance is determined by the preferences of the decision makers and the ranges of PCA values associated with each criterion. Given a specific preference of the importance of one criterion relative to the others, adjustments to the numbers might be necessary to reflect the relative sizes of the criteria ranges. For example, the numbers for criteria with relatively small ranges might be reduced and the numbers for criteria with relatively large ranges might be increased in order to effectively judge the PCAs.

5 *InfoHarvest, Inc., Criterium Decision Plus, Version 3.0, Seattle, Washington, 2001.*

The assigned numbers were converted to the weights used in the evaluation. The conversion is the proportion of the criterion's number that represents the total of the numbers of all ten criteria. The numbers and weights for each criterion are presented in Table 3-11.

Table 3-11
Weighting of Evaluation Criteria

	Phosphorus Control Alternative (PCA)	Value	Weight
1	Average Annual Reduction in Phosphorus to Lake	100	0.179
2	Phosphorus Concentration at Site After PCA Implemented	75	0.134
3	Present Value Cost/lb of Phosphorus Removed from Lake	100	0.179
4	Surface Water Management Objectives	25	0.045
5	Water Supply Benefits	25	0.045
6	Enhanced Wildlife Habitat	25	0.045
7	Present Value Change in Regional Income	100	0.179
8	Increased Recreation Opportunities	10	0.018
9	Engineering Track Record	50	0.089
10	Environmental Compliance & Permitting Ease	50	0.089
Total		**560**	**1.000**

The values and weights indicate the importance of the criterion relative to the other criteria. For example, Criterion 1, Average Annual Reduction in Phosphorus to Lake Okeechobee, received 100 points and Criterion 5, Water Supply Benefits, received 25 points. This means that Criterion 1 is four times more important in the evaluation of the PCAs than is Criterion 5.

Scoring and Ranking of PCAs. The scoring and ranking of the PCA combinations are presented in Figure 3-1. The PCA combination name is presented in the first column, the total score is presented in the second column and a bar chart reflecting the total score is presented in the third column. Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs has the highest score of all 18 combinations. For informational purposes, the scoring and ranking of the individual PCAs is provided in Table 3-12.

Table 3-12
Scoring and Ranking of Individual PCAs

Rank	PCA Name (Number)	Score
1	Enhanced Cow-Calf BMPs (5)	0.669
2	RASTAs (7)	0.630
3	Non-Structural Management at the Land Parcel Level (3)	0.614
4	Isolated Wetlands Restoration on Pastureland (11)	0.593
5	Chemical Treatment of Runoff at Edge of Property (1)	0.553
6	Terminal Large Scale Water Treatment Facility (10)	0.542
7	Wetlands Treatment of Runoff at Edge of Property (2)	0.539
8	Tributary Sediment Removal (9)	0.461
9	Alternative Land Uses (6)	0.431
10	Optimization of Dairy Rule Design (4)	0.418

Impact of Uncertainty in Criteria Values on Number 1 Ranking. The CDP model allows the user to examine the sensitivity of the total scoring and ranking results to uncertainty in the criteria values. For each PCA and each of the continuous, quantitative criteria, criteria 1, 2, 3, 6 and 7, a probability distribution of values was specified. The average (mean) of the distribution was the value that was used in the evaluation. The model used these distributions to recalculate the total scores based on the probability distribution of the criterion values. The probability distribution specified for each PCA combination and criterion is provided in Appendix C of the Phase II Documentation Report. The distributions were based on the best available information regarding the criterion values for each PCA. The probability distributions for values that have "moderate" confidence levels, such as Criterion 1, Average Reduction in Phosphorus Loads to Lake, for PCA 5 - Enhanced Cow-Calf BMPs and PCA 3 – Non-Structural Management at the Land Parcel Level, were modeled using normal distribution functions with relatively low values defining the left hand side of the distribution (see Appendix C).

The percent of the time that the combination would be ranked number 1 given the uncertainty distributions of the individual criteria scores was calculated. The probability distributions of the criteria values for each PCA combination results in Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs being ranked number 1 98 percent of the time with second ranked Combination 5: PCAs 7 and 3 – RASTAs with Non-Structural Management at the Land Parcel Level ranked number 1 two percent of the time.

Summary of Results. Combination 2: PCAs 7, 4, and 5 – RASTAs with Dairy Rule Optimization and Enhanced Cow Calf BMPs has the highest score of all 18 combinations even when uncertainty in the criteria values is considered. Its score is 0.924 and it is ranked highest above all the others 98 percent of the time when uncertainty is considered. The second ranked combination is number 5: PCAs 7 and 3 - RASTAs with Non-Structural Management at the Land Parcel Level. Its score is 0.787. Combination 8: PCAs 10, 4 and 5 - Terminal Large Scale Water Treatment Facility with Dairy Farm Optimization and Enhanced Cow-Calf BMPs is a close third with a score of 0.756. The rankings of the 18 combinations are not sensitive to the weighting of the criteria values.

The impact of uncertainty on the total score for the top five PCA combinations is provided in Figure 3-2. The horizontal axis indicates the combination's score and the vertical axis indicates the frequency at which the combination obtains that score given the uncertainty in the criteria values. The distribution of scores for top ranked Combination 2 is to the right of the other combinations and would score higher than all the other combinations under practically all uncertainty scenarios. The distribution of fourth-ranked Combination 14 overlaps the distributions of Combinations 1, 5, and 8. Of these three combinations, 5 and 8 have higher scores and rankings than Combination 14. Thus, when uncertainty is considered, Combination 14 would rank higher than Combination 8 under many uncertainty scenarios and would rank higher than Combination 5 under a small portion of uncertainty scenarios.

Figure 3-1
Summary of Evaluation Results - PCA Combination Scores

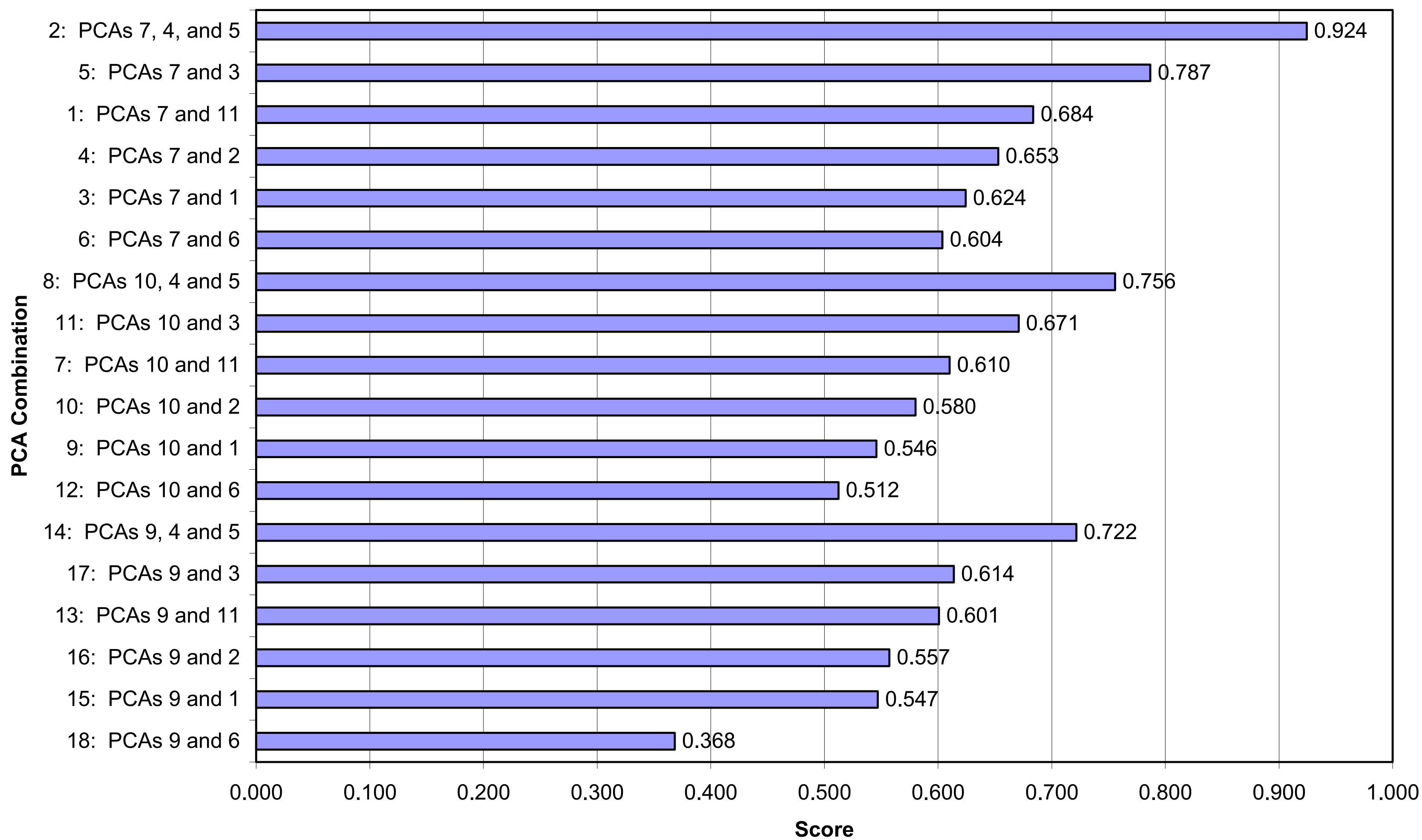
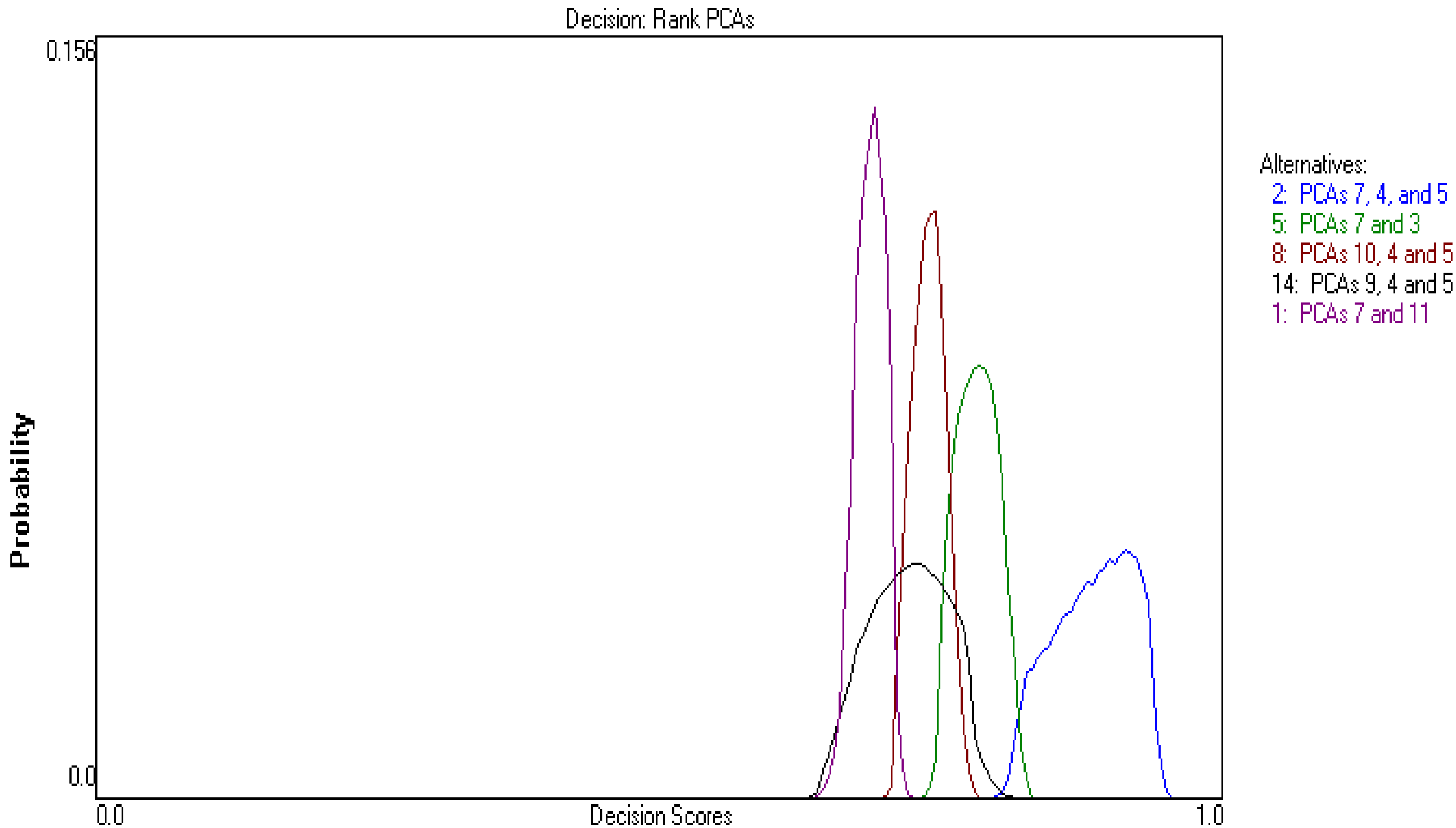


Figure 3-2
Impact of Uncertainty on Total Score for Top Five PCA Combinations



The values for criteria 1, 2 and 3 for each PCA combination are reprinted in Table 3-13 where the PCA combinations are in the order of the regional PCA ranking. The values for criterion 4 though 10 are provided in Table 3-14. The corresponding percent reduction in the controllable phosphorus loads to Lake Okeechobee due to the PCA combination is provided in the last column of Table 3-13. The total controllable load to the Lake represents ONLY those controllable phosphorus loads from the sub-basins of the study area. This load is the 1996 through 2000 average load to the Lake of 247.2 metric tons per year or 545,076 pounds per year. The itemized phosphorus loads by sub-basin in the study area is provided in Table 3-15. The targeted land uses and sub-basins of each PCA combination are summarized in Table 3-16. These targets are based on the predominant land uses in the sub-basins.

Contributions of Criteria to Total Scores. The contributions of the individual criteria to the total score for each PCA combination are provided in Figure 3-3. The scores by criteria and in total are shown on the vertical axis and the PCAs are shown on the horizontal axis. The PCA combinations are listed in the order of ranking. The top ranked Combination 2 (PCAs 7, 4 and 5), scored well with respect to all ten criteria. Second-ranked Combination 5 (PCAs 7 and 3) also scored well with respect to all ten criteria, but its score for present value change in regional income was not nearly as large as was Combination 2's.

Table 3-13
Summary of Values for Criteria 1, 2, and 3 for Each PCA Combination, In Order of Ranking

Rank	PCA Combination	Criterion 1: Pounds P Removed per Year	Criterion 2: Resulting P Concenraton in ppb	Criterion 3: Present Value Cost per Pound Removed, 2001$	% of Controllable Load to Lake Removed (545,076 lbs/year)
RASTAS					
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Optimization & Enhanced Cow-Calf BMPs**	301,242	40	$54	55%
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	327,788	40	$68	60%
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	188,078	40	$121	35%
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	232,516	40	$121	43%
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	295,426	40	$134	54%
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	159,312	40	$181	29%
TERMINAL LARGE SCALE WATER TREATMENT FACILITY					
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	319,592	10	$103	59%
6	Comb. 11: PCAs 10 & 3 –**Water Treatment Fac. w/ Non-Structural Mgmt at Land Parcel Level**	345,732	10	$83	63%
10	Comb. 7: PCAs 10 & 11 - **Water Treatment Fac. w/ Isol. Wetlands Restoration on Pastureland**	211,550	10	$139	39%
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	253,053	10	$136	46%
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	313,993	10	$177	58%
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Facility with Alternative Land Uses**	182,186	10	$196	33%
TRIBUTARY SEDIMENT REMOVAL					
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sediment Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	261,258	233	$58	48%
9	Comb. 17: PCAs 9 & 3 – **Trib. Sediment Removal w/ Non-Structural Mgmt at Land Parcel Level**	289,473	216	$46	53%
12	Comb. 13: PCAs 9 & 11 – **Trib. Sediment Removal w/ Isolated Wetlands Restored on Pastureland**	149,710	193	$72	27%
14	Comb. 16: PCAs 9 & 2 – **Trib. Sediment Removal w/ Wetlands Treatment of Runoff at Edge of Property**	183,544	306	$103	34%
15	Comb. 15: PCAs 9 & 1 – **Trib. Sediment Removal w/ Chem. Treatment of Runoff at Edge of Property**	254,545	125	$157	47%
18	Comb. 18: PCAs 9 & 6 - **Tributary Sediment Removal w/ Alternative Land Uses**	100,738	501	$194	18%

Table 3-14
Summary of Values for Criteria 4 through 10 for Each PCA Combination, In Order of Ranking

Rank	PCA Combination Description	4. Surface Water Mgmt Objectives	5. Water Supply Increase	6.Acres of Wildlife Habitat	7. PV Change in Regional Income (2001 $)	8. Recrea-tion Opport.	9. Engin. / Tech. Track Record	10. Environ. Compliance / Permitting Ease
RASTAS								
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	2	11,000	$182,504,000	1	4	4
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	3	2	11,000	$71,510,000	1	3	4
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	4	3	91,000	$7,696,000	1	3	4
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	4	2	35,000	-$279,715,000	1	3	3
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	4	2	26,000	-$150,998,000	1	3	2
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	4	4	79,000	-$5,834,223,000	1	4	4
TERMINAL LARGE SCALE WATER TREATMENT FACILITY								
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	2	1,000	$196,671,000	1	2	1
6	Comb. 11: PCAs 10 & 3 –**Water Trtmt Fac. w/ Non-Structural Mgmt at Parcel Level**	3	2	1,000	$85,677,000	1	2	1
10	Comb. 7: PCAs 10 & 11 - **Water Trtmt Fac. w/ Isol. Wetlands Restored on Pasture**	4	3	81,000	$21,863,000	1	2	1
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	4	2	25,000	-$265,548,000	1	2	1
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	4	2	16,000	-$136,831,000	1	2	1
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Fac. with Alternative Land Uses**	4	4	69,000	-$5,820,056,000	1	2	1
TRIBUTARY SEDIMENT REMOVAL								
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sed. Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	4	1	0	$131,178,000	0	3	3
9	Comb. 17: PCAs 9 & 3 – **Trib. Sed. Removal w/ Non-Structural Mgmt at Parcel Level**	2	0	0	$20,184,000	0	3	3
12	Comb. 13: PCAs 9 & 11 – **Trib. Sed. Removal w/ Isolated Wetlands Restored on Pastureland**	4	3	80,000	-$43,630,000	0	3	3
14	Comb. 16: PCAs 9 & 2 – **Trib. Sed. Removal w/ Wetlands Treatment of Runoff at Edge of Property**	4	1	24,000	-$331,041,000	0	3	3
15	Comb. 15: PCAs 9 & 1 – **Trib. Sed. Removal w/ Chem. Treatment of Runoff at Edge of Property**	4	1	15,000	-$202,324,000	0	3	2
18	Comb. 18: PCAs 9 & 6 – **Tributary Sediment Removal w/ Alternative Land Uses**	4	4	68,000	-$5,843,894,000	1	3	3

Table 3-15
Actual Loads of Phosphorus into Lake Okeechobee From Study Area Sub-Basins – All Sources
From: Lake Okeechobee SWIM Plan Total Phosphorus Report for 1996 through 2000

Controllable Sources	Discharge acre-feet	Area (sq. mi)	Actual Load metric tons/yr
C-40 Basin (S-72) - S68	10,745	87	6.5
C-41 Basin (S-71) - S68	36,581	176	17.8
Fisheating Creek	186,438	462	45.5
L-48 Basin (S-127)	21,773	32	5.2
L-49 Basin (S-129)	13,031	19	1.4
L-59E	6,368	15	1.3
L-59W	8,285	15	2.1
L-60E	1,228	6	0.3
L-60W	417	6	0.1
L-61E	7,011	22	1.0
L-61W	10,669	22	1.3
Taylor Creek/Nubbin Slough (S-191)	79,719	188	63.1
S-131 Basin	7,886	11	1.1
S-133 Basin	7,866	40	3.7
S-135 Basin	17,806	28	2.5
S-154 Basin	27,388	37	27.0
S65E - S65A	**271,753**	**749**	**67.0**
Nicodemus Slough (Culv 5)	3,344	28	0.3
Controllable Totals	**718,308**	**1,943**	**247.2**
Uncontrollable Sources			
Rainfall			64.4
S65 (Lake Kissimmee)	757,004		89.4
Lake Istokpoga (S-68)	260,427		23.2
S5A Basin (S-352-WPB Canal)	21		0.0
East Caloosahatchee (S-77)	411		0.1
L-8 Basin (Culv 10A)	58,066		6.7
Uncontrollable Totals	**1,075,929**		**183.8**
5 Year Yearly Average Total Loadings			**431.0**

Table 3-16
Targeted Land Uses and Basins of the PCA Combinations

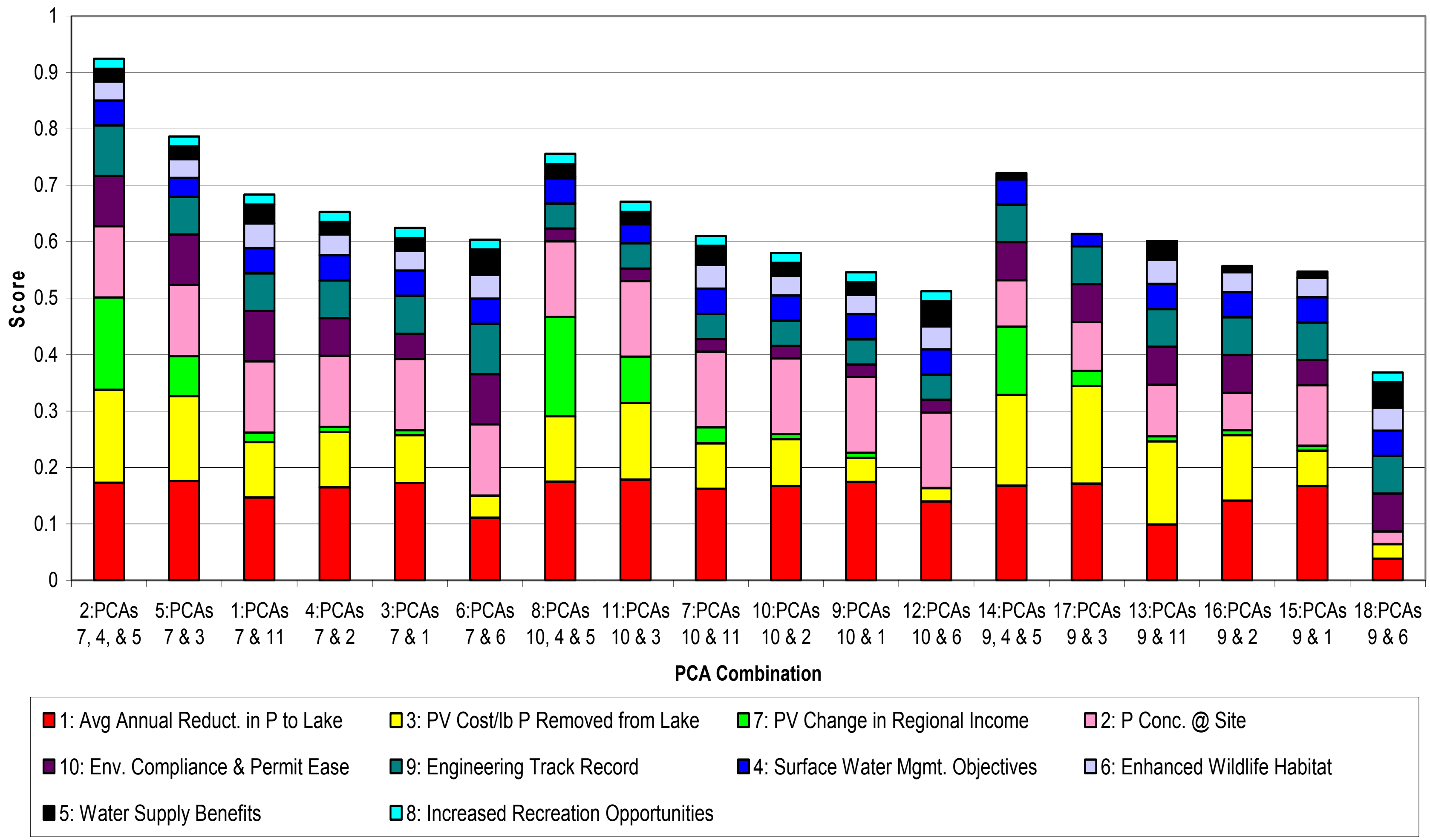
Rank	PCA Combination	Targeted Land Uses	Targeted Sub-Basins	% of Developed Land in Study Area (a)
RASTAS				
1	Comb. 2: PCAs 7, 4 & 5 - **RASTAs w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
2	Comb. 5: PCAs 7 & 3 - **RASTAs w/ Non-Structural Mgmt at Land Parcel Level**	all agricultural land uses	all sub-basins	92%
5	Comb. 1: PCAs 7 & 11 - **RASTAs w/ Isolated Wetlands Restoration on Pastureland**	cow-calf operations	all sub-basins (see Table A-4 in Appendix for acreages by sub-basin)	33%
7	Comb. 4: PCAs 7 & 2 - **RASTAs w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
8	Comb. 3: PCAs 7 & 1 - **RASTAs w/ Chemical Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
11	Comb. 6: PCAs 7 & 6 – **RASTAs w/ Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%
TERMINAL LARGE SCALE WATER TREATMENT FACILITY				
3	Comb. 8: PCAs 10, 4 & 5 –**Water Treatment Fac. w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
6	Comb. 11: PCAs 10 & 3 –**Water Trtmt Fac. w/ Non-Structural Mgmt at Parcel Level**	all agricultural land uses	all sub-basins	92%
10	Comb. 7: PCAs 10 & 11 - **Water Trtmt Fac. w/ Isol. Wetlands Restored on Pasture**	cow-calf operations	all sub-basins (see Table A-4 on page A-5 in Appendix for acreages by sub-basin)	33%
13	Comb. 10: PCAs 10 & 2 - **Water Treatment Fac. w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%

Table 3-16
Targeted Land Uses and Basins of the PCA Combinations

Rank	PCA Combination	Targeted Land Uses	Targeted Sub-Basins	% of Developed Land in Study Area (a)
16	Comb. 9: PCAs 10 & 1 - **Water Treatment Fac. w/ Chem. Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
17	Comb. 12: PCAs 10 & 6 - **Water Treatment Fac. with Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%
TRIBUTARY SEDIMENT REMOVAL				
4	Comb. 14: PCAs 9, 4 & 5 – **Trib. Sed. Removal w/ Dairy Farm Opt. & Enhanced Cow-Calf BMPs**	dairies and cow-calf operations	dairies - S-165; S-191; S-65A,D,E; Improved pasture - all sub-basins	74%
9	Comb. 17: PCAs 9 & 3 – **Trib. Sed. Removal w/ Non-Structural Mgmt at Parcel Level**	all agricultural land uses	all sub-basins	92%
12	Comb. 13: PCAs 9 & 11 – **Trib. Sed. Removal w/ Isolated Wetlands Restored on Pastureland**	cow-calf operations	all sub-basins (see Table A-4 in Appendix for acreages by sub-basin)	33%
14	Comb. 16: PCAs 9 & 2 – **Trib. Sed. Removal w/ Wetlands Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
15	Comb. 15: PCAs 9 & 1 – **Trib. Sed. Removal w/ Chem. Treatment of Runoff at Edge of Property**	all agricultural land uses	all sub-basins	92%
18	Comb. 18: PCAs 9 & 6 – **Tributary Sediment Removal w/ Alternative Land Uses**	dairies; citrus; sugarcane; row crops; 12,000 acres of cow-calf	C-40; C-41; C-41A; Fisheating Creek; L-60W; S-135; S-65A, C, D, E; S-191; S-154	17%

(a) Developed acreage is land in agriculture and residential uses and is 613,593 acres. Excludes water, wetlands, unimproved pasture, rangeland and upland forest.

Figure 3-3
Contributions of Criteria to Total Score



3.5 Research Needs

Research needs were identified for five of the ten phosphorus control alternatives evaluated during this study. The recommendations are numbered in sequential order.

PCA 3 – Non-Structural Management at the Land Parcel Level

Of the PCAs evaluated, this one is the most in need of additional research to verify the estimates used in this study. The research recommendations are as follows.

1. **Soil Amendments to Reduce Phosphorus Loads in Water Runoff.** Of the research completed to date, only silicon appears to have potential to reduce phosphorus loads in water runoff. Research by the University of Florida Institute of Food and Agricultural Sciences (IFAS) on the use of silicon as a soil amendment to reduce phosphorus loads in water runoff has been successful. The research was conducted using beef pasture, dairy pasture, citrus and sod on the sandy soils of central and south Florida, including the study area. IFAS researchers have concluded that using silicon as a soil amendment reduces phosphorus leaching by 30 percent to 90 percent.[6] Once the District's study regarding the efficacy of applied limestone and gypsum is complete, the District will then be able to evaluate the use of soil amendments in practical farm management applications. The research should quantify the expected phosphorus reduction and the costs associated with on-farm application of these soil amendments.

2. **Fertilizer Management.** Calibrated soil testing and leaf sampling to determine optimal fertilization[7] holds great potential to minimize the application of phosphorus and nitrogen. No studies currently exist that address phosphorus load reductions from increased use of testing in Florida. Future research should address the phosphorus load reduction, the cost and yield impacts of calibrated nutrient testing and incentives for farmers to use this method when planning fertilizations.

3. **Area- and Crop- Specific Phosphorus Fertilization Requirements.** IFAS now recommends that applied phosphorus is not needed for bahia grass in the study area. The District should support and keep abreast of research regarding applied phosphorus needed by other crops in the study area including other types of pasture grasses, citrus, sod, vegetables, field crops and ornamentals.

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[6] *Vladimir Matichenkov, Ph.D., University of Florida, Institute of Food and Agricultural Sciences, "Silicon Fertilization for Florida Dairy Farms and Beef Ranches" (no date – this is a summary of research results); V.V. Matichenkov, D.V. Calvert and E.A. Bocharnikova, University of Florida, Institute of Food and Agricultural Sciences, Florida Agricultural Experiment Station, "Effect of Si Fertilization on Growth and P Nutrition of Bahiagrass", Journal Series No. N-02067, 2001; Vladimir Matichenkov, Elena Bocharnikova and David Calvert, , University of Florida, Institute of Food and Agricultural Sciences, "Response of Citrus to Silicon Soil Amendments", Proceedings of the Florida State Horticultural Society, 2001.*

[7] *Calibrated soil testing determines the minimum fertilization necessary for desired plant response.*

PCA 5 – Enhanced Cow-Calf Best Management Practices

The District, the University of Florida, the Florida Cattlemen's Association and the USDA Natural Resource Conservation Service (NRCS) support current research that identifies methods to reduce phosphorus in runoff from beef cattle pastures. The District's current project titled, "Beef Cattle Optimization Research at Buck Island" supports this effort. The overall goal of this project is to design cattle BMPs to reduce phosphorus loads from pastures while not substantially increasing costs to the rancher. Phase I of this research is underway and focuses on manipulation of cattle stocking rates to reduce phosphorus loads. Upon completion of Phase I, other management issues and potential cattle BMPs will be evaluated.

The following research recommendations address the need for estimates of phosphorus reduction and net revenue impacts associated with specific cow-calf BMPs that either comprise PCA 5 or were not evaluated as part of PCA 5 because cost and benefit information did not exist. These BMPs were selected from the document titled "Water Quality Best Management Practices for Cow/Calf Operations in Florida", June 1999. The selection of BMPs from this document was based on interviews with experts in cow-calf operations in the study area. The BMP report was prepared by staff of the Florida Cattlemen's Association, the NRCS, the Florida Department of Agriculture and Consumer Services (FDACS), the five Water Management Districts, the Florida Department of Environmental Protection and the University of Florida Institute of Food and Agricultural Sciences. The Florida Department of Agriculture and Consumer Services is considering these BMPs as they develop a Comprehensive Nutrient Management Plan that will be used for State rulemaking.

4. **Cattle BMP Research.** This study's estimates of the phosphorus reduction benefits and changes in net revenue from cattle operations associated with the following BMPs should be verified through current and future research efforts. Net revenue is revenue minus cost.

    a. **Animal Stocking Rates.** Identify cattle stocking rates that are effective in reducing phosphorus loads while minimizing negative farm impacts. Research results should include the impact of changing existing stocking rate levels on phosphorus loads and the net revenue impact per acre to landowners and identifying the current stocking rates of cow-calf operations in the study area such that an average stocking rate could be calculated. The District's Beef Cattle Optimization Project should address these issues.

    b. **Water Management to Slow or Eliminate Movement of Off-site Drainage.** Under this BMP, water control structures would be constructed in ditches within pastures to control the flow of surface water. Water would be held or released in selected pastures to maximize retention of phosphorus during and after storm events and minimize detrimental effects of flooding on vulnerable pasture grasses. Selected conveyance ditches that drain water directly off the property would be filled to slow the off-site movement of phosphorus-laden stormwater.

c. **Filter Strips.** A strip of herbaceous vegetation would be planted between surface waters and grazing land to filter nutrients from runoff water. Filter strips would be applied in association with fencing.

d. **Nutrient Management.** A nutrient budget for the operation would be developed so that phosphorus from all sources is accounted for. Nutrient sources include soil residuals, crop residues, organic and chemical fertilizer, and irrigation water. The nutrient budget would be used to determine the appropriate amount of fertilizer phosphorus to be added to pastures. Forage phosphorus content would be tested to determine the amount of phosphorus needed in the dry feed rations. Nutrients would be applied at times with the lowest likelihood of runoff occurring.

e. **Alternative Pasture Grasses.** Existing grasses would be replaced with types that do not require phosphorus fertilization and are flood tolerant to support extended on-site water retention in selected areas of pastures.

f. **All of the Above BMPs.** Conduct research to obtain estimates of the phosphorus load reductions and changes in net revenue from implementing all or a combination of the above listed BMPs.

5. **PCA 10 - Flow Equalization Associated with PCA 10 – Terminal Large Scale Water Treatment Facility.** PCA 10's conceptual design requires about 4,000 acres of land to support a flow equalization area. The overland flow hydraulics and spillway control strategy should be reviewed in detail to assess the best alternative for flow equalization in the area. The feasibility of using aquifer storage and recovery (ASR) instead of surface storage should be investigated. In addition, it may be possible to use the reservoirs of local CERP projects for storage. ASR and/or the reservoirs of local CERP projects have the potential to reduce the cost of PCA 10 by about four percent.

6. **PCAs 7 and 8 - Influent Phosphorus Concentrations of Water Entering the RASTAs (PCAs 7 and 8).** The influent phosphorus concentrations used in this study were based on existing historic measurements at structures that were closest to the locations of the RASTAs. This parameter and the availability of a continuous supply of water are important determinants of phosphorus load reductions to the Lake. The District's Lake Okeechobee Watershed Project – Project Implementation Plan, which has recently begun, will address these issues.

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