M E M O R A N D U M

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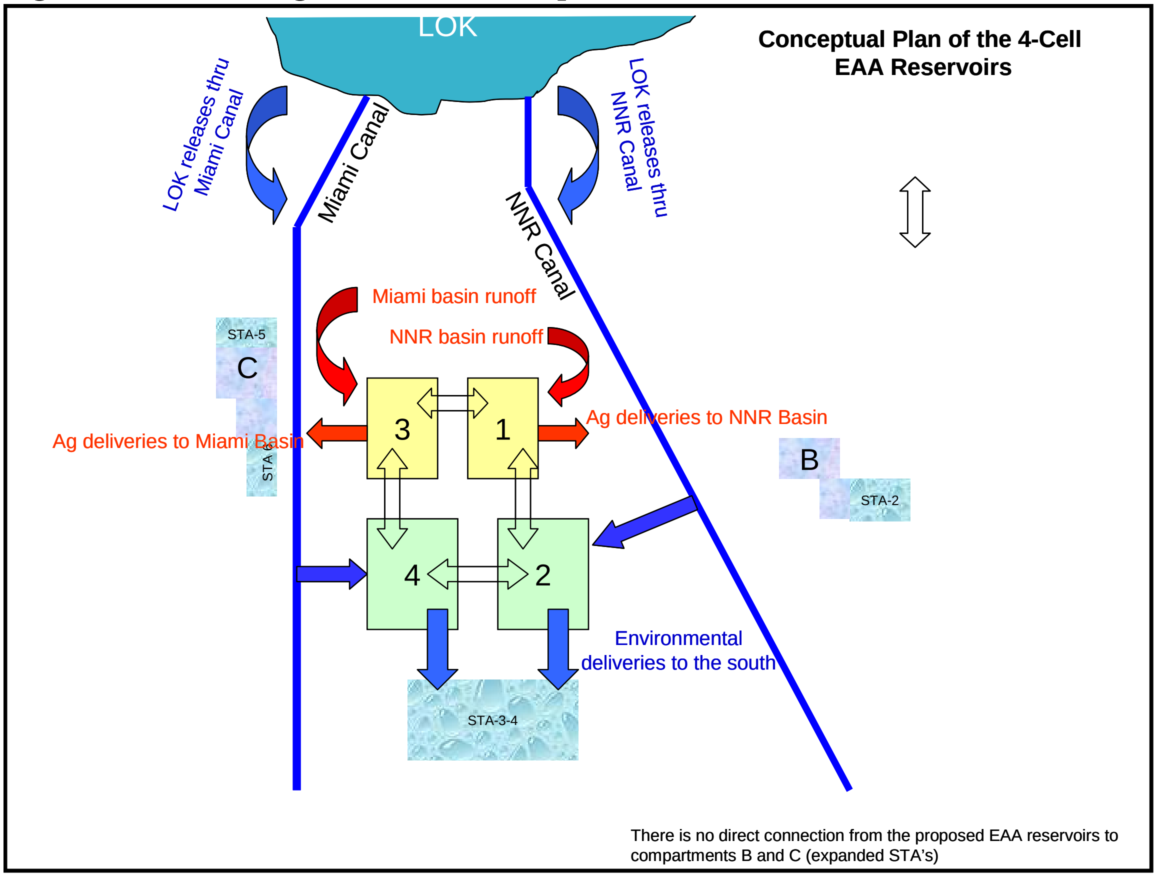
FROM: Gary Goforth
DATE: August 12, 2006
SUBJECT: Conceptual-level Sizing Analysis of the Proposed EAASR STA

1.0 EXECUTIVE SUMMARY

The South Florida Water Management District (SFWMD) in partnership with the U. S. Army Corps of Engineers (USACE) is developing a Project Implementation Report for the Everglades Agricultural Area Storage Reservoir (EAASR). In order to achieve appropriate water quality in environmental deliveries to the Everglades Protection Area (EPA), the Project Development Team (PDT) is evaluating the use of a stormwater treatment area (STA) as part of the regional set of projects (see Figure 1 for conceptual schematic of the EAASR). Acknowledging that significant uncertainty exists in many critical design factors, a conceptual-level analysis was performed to assist the PDT identify the key parameters that influence the size of the proposed STA. This analysis established a preliminary set of inflow volumes and phosphorus loads based on a comparison of the With Project simulation (EAA1-4) to the Without Project simulation (2050B3EAA). Using performance results from the recent EAA A1 Storage Reservoir Basis of Design Report (Black & Veatch 2006) and the EAA Regional Feasibility Study (ADA/Burns & McDonnell 2005), preliminary phosphorus reduction characteristics were established for the A1 and A2 reservoirs, as well as STA-3/4 and the proposed STA. A steady-state model was used to forecast phosphorus removal performance of the A1 and A2 reservoirs, as well as STA-3/4 and the proposed STA. Although considerable technical uncertainties remain regarding the flows and phosphorus levels that may enter the proposed STA, a conceptual-level range of 5,900 – 8,300 acres of effective treatment area was estimated based on a potential range in STA performance and a specific set of assumed base conditions. Recognizing the sensitivity of the estimated area to critical design factors that contain high levels of uncertainty, a sensitivity analysis was performed for the following parameters: STA outflow phosphorus concentration, phosphorus concentration in Lake Okeechobee releases, STA settling rate, reservoir settling rate, and water supply diversion. Within the parameter ranges evaluated, the estimated effective treatment area was most sensitive to the STA target outflow phosphorus concentration, with a range of 5,900 to 11,000 acres of effective treatment area estimated for an outflow concentration range of 15-20 ppb (all other values held constant at their Base Condition values). The phosphorus concentration in Lake Okeechobee releases was also a very sensitive parameter, with a range of 1,800 to 9,700 acres of effective treatment area identified for a concentration range of 70-200 ppb. The sensitivity of the effective treatment area to the other parameters is summarized in tables and figures of this report. This conceptual-level analysis and related sensitivity analysis should allow the EAASR PDT to move forward in addressing remaining water and mass balance issues, selecting design values and conducting more detailed analyses, including use of a dynamic simulation model for reservoir and STA performance forecasting, consistent with the adaptive management philosophy of CERP.

Figure 1. EAA Storage Reservoir Conceptual Schematic.



2.0 STA SIZING STRATEGY

An initial strategy for sizing the proposed STA was developed by the EAASR PDT. That strategy was slightly refined during the course of this analysis. The revised strategy below was used in developing conceptual-level estimates of effective treatment area for the proposed STA.

1. Determine the source and initial estimate of the volume of "new water" to be treated by the proposed STA. An initial estimate of the inflow volume will be obtained using South Florida Water Management Model (SFWMM) data by comparing the "With Project" and "Without Project" conditions. These volumes will be derived from SFWMM variables demonstrating 1) reservoir inputs from the Lake Okeechobee, 2) reservoir inputs from EAA basin runoff, 3) deliveries to the environment [currently represented in the SFWMM by deliveries to STA-3/4 and bypass], and 4) consideration of phosphorus performance of the integrated project components. The ultimate difference between the "With Project" and "Without Project" conditions will be greater than the simple numerical difference between the simulated net flows, in that redistribution of flows will likely be necessary in order to achieve the appropriate

phosphorus water quality levels. Depending on the inflow source, the phosphorus concentration will vary, and to the extent that the "With Project" and "Without Project" simulations result in different volumes and sources, the associated phosphorus loads to the reservoirs and STAs will differ. An iterative process of hydrologic and water quality modeling will likely be required to finalize the "With Project" conditions and determine the ultimate inflow volume and associated phosphorus load to be treated in the new STA. During the EAA PIR modeling meeting on 8/4/06, it was recommended that the model run EAA1-4 be used to estimate flows for the "With Project" condition and that the 2050B3EAA simulation results be used for the "Without Project" condition. The estimated size of the STA will need to be updated later when a final simulation is available.

2. Forecast the phosphorus concentration of Lake Okeechobee releases and basin runoff delivered to the reservoir and STA-3/4 under the "With Project" and "Without Project" conditions. These forecasts will be based on recent studies.

3. Estimate the phosphorus settling rate and other treatment characteristics of the EAASR, STA-3/4 and the proposed STA based on recent studies.

4. Estimate the anticipated volume and phosphorus load of water delivered to the proposed STA after consideration of STA-3/4 treatment capacity. The volume of water re-directed to the new STA will vary depending upon the flows and treatment capacity of STA-3/4, as that treatment area must also achieve the appropriate water quality for deliveries to the EPA. At the present time, a steady-state model can be used for estimating phosphorus concentrations from the reservoir cells and from STA-3/4. A dynamic model should be used in subsequent analyses when the model output is finalized and the level of uncertainty surrounding various critical design parameters is reduced.

5. Using a steady-state phosphorus reduction performance model, estimate the effective treatment area required for the proposed STA. The sizing estimate will be consistent with the current treatment levels the SFWMD is using to enhance the performance of the STAs to meet the water quality requirements of the Everglades Forever Act.

6. Conduct a sensitivity analysis to determine the influence of critical design parameters on the estimated effective treatment area of the proposed STA. The sensitivity analysis will determine both the absolute change in effective treatment area for the change in input parameter and the relative sensitivity, defined as the ratio of percent change in estimated area to percent change in input parameter. This analysis can help identify the key parameters that need particular focus during subsequent PIR phases in order to reduce uncertainty. An appropriate range of values will be established based on recent studies, and where recent data are not available, upon best professional judgment.

3.0 ANALYTICAL APPROACH FOR ESTIMATING EFFECTIVE TREATMENT AREA

The original sizing of the Everglades Construction Project's STAs was based on a steady-state form of a first-order equation describing the phosphorus reduction in a shallow freshwater wetland (Walker 1995). While a dynamic model has subsequently been developed and applied to forecast performance resulting from enhancements in those STAs, the steady-state model continues to be used for conceptual-level analyses (Burns & McDonnell 2005)

$$\frac{(C_o - C^*)}{(C_i - C^*)} = \left[\frac{1}{\left(1 + \frac{\mathrm{K}}{\mathrm{Qn}}\right)} \right]^n$$

Where

Co = flow weighted mean outflow concentration (mg/l of total phosphorus)
Ci = flow weighted mean inflow concentration (mg/l of total phosphorus)
C* = probable lowest water column concentration in a steady state system
Q = hydraulic loading rate (m/yr)
K = net first-order removal rate in a steady state system (m/yr)
n = number of continuous stirred tank reactors (CSTRs) in series

with Q=V/A

where V = long-term average annual inflow volume
A = effective treatment area

Solving for A yields

$$A = \frac{Vn}{K} \left\{ \left[\frac{(C_i - C^*)}{(C_o - C^*)} \right]^{1/n} - 1 \right\}$$

Using this equation with K values derived from STA performance may yield overly optimistic performance forecasts relative to DMSTA, a reflection of DMSTA's ability to consider pulsed flows and atmospheric deposition, which become more important as the outflow concentrations decrease. The following is a comparison against performance projections from EAA Regional Feasibility Study for Alternative 1 with the WY2010-2014 input data set (ADA/Burns & McDonnell 2005).

Table 1. Comparison of Steady-State Model Forecasts with Dynamic Model Forecasts

STA	V	V	TP Load	n	K	C_i	C_o	C*	A	A	Reported	Difference
	AF/yr	hm^3/yr	kg/yr	dimensionless	m/yr	ppb	ppb	ppb	hm^2	ac	ac	%
STA-1E	171,800	211.9	27,030	6	28	128	13.3	4	24.5	6,045	6,176	2%
STA-1W	131,400	162.1	25,800	6	28	159	18.9	4	16.6	4,099	6,670	39%
STA-2	180,700	222.9	20,300	6	28	91	16.9	4	17.9	4,421	6,240	29%
STA-3/4	585,500	722.2	65,920	6	28	91	18.6	4	53.7	13,271	16,543	20%
STA-5	159,100	196.2	39,140	6	28	199	15.2	4	25.7	6,342	13,150	52%
STA-6	40,200	49.6	4,880	6	28	98	17.1	4	4.1	1,023	897	-14%
										35,200	49,676	29%

For the purpose of this analysis, the value of K was adjusted to match STA-3/4 performance projection from DMSTA, yielding a reduction of K to 22.46 m/yr from the calibration median of 28 m/yr. For the sensitivity analysis, the lower bound of K was set by matching the DMSTA simulated performance of STA-3/4 using the lower 10% confidence level of the calibration data set, yielding an adjusted K of 18.6 m/yr. The upper bound was set by matching the DMSTA simulated performance of STA-3/4 using the upper 10% confidence level of the calibration data set, yielding an adjusted K of 26.3 m/yr.

Similarly, a range of adjusted K values was obtained for the reservoirs by matching the DMSTA simulated performance of the EAASR A1 as presented in the EAASR A1 Basis of Design Report (Black and Veatch 2006), yielding a range of 1.17 – 3.625 m/yr, with a median value of 1.175 m/yr. These correspond to the reported load reductions of 13%, 17% and 34% (Table 2 of Appendix 3-2, Black & Veatch 2006).

For the STAs, the number of CSTRs, ***n***, will be assumed to be 6, which is typical of two treatment cells in series. The EAASR will be modeled as two cells, representing the A1 and A2 components. For each reservoirs, ***n*** will be assumed to be 1, consistent with previous modeling studies (ADA/Burns & McDonnell 2005, Black and Veatch 2006). A C* of 4 ppb will be used for STAs and reservoirs.

4.0 INFLOW VOLUMES AND LOADS

Although the regional modeling is not yet finalized and some key issues are not fully resolved, an estimate of the inflows and phosphorus loads can be developed by utilizing reasonable assumptions. A summary of the assumptions is presented below.

1. Consistent with the EAA Regional Feasibility Study (ADA/Burns and McDonnell 2005, RFS), the only STA that will be used to capture and treat Lake Okeechobee regulatory releases are STA-3/4 and the new STA, no other STA will receive regulatory releases and water supply deliveries intended for downstream receiving waters.
2. All runoff from extreme meteorological events simulated in the 1995-2000 period of simulation will be treated, as opposed to being diverted into the WCAs without treatment.
3. EAA irrigation water releases do not need to be treated to Everglades water quality standards prior to discharge back to the EAA.

4. The new STA, working in conjunction with STA-3/4, will treat the volumes of water anticipated to be discharged into the Everglades associated with the EAASR. In other words, the combined areas of STA-3/4 and the new STA are to be used to meet the treatment goals of the project.
5. Compartment B will be used primarily to capture and treat water from the S-6 and S-5A basins, and will not be used to capture and treat any Lake Okeechobee releases, or EAASR releases conveyed through the North New River Canal.
6. The RECOVER process will identify any phosphorus load constraint for waters entering the EPA from these projects.
7. Phosphorus concentrations developed during the EAA RFS can be used for EAA runoff, Ch. 298 District runoff and the C-139 Basin inflows to the EAASR.
8. A phosphorus concentration of 145.5 ppb was used as the base value for the Lake Okeechobee releases, consistent with the recent evaluation conducted for the Lake Okeechobee Regulation Schedule Study (Goforth 2006). A range of concentrations was used in the sensitivity analysis.
9. A steady-state form of the phosphorus removal equation is appropriate at this conceptual level.
10. A May 1 – April 30 Water Year was used in these analyses.
11. An initial target long-term average flow-weighted mean STA outflow phosphorus concentration was established at 18.6 ppb, consistent with projections from the EAA RFS for Alternative 1 of the WY2010-2014 conditions (ADA/Burns & McDonnell 2005). The sensitivity of the effective treatment area to this parameter was assessed in the sensitivity analysis.
12. A portion of the water supply deliveries for downstream areas will be diverted untreated around STA-3/4 and the new STA. The SFWMM simulations for the "With Project" will define the base value for the volume diverted, e.g. the "With Project" simulation resulted in the diversion of approximately 68,300 AF/yr. The sensitivity of the effective treatment area to this parameter was assessed in the sensitivity analysis by varying the volume diverted.

In addition to the above assumptions, discharges from STA-3/4 must continue to meet the appropriate water quality target under the "With Project" conditions. Because of the dependency of the new STA inflow volumes and phosphorus loads to the phosphorus reduction performance of the reservoirs and STA-3/4, the new STA inflow volumes and phosphorus loads will vary under the different scenarios.

A comparison of the terms of the SFWMM simulation results is presented in Table 2. An estimate of the initial component of the inflow volume to the new STA was obtained using South Florida Water Management Model (SFWMM) data by comparing the "With Project" and "Without Project" conditions. These volumes were derived from SFWMM variables demonstrating 1) reservoir inputs from the Lake Okeechobee, 2) reservoir inputs from EAA basin runoff, 3) deliveries to the environment [currently represented in the SFWMM by deliveries to STA-3/4 and bypass], and 4) consideration of phosphorus performance of the integrated project components. The ultimate difference between the "With Project" and "Without Project" conditions will be greater than the simple numerical difference between

Table 2. Initial Comparison of "Without Project" and "With Project" Simulations

Destination	Source		Without Project 2050B3EAA	With Project EAA1-4	Difference From 2050B3[1]
A1 Cell 2	Lake Okeechobee	Reg Rel - NNRC	0	293,318	293,318
	A2	Cell 1	0	150,928	150,928
	Total to A1 Cell 2		0	444,245	444,245
A1 Cell 4	A1	Cell 2	0	2,252	2,252
	Lake Okeechobee	Reg Rel - MC	0	79,397	79,397
	A2	Cell 3	0	60,186	60,186
	Total to A1 Cell 4		0	141,835	141,835
	Total to A1		0	583,828	583,828
A2 Cell 1	EAA Runoff	NNRC	0	152,231	152,231
	A1	Cell 2	0	47,190	47,190
	A2	Cell 3	0	51,794	51,794
	Total to A2 Cell 1		0	251,214	251,214
A2 Cell 3	EAA Runoff	Miami Canal	0	110,248	110,248
	A1	Cell 4	0	81,291	81,291
	Total to A2 Cell 3		0	191,539	191,539
	Total to A2		0	390,960	390,960
	Total to EAA SR		0	635,194	635,194
STA-3/4	EAA Runoff	NNRC	251,416	101,425	-149,991
	EAA Runoff	Miami Canal	225,262	97,511	-127,751
	C-139 RO	Miami Canal	13,280	13,667	387
	SSDD		3,944	4,151	207
	SFCD		11,544	12,025	481
	Lake Okeechobee	Reg Rel - NNRC	61,849	21,479	-40,370
	Lake Okeechobee	Reg Rel - MC	72,918	20,536	-52,382
	Lake Okeechobee	WS for STA-3/4	0	0	0
	Lake Okeechobee	WS - NNRC	41,689	8,213	-33,476
	Lake Okeechobee	WS - MC	84,241	74,370	-9,872
	Lake Okee water supply	Diverted	-58,372	-68,278	-9,906
	A1	Cell 2	0	389,116	389,116
	A1	Cell 4	0	54,193	54,193
	Total to STA-3/4		707,772	728,407	20,635

Note: 1. The initial difference between simulation runs does not take into account phosphorus loads associated with the various source waters and phosphorus removal performance of the project components. Redistribution of flows from the above table will be necessary to achieve the water quality requirements of the project. The final difference between simulations will be greater than this after consideration of phosphorus performance.

the simulated net flows, in that redistribution of flows will likely be necessary in order to achieve the appropriate phosphorus water quality levels. Depending on the inflow source, the phosphorus concentration will vary, and to the extent that the "With Project" and "Without Project" simulations result in different volumes and sources, the associated phosphorus loads to the reservoirs and STAs will differ. An iterative process of hydrologic and water quality modeling will likely be required to finalize the "With Project" conditions and determine the ultimate inflow volume and associated phosphorus load to be treated in the new STA. During the EAA PIR modeling meeting on 8/4/06, it was recommended that the model run EAA1-4 be used to estimate flows for the "With Project" condition and that the 2050B3EAA simulation results be used for the "Without Project" condition. The estimated size of the STA will need to be updated later when a final simulation is available.

A Base Condition was assembled based on the current estimate of the anticipated flow and treatment characteristics.

Table 3. Base Condition Parameter Values

Parameter	Unit	Base Value
New STA Effective Settling Rate	m/yr	22.46
Lake Okeechobee Discharge Conc	ppb	145.5
Outflow TP Target	ppb	18.6
Reservoir Settling Rate	m/yr	1.575
Lake water supply releases to be diverted	AF/yr	68,278

Application of the values in the table above led to the following set of inflows to the proposed STA. In addition to providing an initial estimate of the effective treatment area required for the new STA, the Base Condition values in the table below provide the starting point for the subsequent sensitivity analysis.

Table 4. Summary of Base Condition

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	89	16,569						
	EAASR A2 Cell 3	60,186	89	6,607						
	Total	583,828	125	90,069	720.142	1	1.6	16,000	64.777	110
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	110	6,406						
	EAASR A1 - Cell 4	81,291	110	11,034						
	Total	390,960	105	50,491	482.242	1	1.6	14,000	56.680	89
STA-3/4	Lake O water supply	82,583	146	14,821						
	Lake O ws diverted	-68,278	146	-12,254						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	110	60,175						
	Total	728,407	111	100,160	898.478	6	22.5	16,543	66.976	28.5
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	285,099	114	39,985						
	EAASR A1	228,150	110	30,969						
	Total	513,249	112	70,954	633.083	6	22.5	16,543	66.976	18.6
To New STA:	EAASR A1	215,158	110	29,206						
New STA		**Flow AF/yr**	**TP Conc ppb**	**TP Load kg/yr**	**V hm^3/yr**	**n dimensionless**	**K m/yr**	**C_o ppb**	**A km^2**	**A ac**
	Redirection from EAASR A1	215,158	110	29,206						
Base STA K	Total	215,158	110	29,206	265.394	6	22.5	18.6	27.766	6,858
Min. STA K	Total	215,158	110	29,206	265.394	6	18.6	18.6	33.582	8,295
Max. STA K	Total	215,158	110	29,206	265.394	6	26.3	18.6	23.748	5,866

5.0 CONCEPTUAL-LEVEL ESTIMATE OF EFFECTIVE TREATMENT AREA

Using a steady-state model to forecast phosphorus removal performance of the A1 and A2 reservoirs, as well as STA-3/4 and the proposed STA, a conceptual-level range of 5,900 – 8,300 acres of effective treatment area was estimated for the proposed STA. The range reflects the likely range of phosphorus removal performance of the new STA after start-up and stabilization of the treatment cells are complete. While the use of long-term average annual values is appropriate for the present conceptual-level analysis, it will be important to utilize a dynamic model for future design efforts in order to better understand the short-term flow pulses associated with the project components, and their influence on phosphorus removal.

6.0 SENSITIVITY ANALYSIS

Recognizing that the estimated area is influenced by critical design factors that contain considerable levels of uncertainty, a sensitivity analysis was performed for the following parameters: target STA outflow phosphorus concentration, phosphorus concentration in Lake Okeechobee releases, the phosphorus settling rate of the new STA, reservoir settling rate, and volume of water supply diversions. The sensitivity analysis determined both the absolute change in effective treatment area for the change in input parameter and the relative sensitivity, defined as the ratio of the percent change in estimated area to percent change in input parameter. This analysis can help identify the key parameters that need particular focus during subsequent PIR phases in order to reduce uncertainty. The table below identifies the upper and lower bounds of the parameter values, and identifies the basis for the values.

Table 5. Enumeration and Basis of Parameter Ranges

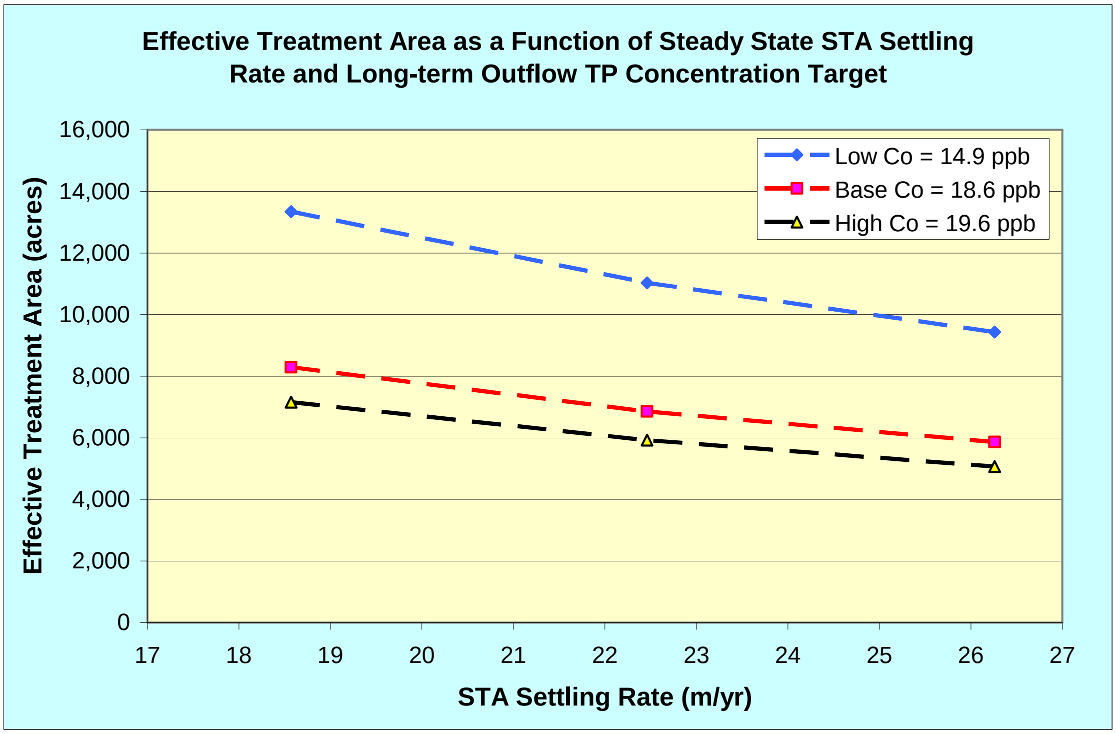
	New STA Effective Settling Rate m/yr	Lake Okeechobee Discharge Conc ppb	Outflow TP Target ppb	Lake water supply releases to be diverted AF/yr
Minimum Value	18.57	70.0	14.85	58,372
Basis for Value	Steady-state adjustment of EAA RFS lower confidence level	Values assumed during EAA RFS; anticipated after Lake recovery	Lowest sustainable concentration from large-scale SAV treatment wetland in DMSTA calibration data set	Volume diverted in 2050B3EAA SFWMM scenario
Maximum Value	26.3	200	19.6	120,763
Basis for Value	Steady-state adjustment of EAA RFS upper confidence level	Arbitrary estimate of upper long-term level	Current proposed Technology Based Effluent Limitation for STA-3/4	Volume diverted in EAA RFS SFWMM scenario

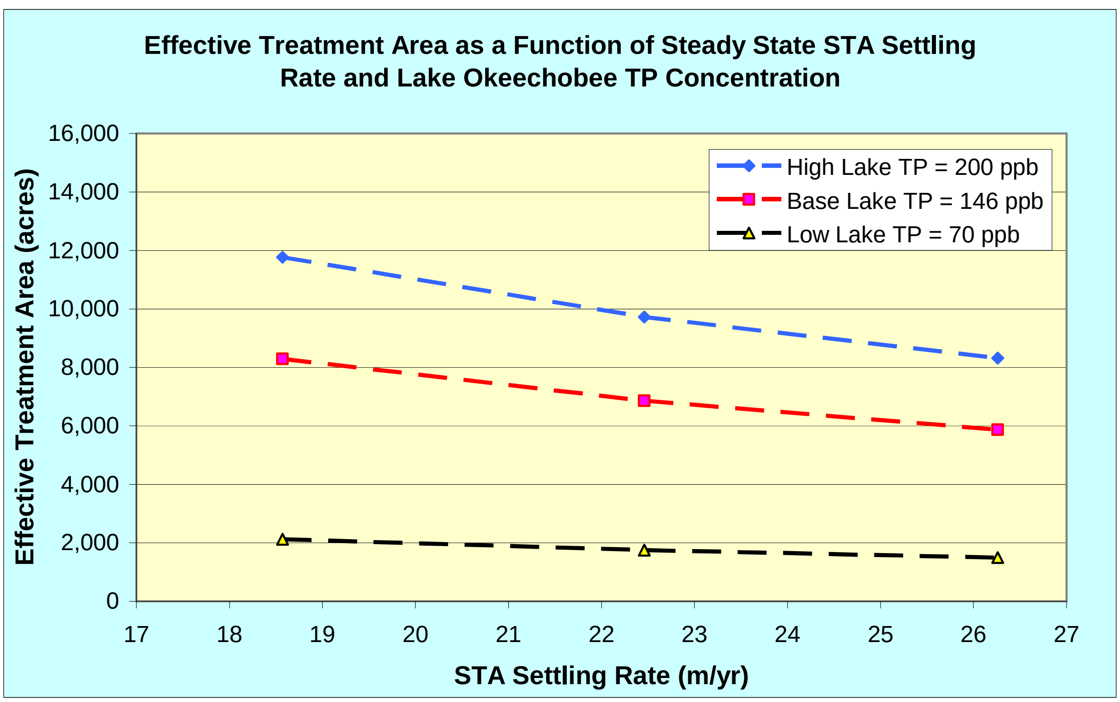
The sensitivity of the effective treatment area to the various parameters is summarized in the table and figures below. Within the parameter ranges evaluated, the estimated effective treatment area was most sensitive to the STA target outflow phosphorus concentration, with a range of 5,900 to 11,000 acres of effective treatment area estimated for an outflow concentration range of 15-20 ppb (all other values held constant at their Base Condition values). The phosphorus concentration in Lake Okeechobee releases was also a very sensitive parameter, with a range of 1,800 to 9,700 acres of effective treatment area identified for a concentration range of 70-200 ppb. This finding underscores the importance of explicitly incorporating water quality considerations associated with Lake releases. As expected, the estimated effective treatment area was sensitive to the net settling rate of the proposed STA, with a range of 5,900 – 8,300 acres estimated for (adjusted) K values ranging from 18.6 to 26.3 m/yr. Of the parameters evaluated, the effective treatment area was least sensitive to the net settling rate of the reservoir within the range of values derived from the recent Acceler8 analyses (Black & Veatch 2006). For the Base Condition, phosphorus load reduction was estimated at 12% and 15% for the A1 and A2 reservoirs, respectively. This estimated load reduction ranged from 9% to 29% for K values of 1.6 – 3.6 m/yr. Additional details of the individual sensitivity analyses are presented in Appendix 1.

Table 6. Summary of Sensitivity Analysis Results

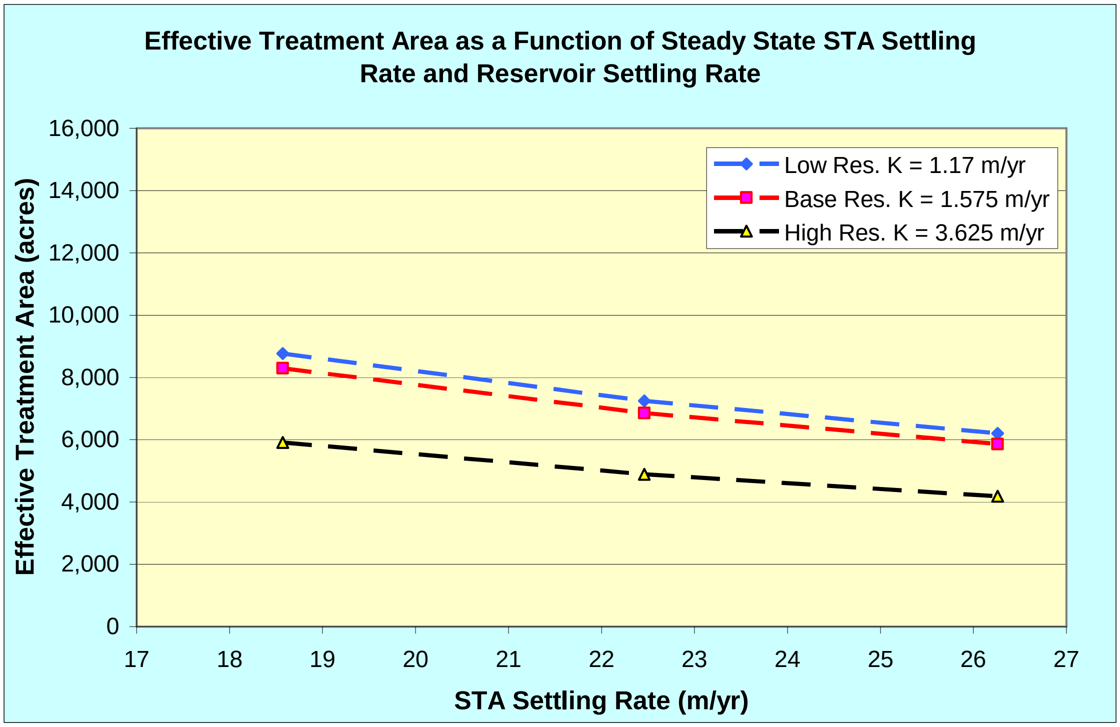
Parameter	Unit	Base Value	Area acres	Minimum Parameter Value	Revised Area acres	Relative Sensitivity	Maximum Parameter Value	Revised Area acres	Relative Sensitivity	Overall Parameter Sensitivity
Effective Treatment Area of new STA	acres	6,858								
New STA Effective Settling Rate	m/yr	22.46	6,858	18.6	8,295	-1.21	26.3	5,866	-0.86	1.03
Lake Okeechobee Discharge Conc	ppb	145.5	6,858	70	1,751	1.44	200	9,727	1.12	1.30
w/ min STA K			8,295		2,118			11,764		
w/ max STA K			5,866		1,498			8,319		
STA Outflow Phosphorus Target	ppb	18.6	6,858	14.85	11,036	-3.02	19.6	5,921	-2.54	2.92
w/ min STA K			8,295		13,348			7,162		
w/ max STA K			5,866		9,439			5,064		
Reservoir Settling Rate	m/yr	1.575	6,858	1.17	7,252	-0.22	3.625	4,890	-0.22	0.22
w/ min STA K			8,295		8,772			5,914		
w/ max STA K			5,866		6,203			4,182		
Lake water supply to be diverted	AF/yr	68,278	6,858	58,372	7,234	N/A	120,763	4,544	N/A	0.35
w/ min STA K			8,295		8,750			5,496		
w/ max STA K			5,866		6,187			3,886		

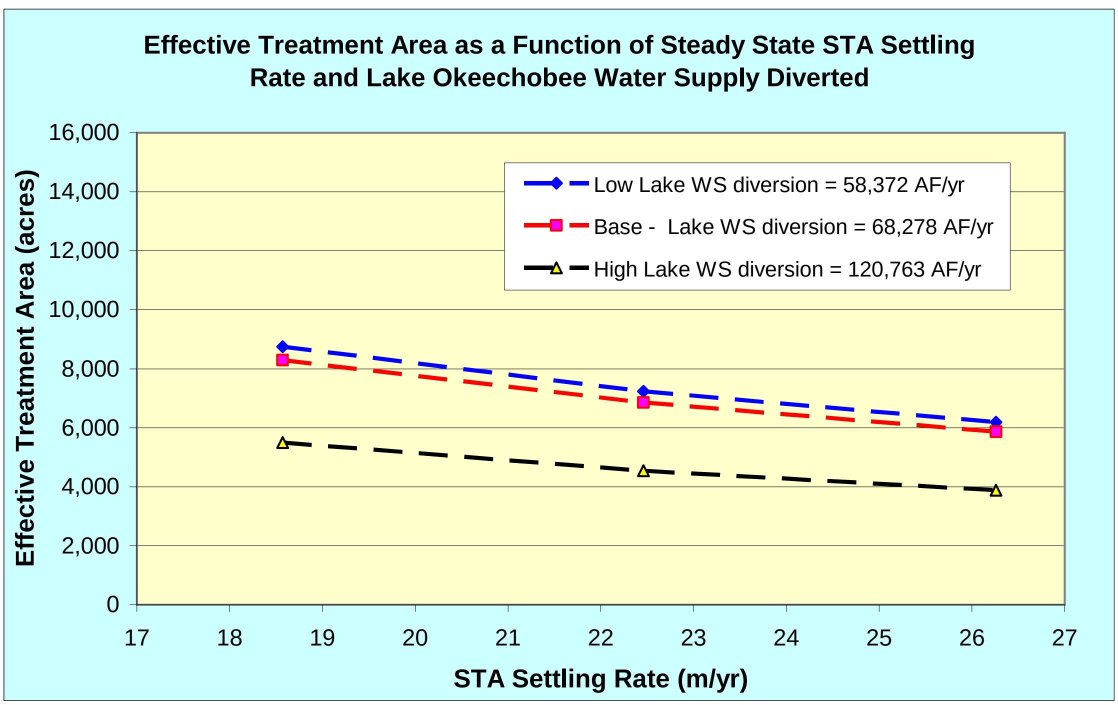
Figures 2 and 3.





Figures 4 and 5.





7.0 DISCUSSION

Although considerable technical uncertainties remain regarding the flows and phosphorus levels that may enter the proposed STA, a conceptual-level range of 5,900 – 8,300 acres of effective treatment area was estimated based on a specific set of assumed base conditions. This conceptual-level analysis and related sensitivity analysis should allow the PDT to move forward in addressing remaining water and mass balance issues, selecting design values and conducting more detailed analyses, including use of a dynamic simulation model for reservoir and STA performance forecasting. Suggested issues to address include:

1. **Changing conditions.** Agreement on an appropriate adaptive management approach for addressing future changes in
    a. the Lake Okeechobee discharge phosphorus levels as CERP and other projects combine to aid in the recovery of the Lake,
    b. STA performance, as large-scale enhancements are implemented, and
    c. Everglades inflow targets, as additional regulatory criteria are refined.

2. **STA Design.** The design of the new STA should build on the lessons learned from the design, construction and operation of the Everglades STAs, and incorporate the most effective phosphorus removal features available.

3. **Water Supply Deliveries.** Evaluating the timing and distribution of untreated water supply deliveries to points downstream of the STAs, e.g., it may be possible to make low flow water supply deliveries at times when water levels in the Water Conservation Areas (WCAs) are below certain minimum elevations such that the water remains within the canals and does not overflow into the adjacent marsh.

4. **Refinement of Reservoir Operations and Possible Configuration Revision.** There may be considerable opportunity to refine the operations of the EAASR treatment cells in order to enhance the performance of the STAs. For example, it is noted that the annual volume of water projected to enter the combined 30,000 + acre EAASR was less than the annual inflow volume to STA-3/4 – even though the STA is approximately 50% of the area. This may also suggest that a portion of the footprint designated for the EAASR might be more effectively utilized for the proposed STA, although more rigorous hydraulic modeling will be necessary to ensure the hydraulic constraints and storage requirements of the EAASR are preserved.

5. **Integration with Compartment B.** Consistent with the simulated conditions, no consideration was given to integrating the operation of the EAASR and the STAs with the treatment area being designed for Compartment B. Developing an integrated regional operations strategy will likely minimize the additional treatment area of the proposed STA and enhance the overall STA performance, thereby ensuring the highest quality of water entering the Everglades.

6. **Dynamic phosphorus modeling.** While the use of long-term average annual values is appropriate for the present conceptual-level analysis, it will be important to utilize a dynamic model for future design efforts in order to better understand the short-term flow pulses associated with the project components, and their influence on phosphorus removal.

8.0 REFERENCES

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CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Florida, that the information in this report was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse without specific verification or adaptation by the Engineer. This certification is made in accordance with the provisions of the Laws and Rules of the Florida Board of Professional Engineers under Chapter 61G15-29, Florida Administrative Code.

GF Goforth

Gary F. Goforth, P.E. Florida P.E. # 35525

Date: August 12, 2006

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Appendix 1. Sensitivity of Effective Treatment Area Estimates to Various Parameters

Sensitivity to Lower Target Outflow Phosphorus Concentration

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	90	16,755						
	EAASR A2 Cell 3	60,186	90	6,682						
	Total	583,828	125	90,329	720.142	1	1.6	16,000	64.777	110
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	110	6,424						
	EAASR A1 - Cell 4	81,291	110	11,066						
	Total	390,960	105	50,541	482.242	1	1.6	14,000	56.680	89
STA-3/4	Lake O water supply	82,583	146	14,821						
	Lake O ws diverted	-68,278	146	-12,254						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	110	60,348						
	Total	728,407	112	100,334	898.478	6	22.5	16,543	66.976	28.6
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						14.9				
	other inflow	285,099	114	39,985						
	EAASR A1	150,400	110	20,474						
	Total	435,499	113	60,459	537.180	6	22.5	16,543	66.976	14.90
To New STA:	EAASR A1	292,908	110	39,874						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	292,908	110	39,874						
Base STA K	Total	292,908	110	39,874	361.297	6	22.5	14.9	44.682	11,036
Min. STA K	Total	292,908	110	39,874	361.297	6	18.6	14.9	54.042	13,348
Max. STA K	Total	292,908	110	39,874	361.297	6	26.3	14.9	38.216	9,439

Sensitivity to Higher Target Outflow Phosphorus Concentration

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	89	16,569						
	EAASR A2 Cell 3	60,186	89	6,607						
	Total	583,828	125	90,069	720.142	1	1.6	16,000	64.777	110
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	110	6,406						
	EAASR A1 - Cell 4	81,291	110	11,034						
	Total	390,960	105	50,491	482.242	1	1.6	14,000	56.680	89
STA-3/4	Lake O water supply	82,583	146	14,821						
	Lake O ws diverted	-68,278	146	-12,254						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	110	60,175						
	Total	728,407	111	100,160	898.478	6	22.5	16,543	66.976	28.5
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						19.6				
	other inflow	285,099	114	39,985						
	EAASR A1	250,000	110	33,935						
	Total	535,099	112	73,920	660.035	6	22.5	16,543	66.976	19.6
To New STA:	EAASR A1	193,308	110	26,240						
New STA		**Flow AF/yr**	**TP Conc ppb**	**TP Load kg/yr**	**V hm^3/yr**	**n dimensionless**	**K m/yr**	**C_o ppb**	**A km^2**	**A ac**
	Redirection from EAASR A1	193,308	110	26,240						
Base STA K	Total	193,308	110	26,240	238.443	6	22.5	19.6	23.973	5,921
Min. STA K	Total	193,308	110	26,240	238.443	6	18.6	19.6	28.994	7,162
Max. STA K	Total	193,308	110	26,240	238.443	6	26.3	19.6	20.504	5,064

Sensitivity to Lower Lake Okeechobee Outflow Phosphorus Concentration

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	70	25,327						
	Lake O reg rel MC	79,397	70	6,856						
	EAASR A2 Cell 1	150,928	76	14,149						
	EAASR A2 Cell 3	60,186	76	5,642						
	Total	583,828	72	51,973	720.142	1	1.6	16,000	64.777	64
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	64	3,708						
	EAASR A1 - Cell 4	81,291	64	6,388						
	Total	390,960	89	43,148	482.242	1	1.6	14,000	56.680	76
STA-3/4	Lake O water supply	82,583	70	7,131						
	Lake O ws diverted	-68,278	70	-5,895						
	Lake O reg rel	42,014	70	3,628						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	64	34,838						
	Total	728,407	77	69,578	898.478	6	22.5	16,543	66.976	20.8
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	285,099	99	34,740						
	EAASR A1	362,000	64	28,448						
	Total	647,099	79	63,188	798.185	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	81,308	64	6,390						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	81,308	64	6,390						
Base STA K	Total	81,308	64	6,390	100.293	6	22.5	18.6	7.089	1,751
Min. STA K	Total	81,308	64	6,390	100.293	6	18.6	18.6	8.574	2,118
Max. STA K	Total	81,308	64	6,390	100.293	6	26.3	18.6	6.063	1,498

Sensitivity to Higher Lake Okeechobee Outflow Phosphorus Concentration

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	200	72,361						
	Lake O reg rel MC	79,397	200	19,587						
	EAASR A2 Cell 1	150,928	98	18,245						
	EAASR A2 Cell 3	60,186	98	7,275						
	Total	583,828	163	117,469	720.142	1	1.6	16,000	64.777	143
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	143	8,345						
	EAASR A1 - Cell 4	81,291	143	14,376						
	Total	390,960	116	55,772	482.242	1	1.6	14,000	56.680	98
STA-3/4	Lake O water supply	82,583	200	20,373						
	Lake O ws diverted	-68,278	200	-16,844						
	Lake O reg rel	42,014	200	10,365						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	143	78,399						
	Total	728,407	136	122,170	898.478	6	22.5	16,543	66.976	34.1
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	285,099	124	43,771						
	EAASR A1	181,500	143	32,098						
	Total	466,599	132	75,869	575.541	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	261,808	143	46,300						
New STA		Flow AF/yr	**TP Conc ppb**	**TP Load kg/yr**	**V hm^3/yr**	**n dimensionless**	**K m/yr**	**C_o ppb**	**A km^2**	**A ac**
	Redirection from EAASR A1	261,808	143	46,300						
Base STA K	Total	261,808	143	46,300	323	6	22	18.6	39.380	9,727
Min. STA K	Total	261,808	143	46,300	323	6	19	18.6	47.629	11,764
Max. STA K	Total	261,808	143	46,300	323	6	26	18.6	33.682	8,319

Sensitivity to Lower Reservoir Settling Rate

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	94	17,500						
	EAASR A2 Cell 3	60,186	94	6,978						
	Total	583,828	127	91,371	720.142	1	1.2	16,000	64.777	115
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	115	6,704						
	EAASR A1 - Cell 4	81,291	115	11,549						
	Total	390,960	106	51,304	482.242	1	1.2	14,000	56.680	94
STA-3/4	Lake O water supply	82,583	146	14,821						
	Lake O ws diverted	-68,278	146	-12,254						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	115	62,981						
	Total	728,407	115	102,966	898.478	6	22.5	16,543	66.976	29.3
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	285,099	114	39,985						
	EAASR A1	222,000	115	31,540						
	Total	507,099	114	71,525	625.497	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	221,308	115	31,441						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	221,308	115	31,441						
Base STA K	Total	221,308	115	31,441	272.980	6	22.5	18.6	29.362	7,252
Min. STA K	Total	221,308	115	31,441	272.980	6	18.6	18.6	35.512	8,772
Max. STA K	Total	221,308	115	31,441	272.980	6	26.3	18.6	25.113	6,203

Sensitivity to Higher Reservoir Settling Rate

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	70	13,032						
	EAASR A2 Cell 3	60,186	70	5,197						
	Total	583,828	118	85,121	720.142	1	3.6	16,000	64.777	90
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	90	5,246						
	EAASR A1 - Cell 4	81,291	90	9,036						
	Total	390,960	98	47,333	482.242	1	3.6	14,000	56.680	70
STA-3/4	Lake O water supply	74,370	146	13,347						
	Lake O ws diverted	-68,278	146	-12,254						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	90	49,279						
	Total	720,194	99	87,790	888.347	6	22.5	16,543	66.976	25.3
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	276,886	113	38,511						
	EAASR A1	268,750	90	29,874						
	Total	545,636	102	68,386	673.032	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	174,558	90	19,404						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	174,558	90	19,404						
Base STA K	Total	174,558	90	19,404	215.315	6	22.5	18.6	19.797	4,890
Min. STA K	Total	174,558	90	19,404	215.315	6	18.6	18.6	23.944	5,914
Max. STA K	Total	174,558	90	19,404	215.315	6	26.3	18.6	16.932	4,182

Sensitivity to Lower Lake Okeechobee Water Supply Diversions

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	89	16,569						
	EAASR A2 Cell 3	60,186	89	6,607						
	Total	583,828	125	90,069	720.142	1	1.6	16,000	64.777	110
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	110	6,406						
	EAASR A1 - Cell 4	81,291	110	11,034						
	Total	390,960	105	50,491	482.242	1	1.6	14,000	56.680	89
STA-3/4	Lake O water supply	82,583	146	14,821						
	Lake O ws diverted	-58,372	146	-10,476						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	110	60,175						
	Total	738,313	112	101,938	910.696	6	22.5	16,543	66.976	29.1
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	295,005	115	41,763						
	EAASR A1	216,350	110	29,368						
	Total	511,355	113	71,131	630.747	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	226,958	110	30,808						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	226,958	110	30,808						
Base STA K	Total	226,958	110	30,808	279.949	6	22.5	18.6	29.288	7,234
Min. STA K	Total	226,958	110	30,808	279.949	6	18.6	18.6	35.424	8,750
Max. STA K	Total	226,958	110	30,808	279.949	6	26.3	18.6	25.050	6,187

Sensitivity to Higher Lake Okeechobee Water Supply Diversions

Component	Source	Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	A acres	A km^2	Co ppb
EAASR A1	Lake O reg rel NNRC	293,318	146	52,643						
	Lake O reg rel MC	79,397	146	14,250						
	EAASR A2 Cell 1	150,928	89	16,569						
	EAASR A2 Cell 3	60,186	89	6,607						
	Total	583,828	125	90,069	720.142	1	1.6	16,000	64.777	110
EAASR A2	NNRC runoff	152,231	116	21,769						
	MC runoff	110,248	83	11,282						
	EAASR A1 - Cell 2	47,190	110	6,406						
	EAASR A1 - Cell 4	81,291	110	11,034						
	Total	390,960	105	50,491	482.242	1	1.6	14,000	56.680	89
STA-3/4	Lake O water supply	74,370	146	13,347						
	Lake O ws diverted	-120,763	146	-21,674						
	Lake O reg rel	42,014	146	7,541						
	NNRC runoff	101,425	116	14,504						
	MC runoff	97,511	83	9,978						
	C-139 runoff	13,667	182	3,062						
	Ch 298 Dist. runoff	16,176	117	2,333						
	EAASR A1	443,308	110	60,175						
	Total	667,709	108	89,267	823.607	6	22.5	16,543	66.976	25.2
Reduce EAA SR A1 inflow in order to meet target outflow concentration =						18.6				
	other inflow	224,401	105	29,091						
	EAASR A1	300,750	110	40,824						
	Total	525,151	108	69,916	647.764	6	22.5	16,543	66.976	18.60
To New STA:	EAASR A1	142,558	110	19,351						

New STA		Flow AF/yr	TP Conc ppb	TP Load kg/yr	V hm^3/yr	n dimensionless	K m/yr	C_o ppb	A km^2	A ac
	Redirection from EAASR A1	142,558	110	19,351						
Base STA K	Total	142,558	110	19,351	175.843	6	22.5	18.6	18.397	4,544
Min. STA K	Total	142,558	110	19,351	175.843	6	18.6	18.6	22.251	5,496
Max. STA K	Total	142,558	110	19,351	175.843	6	26.3	18.6	15.735	3,886